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Using Educational Computer Games in the Classroom: Science Teachers' Experiences, Attitudes, Perceptions, Concerns, and Support Needs

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Abstract

Science teachers' experiences, attitudes, perceptions, concerns, and support needs related to the use of educational computer games were investigated in this study. Data were collected from an online survey, which was completed by 111 science teachers. The results showed that 73% of participants had used computer games in teaching. Participants who had used computer games in teaching had more positive attitudes toward the use of educational computer games in the classroom than those who had not used games. Middle school teachers were more confident and reported a higher level of perceived benefits than did high school teachers. Potential distractions appeared to be the major concern the participants had about using computer games in the classroom. The major barriers to integrating educational computer games into the classroom included lack of computers, lack of time, time needed for preparation for school and national high-stakes testing, and lack of knowledge about science games. Participants indicated their greatest needs were computers and access to trial versions of games to integrate educational computer games effectively in their classrooms. Participants reported that a computer game must be aligned with state and national standards, free, compatible with school computers, fun, challenging, proven to be effective, and easy to use in order to be used in their classroom.

In the science classroom, computer games can present unique opportunities for teachers and students, as they involve activities of observation, interpretation, simulation, inference, prediction, hypothesis, classification, and communication (Lowe, 1988). Indeed, computer games offer much potential to make the scientific inquiry process more engaging by providing a rich and interactive environment that challenges students to solve a complex problem in a meaningful context and enables them to gather information and evidence from multiple sources using authentic tools (An, 2015).

While game researchers have designed and developed many educational computer games or game-based learning environments that help students develop scientific inquiry and 21st-century skills (e.g., River City, rivercity.activeworlds.com, and Alien Rescue alienrescue.edb.utexas.edu), they have not been widely adopted in schools. Many teachers are still unaware of those games and view computer games merely as motivational tools (Gaudelli & Taylor, 2011; Schrader, Zheng, & Young, 2006).

Computer games are well suited to the *Next Generation Science Standards* (NGSS) because they enable students to learn by doing and help them develop transferable knowledge and skills by allowing them to practice newly learned skills in a variety of situations (An & Bonk, 2009; Gee, 2005; Shaffer, Squire, Halverson, & Gee, 2005). Unlike traditional content-focused standards, the NGSS are written as performance expectations that depict what students should be able to do beyond what they should know to show proficiency in science. Each NGSS has three dimensions: disciplinary core ideas, scientific and engineering practices, and crosscutting concepts. By coupling practice with content, the NGSS emphasizes the development of scientific knowledge and skills in authentic contexts (NGSS Lead States, 2013).

The Entertainment Software Association (2014) reported that 82% of American teachers play computer games. Recently, the Joan Ganz Cooney Center surveyed 694 K-8 teachers from across the United States regarding whether and how they are using computer games with their students (Takeuchi & Vaala, 2014). The results of the national survey showed that 74% of participants were using computer games for instruction. Eighty-one percent of the game-using teachers reported that their students primarily play educational games.

In terms of the perceived effectiveness of computer games for improving student learning, mathematics ranked highest, with 71% of game-using teachers reporting that computer games have been effective in improving their students' math learning. Conversely, only 42% of the participants reported that computer games have been effective in improving students' science learning. This finding lends itself to the rationale for the current study to examine science teachers' experiences, attitudes, perceptions, concerns, and support needs related to the use of educational computer games specifically in the science classroom.

Literature Review

Teachers' Attitudes Toward and Perceptions of Computer Games

Over the last 10 years, researchers have investigated preservice and in-service teachers' perceptions regarding the use of computer games and reported mixed findings. Can and Cagiltay (2006) investigated Turkish prospective teachers' perceptions and future plans regarding the use of computer games with educational features. The study findings showed that the prospective teachers had positive perceptions regarding the use of computer games

with educational features in education. Eighty-three percent of the participants expressed the intention to use computer games with educational features in their courses in the future.

Similarly, Schrader et al. (2006) examined preservice teachers' perceptions of video games, particularly massively multiplayer online games. Their survey results revealed that the majority of the participants had no or limited experiences with social aspects of gaming and gaming communities and were not fully aware of their pedagogical value. The results indicated that preservice teachers valued games as a motivational tool or a reward for positive behaviors.

Gaudelli and Taylor (2011) found that in-service teachers were skeptical about the pedagogical value of video games. The teachers participating in the study viewed video games as motivational tools. Takeuchi and Vaala (2014) reported that more than half the game-using teachers in their study used digital games to motivate and reward students.

Pastore and Falvo (2010) examined both pre- and in-service teachers' perceptions of gaming in the classroom environment. Ninety-eight participants, 53 in-service and 45 preservice teachers, completed a survey. The results of the study revealed that a majority of both pre- and in-service teachers agreed that gaming enhances students' learning and motivates students. However, only about half the participants indicated that they used or intended to use gaming in their teaching. Although these findings indicate that positive attitudes or perceptions do not always lead to behavioral intention, the literature does not explain the support needs of the teachers who intend to use gaming in the classroom.

Effects of Computer Game Experience on Teachers' Attitudes and Perceptions

Research shows that exposure to games can positively influence preservices teachers' attitudes toward and perceptions of games or game-based learning (Kennedy-Clark, Galstaun, & Anderson, 2011; Kenny & McDaniel, 2011; Ray & Coulter, 2010; Sardone & Devlin-Scherer, 2010). For example, Kennedy-Clark et al. (2011) examined the change of preservice teachers' perceptions of game-based learning. Eighteen preservice science teachers participated in a 2-hour workshop on the integration of game-based learning into inquiry learning, which involved the play of Death in Rome (www.bbc.co.uk/history/interactive/games/death_rome/index.shtml), an inquiry-based game. The results indicated a significant shift in the participants' attitudes toward game-based learning as a result of the workshop.

Only a few studies have investigated whether and how exposure to games influences in-service teachers' perceptions of educational computer games. Gerber and Price (2013) examined in-service teachers' perceptions of the use of commercial off-the-shelf video games in English language arts classrooms. The participants, 10 literacy teachers, were required to complete multiple readings, explore several multi-user virtual environments, and play a commercial off-the-shelf video game through to completion while at the same time researching literacy activities directly related to the game they had selected to play. The results of the study indicated that the participants saw the value of game-based pedagogy and wanted to use game-based learning, but they believed that the schools where they taught would not be open to game-based pedagogy.

Becker (2007) exposed teachers to a wide variety of games in a graduate-level course on digital game-based learning. The participants played, examined, and discussed various games. At the end of the class, all participants were enthusiastic about the potential of digital games to enhance learning as a result of the analyses and discussions. However,

many teachers still continued to feel that integrating games in the formal curriculum was not likely to occur in the near future.

Gaudelli and Taylor (2011) investigated teachers' views of serious video games before, during, and after game play in the context of global education. Seven social studies teachers participated in a series of activities, including an initial focus group meeting, both extended and short-play games, blogging, and a focus-group reflection. The data from the initial focus group meeting revealed that the participants were generally skeptical about the pedagogical value of video games, due in part to their lack of familiarity with this type of media. Interestingly, even during and after the video game experience, the teachers remained skeptical about teaching global content through video games. They consistently mentioned that games should not replace teacher instruction.

Factors Affecting Teachers' Game Adoption

The literature suggests that multiple factors influence teachers' perceptions and adoption of games. Using Rogers' (2003) theory of diffusion of innovation as the conceptual framework, Kebritchi (2010) conducted a case study to identify the factors affecting the adoption of Dimenxian (dimenxian.en.softonic.com), which was an educational computer game designed to teach algebra to middle school students. The results showed that the key factors affecting the adoption of Dimenxian included evidence of effectiveness of the game from credible empirical studies, rich mathematical content, the alignment between the game's learning objectives and the state and national standards, time and technology compatibility, an appropriate amount of complexity, and access to a trial version of the game. Interestingly, the observability of the game was not identified as a strong factor influencing teachers' adoption decisions.

Bourgonjon et al. (2013) found that perceived usefulness strongly affected behavioral intention to use video games in the classroom. They hypothesized that complexity would negatively relate to behavioral intention, but complexity did not yield a significant effect on behavioral intention. Another interesting finding was that video game experience did not affect usefulness or behavioral intention.

Barriers to the Use of Computer Games in the Classroom

Research studies report a number of challenges and barriers to the use of computer games in the classroom. The results of Kebritchi's (2010) study indicated that the alignment of the games with the school curriculum was one of the greatest challenges of using educational computer games in schools. Baek (2008) identified six barriers that hindered Korean teachers from using computer games in the classroom: the inflexibility of the curriculum, negative effects of gaming, students' lack of readiness, the lack of supporting materials, fixed class schedules, and limited budgets.

Takeuchi and Vaala (2014) reported that the major barriers faced by game-using teachers when integrating digital games into their teaching include insufficient time (46%), cost (44%), lack of technology resources (35%), and uncertainty about where to find high-quality games (31%). Gerber and Price (2013) found that fear of reprisal and condemnation from colleagues could hinder teachers from using video games in the classroom. Bourgonjon et al. (2013) also found that social influences, including the perceived social pressure to use games or not, played an important part in the acceptance of game-based learning by secondary school teachers.

Purpose of the Study

According to the national survey conducted by the Joan Ganz Cooney Center (Takeuchi & Vaala, 2014), only 42% of game-using teachers reported that computer games have been effective in improving students' science learning, while 71% reported that computer games have been effective in improving students' mathematics learning. The finding suggests that teachers' perceptions of the value of computer games might be different in different subject areas. Therefore, exploring teachers' game integration experiences and perceptions in a specific subject area such as science is worthwhile.

In an attempt to better understand science teachers' experiences, attitudes, perceptions, concerns, and support needs related to the use of educational computer games in the classroom, this study focused on the following:

1. Science teachers' experiences with computer games.
2. Science teachers' attitudes toward and readiness for the use of educational computer games in the classroom.
3. Science teachers' perceptions of the benefits of educational computer games.
4. Science teachers' concerns related to using educational computer games in the classroom.
5. Science teachers' perceived barriers and support needs.
6. Important features of computer games that affect science teachers' adoption decisions.

By examining science teachers' experiences, attitudes, perceptions, concerns, and support needs related to computer game integration, this study aimed to inform science teacher education and professional development programs of how they can better support science teachers in integrating educational computer games in the classroom. Further, this study aimed to inform game researchers and game developers about developing effective science games that meet science teachers' needs by examining the features of computer games they value.

Method

Participants

We sent email invitations, including the link to an online survey, to 1,409 science teachers (Grades 6-12) in Georgia, and 111 science teachers from 16 school districts completed the online survey. Email addresses were gathered from publicly available links on school websites, and the participants comprised a convenience sample. One third of participants reported teaching at the middle school level (n = 37), while the other two-thirds identified themselves as high school teachers (n = 74). Participants' teaching experience varied from less than 1 year to 35 years, with about half of participants (n = 57) reporting having 11 years or more of experience teaching science. The science subjects they taught included biology, chemistry, Earth science, life science, physics, physical science, environmental science, oceanography, and forensics. Approximately 64% of participants (n = 71) were female. Table 1 summarizes the demographic information of the participants.

Table 1
Summary of Participant Demographic Information (*N* = 111)

Characteristic	*n*	%
Age		
18-25 years	7	6.3%
26-35 years	24	21.3%
36-45 years	22	19.8%
46-55 years	43	38.7%
Over 55 years	15	13.5%
Ethnicity		
African-American	12	10.8%
Asian	1	0.9%
Caucasian	89	80.2%
Hispanic	4	3.6%
Multiracial	5	4.5%
Gender		
Female	71	64%
Male	40	36%
Teaching Experience		
0-5 years	27	24.3%
6-10 years	27	24.3%
11-20 years	36	32.4%
21-30 years	16	14.4%
31-35 years	5	4.5%

Instruments

Data for this study were collected from an online survey administered using Google Forms. The instrument included demographic questions, 15 Likert-scale items, two multiple choice items, four check-all-that-apply items, and one open ended question (i.e., "What else would you like to tell us about using educational computer games in science classrooms?"). The items written for this instrument were crafted to measure specific constructs identified through extensive literature review as important factors in shaping

perceptions and decisions about the use of educational computer games in the science classroom (i.e., perceived benefits, concerns, perceived barriers, and support needs). For each Likert-scale item, participants used a 5-point scale to indicate the extent to which they agreed or disagreed with each statement. Items are presented with the appropriate descriptive statistics in the results section.

The items used to measure teachers' attitudes, readiness, and perceived benefits were developed based on the relevant literature (Kebritchi, 2010; Kennedy-Clark et al., 2011; Prensky, 2007; Ray & Coulter, 2010; Rogers, 2003; Sardone & Devlin-Scherer, 2010; Takeuchi & Vaala, 2014). Four Likert-scale items were created to measure teachers' attitudes toward the use of educational computer games in the classroom. One check-all-that-apply item was developed to measure teachers' readiness to use educational computer games in the classroom. Four Likert-scale items were developed to measure perceived benefits of educational computer games.

The existing literature base identifies myriad factors related to teachers' concerns about using educational computer games in the classroom, barriers to integrating educational computer games in the classroom, and the supports needed in effectively integrating educational computer games in the classroom. The common factors identified by more than one source were the basis for the development of five Likert-scale items and one check-all-that-apply item related to concerns (Can & Cagiltay, 2006; Gaudelli & Taylor, 2011; Gerber & Price, 2013; Kebritchi, 2010; Kennedy-Clark et al., 2011; Rogers, 2003; Schrader et al., 2006), a check-all-that-apply item used to measure perceived barriers (Baek, 2008; Bourgonjon et al., 2013; Gerber & Price, 2013; Kennedy-Clark et al., 2011; Schrader et al., 2006; Takeuchi & Vaala, 2014), and two Likert-scale items and a multiple-choice item related to support needs (Gerber & Price, 2013; Sardone & Devlin-Scherer, 2010). One multiple-choice item and one check-all-that-apply item were developed to measure features that affect teachers' game adoption decisions based on the work of Kebritchi (2010) and Rogers (2003).

Data Analysis

The data collected from the survey were analyzed using a variety of analytic techniques. Descriptive statistics were computed to investigate the distributions of demographic variables. Confirmatory factor model fit statistics and model-based reliability statistics were used to investigate the relationships between subsets of items. Correlations, independent *t* tests, and effect sizes were used to investigate group differences.

Results

Experiences with Computer Games

Computer gaming experiences varied among participants (See Table 2). Almost half (49%) of the participants indicated that they do not play computer games. Slightly fewer participants (48%) played computer games 1-9 hours per week, and 3% reported spending 10 or more hours playing computer games each week. The computer games played by the participants include popular games such as Candy Crush, Solitaire, Angry Birds, Temple Run 2, and Farmville.

Table 2
Computer Gameplay (N = 111)

Hours of Gameplay	%
I don't play computer games.	49
1-3 hours /week	32
4-6 hours/week	13
7-9 hours/week	3
10+ hours/week	3

Participants were asked if they had used a computer game in teaching and were asked to tell what game was used and how. Most participants indicated they had used short-form games, such as drill-and-practice games, games embedded in online lessons, and Jeopardy-style review games. In most instances, the participants briefly described the game but did not specify the game title. The specific game titles provided by the participants included USA Testprep, Jeopardy, Angry Birds, Gizmos, Zoo Tycoon, and Edheads.

Attitudes and Readiness

Attitudes. Participants' attitudes toward the use of educational computer games in the classroom were measured using four Likert-scale items (responses to this set of items were found to be reliable, Cronbach's $\alpha = 0.82$). Seventy-nine percent of participants indicated an interest in using educational computer games in their classrooms. Seventy-three percent reported having used computer games in their classrooms prior to this study. Although 84% of participants felt they had the technology skills required for using educational computer games in the classroom, 70% felt comfortable using computer games in the classroom, and only 58% felt confident in their ability to do so. Five participants (4.5%) were against the use of educational computer games in the classroom. Eleven percent reported that they did not want to use class time for computer games even though they are educational.

Significant differences in attitudes were found between teachers who had prior experience in using computer games in the classroom and those without prior experience. For example, teachers with prior experience were more interested in using educational computer games in teaching (n = 79, M = 4.19, SD = 0.735) than those without prior experience (n = 32, M = 3.41, SD = 1.241), $t(109) = 4.118$, $p < 0.001$, $d = 0.77$. For all four attitudinal items (see Table 3), participants who had prior experience scored higher than those without prior experience.

Interestingly, middle school teachers reported a higher level of confidence (n = 36, M = 3.92, SD = 0.841) than did high school teachers (n = 75, M = 3.47, SD = 1.031), $t(109) = 2.279$, $p < 0.05$, $d = 0.48$.

Table 3
Attitudes Toward the Use of Educational Computer Games in the Classroom

Dependent Variables	**Prior Experience Using Computer Games in the Classroom**			
	No (*n* = 32)	**Yes (*n* = 79)**	***t***	***d***
I am interested in using educational computer games in my classroom.	3.41 (*SD* = 1.24)	4.19 (*SD* = 0.74)	4.12***	0.77
I feel comfortable using educational computer games in my classroom.	2.94 (*SD* = 1.19)	4.14 (*SD* = 0.81)	6.13***	1.15
I am confident using educational computer games in my classroom.	2.78 (*SD* = 0.91)	3.95 (*SD* = 0.82)	6.62***	1.36
I have technology skills required for using computer games in the classroom.	3.75 (*SD* = 1.05)	4.34 (*SD* = 0.71)	3.43**	0.66
	School Level			
	Middle (*n* = 36)	**High (*n* = 75)**	***t***	***d***
I am interested in using educational computer games in my classroom.	4.22 (*SD* = 0.93)	3.84 (*SD* = 0.97)	1.97	0.40
I feel comfortable using educational computer games in my classroom.	3.97 (*SD* = 0.91)	3.71 (*SD* = 1.15)	1.22	0.25
I am confident using educational computer games in my classroom.	3.92 (*SD* = 0.84)	3.47 (*SD* = 1.03)	2.28*	0.48
I have technology skills required for using computer games in the classroom.	4.36 (*SD* = 0.80)	4.08 (*SD* = 0.88)	1.16	0.33
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$				

Readiness. Participants were presented with a check-all-that-apply item with the stem, "Suppose you have been given a choice to use a computer game for your science classroom. Which of the following best describes you?" The most commonly selected response (75%) was "I would like to try the game before adopting it." This was the only response selected by 42% of the participants. The next most commonly selected response (18%) was "I need to learn about ways to integrate computer games into classrooms before adopting it [sic]," but only 1% of participants chose it as their only response. Approximately 16% of participants indicated they would be "willing to use the computer game right away."

Perceived Benefits of Educational Computer Games

Participants' perceptions regarding the benefits of educational computer games were measured using four Likert-scale items (see Table 4). Confirmatory factor analysis (CFA) indicated that the four items together make up a factor with desirable statistical properties, χ^2 (4) = 5.599, $p > 0.05$. Further, for the sample described for this study, responses to this set of items were found to be reliable (i.e., Cronbach's alpha, $\alpha = 0.89$). Higher scores on this factor indicate more perceived benefits to students from educational computer games. Scores on this factor ranged from 1.25 to 5.00, with $M = 3.84$ ($SD = 0.80$). Factor scores for perceived benefits of educational games in the science classroom were found to have an approximately normal distribution.

Most participants (82%) believed that educational computer games could be helpful for their students' learning. About 70% believed that educational computer games would motivate their students to learn science and help them develop science knowledge and skills. Approximately 60% of the participants believed that educational computer games would help their students develop 21st-century skills.

A significant difference between middle school teachers and high school teachers was found for perceived benefits of educational computer games, $t(109) = 2.804$, $p < 0.01$. Middle school teachers reported a higher level of perceived benefits ($n = 36$, $M = 4.13$, $SD = 0.82$) than did high school teachers ($n = 75$, $M = 3.69$, $SD = 0.75$; see Table 4). This group difference is qualified by a moderate effect size, Cohen's $d = 0.56$. No relationship was found between perceived benefits of educational computer games and years of teaching experience, participant gender, participant age, or whether the participant plays computer games.

Participants who had previous experience using educational computer games in the classroom reported a significantly higher level of perceived benefits ($n = 79$, $M = 4.03$, $SD = 0.71$) compared to participants without previous experience ($n = 32$, $M = 3.36$, $SD = 0.80$), $t(109) = 4.33$, $p < 0.001$, $d = 0.89$.

Concerns Related to Using Educational Computer Games in the Classroom

Participants' concerns related to using computer games in the classroom were measured using five Likert-scale items (see Table 5). Confirmatory factor analysis indicated that the five items together make up a factor with desirable statistical properties, χ^2 (5) = 9.120, $p > 0.05$. Scores on this factor ranged from 1.00 to 4.00, with $M = 2.48$ ($SD = 0.65$). Factor scores for concerns were found to have an approximately normal distribution. Overall, participants did not feel that using educational computer games in the classroom was too complicated or difficult. They also did not think that computer games were incompatible with their teaching style.

Table 4
Perceived Benefits of Educational Computer Games

Dependent Variables	**School Level**			
	Middle (*n* = 36)	**High (*n* = 75)**	***t***	***d***
Educational computer games can be helpful for my students' learning.	4.16 (*SD* = 0.88)	3.91 (*SD* = 0.70)	1.682	0.31
Educational computer games will motivate my students to learn science.	4.11 (*SD* = 0.98)	3.71 (*SD* = 0.91)	2.135*	0.42
Educational computer games will help my students develop science knowledge and skills.	4.17 (*SD* = 0.81)	3.68 (*SD* = 0.86)	2.850**	0.59
Educational computer games will help my students develop 21st century skills.	4.08 (*SD* = 1.03)	3.48 (*SD* = 1.01)	2.942**	0.59
	Prior Experience Using Computer Games in the Classroom			
	No (*n* = 32)	**Yes (*n* = 79)**	***t***	***d***
Educational computer games can be helpful for my students' learning.	3.48 (*SD* = 0.91)	4.21 (*SD* = 0.59)	4.208***	0.95
Educational computer games will motivate my students to learn science.	3.33 (*SD* = 0.99)	4.05 (*SD* = 0.85)	3.637**	0.81
Educational computer games will help my students develop science knowledge and skills.	3.33 (*SD* = 0.92)	4.05 (*SD* = 0.75)	3.942***	0.86
Educational computer games will help my students develop 21st century skills.	3.12 (*SD* = 0.99)	3.91 (*SD* = 0.98)	3.855***	0.80
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$				

Table 5
Concerns Related to Using Educational Computer Games

Dependent Variables	School Level			
	Middle (*n* = 36)	**High (*n* = 75)**	***t***	***d***
It is too complicated to use educational computer games in the classroom.	1.86 (*SD* = 0.83)	2.29 (*SD* = 0.94)	2.348*	0.48
It is difficult to use educational computer games in the classroom.	2.33 (*SD* = 1.26)	2.79 (*SD* = 1.07)	1.969	0.39
I have no idea how to teach science using educational computer games.	1.75 (*SD* = 0.84)	2.24 (*SD* = 1.00)	2.543*	0.53
Computer games can be distracting even though they are educational.	3.42 (*SD* = 1.00)	3.44 (*SD* = 0.90)	0.123	0.02
Computer games are not compatible with my teaching style.	1.75 (*SD* = 0.91)	2.25 (*SD* = 1.00)	2.554*	0.52
	Prior Experience Using Computer Games in the Classroom			
	No (*n* = 33)	**Yes (*n* = 78)**	***t***	***d***
It is too complicated to use educational computer games in the classroom.	2.42 (*SD* = 0.83)	2.04 (*SD* = 0.95)	2.034*	0.43
It is difficult to use educational computer games in the classroom.	2.73 (*SD* = 0.98)	2.60 (*SD* = 1.22)	0.520	0.12
I have no idea how to teach science using educational computer games.	2.73 (*SD* = 1.01)	1.81 (*SD* = 0.82)	5.025***	1.00
Computer games can be distracting even though they are educational.	3.39 (*SD* = 0.86)	3.45 (*SD* = 0.96)	-0.282	0.07
Computer games are not compatible with my teaching style.	2.61 (*SD* = 1.06)	1.87 (*SD* = 0.89)	3.756***	0.76

A significant difference between middle school teachers and high school teachers was found for concerns related to the use of educational computer games, $t(109) = -2.969$, $p <$

0.01. High school teachers reported more concerns (n = 75, M = 2.60, SD = 0.61) than did middle school teachers (n = 36, M = 2.22, SD = 0.68). This group difference is qualified by a moderate effect size, Cohen's d = 0.59.

A significant difference in concerns related to the use of educational computer games, $t(109) = 3.237$, $p < 0.01$, was also found between participants with experience using educational computer games in the classroom (n = 78, M = 2.35, SD = 0.66) and those without prior experience (n = 33, M = 2.78, SD = 0.55). This difference was qualified by a moderately large effect size, Cohen's d = 0.71.

As the following quotes indicate, potential distractions appeared to be the major concern the participants had about using computer games in the classroom.

- "I have tried educational simulations and students tend to get easily distracted."
- "The only thing I fear is that students will not stay on task or they will get distracted easily."

Approximately 60% of participants believed that computer games could be distracting even though they are educational (*M = 3.43, SD = 0.93*). No difference was found between middle and high school teachers on this item.

Perceived Barriers and Support Needs

The major barriers to integrating educational computer games into the classroom included lack of computers (70%), lack of time (49%), time needed for preparation for school and national high-stakes testing (27%), lack of knowledge about science games (27%), and a lack of technology support within schools (24%). School schedule, lack of knowledge about ways to integrate educational computer games into the classroom, school culture, lack of personal technology skills, and parents were each identified as perceived major barriers by fewer than 20% of participants. Example statements include the following:

- "The students love them but our classroom doesn't have computers. We have one lab for each grade and about 12 classes per grade. To book a lab is almost impossible."
- "I wish I had more time to find and evaluate computer games for the classroom. I believe they can serve as a powerful tool for student learning."

Participants' support needs were measured by two Likert-scale items (see Table 6) and a multiple-choice item that prompted them to indicate what they needed most to integrate educational computer games effectively into their classrooms. The two most commonly selected responses to the multiple-choice item were access to a trial version of a game (40%) and computers (39%). A small number of participants indicated they need training (8%), tech support (7%), and support from their building administrators (3%). The majority of the participants (87%) indicated that they would like to learn what kinds of science games are available (*M = 4.22, SD = 0.93*).

Approximately 80% wanted to learn more about ways to integrate educational computer games into the classroom (*M = 3.95, SD = 0.97*). No differences were found between high school and middle school teachers for these items. Participants with prior experience using computer games in teaching reported more interest in receiving professional development support in both areas (see Table 6).

Table 6
Support Needs

Dependent Variables	Prior Experience using Computer Games in the Classroom			
	No (n = 33)	**Yes (n = 78)**	***t***	***d***
I would like to learn more about ways to integrate educational computer games into my classroom.	3.42 (SD = 1.28)	4.17 (SD = 0.71)	3.14**	0.72
I want to know what kinds of science games are available.	3.73 (SD = 1.15)	4.42 (SD = 0.73)	3.205**	0.72
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$				

Important Features of Computer Games that Affect Science Teachers' Adoption Decisions

Participants reported that a computer game must be aligned with state and national standards (68%), free (50%), compatible with school computers (49%), fun (46%), challenging (44%), proven to be effective (e.g., research findings) (41%), and easy to use (30%) in order to be used in their classrooms (see Table 7). Of the characteristics of computer games that affected participants' adoption decisions, the alignment with state and national standards was identified as the most important factor by 32% of participants.

Table 7
Features That Affect Teachers' Adoption Decisions (N = 111)

Features	(%)
Aligned with state and national standards	68
Free	50
Compatible with school computers	49
Fun	46
Challenging	44
Proven to be effective	41
Easy to use	30

Discussion

The findings of this study are from 111 science teachers in Georgia. Although their generalizability is unknown, they provide practical insights into how to support science teachers in using educational computer games in the classroom. Further, they have important implications for science teacher education, professional development, and educational game design.

The results revealed that more than 70% of the participants had prior experience in using computer games in teaching. Consistent with the Joan Ganz Cooney Center national survey (Takeuchi & Vaala, 2014), the teachers mostly used short-form games, such as drill-and-practice games and Jeopardy-style review games. While drill-and-practice games can help students memorize simple facts and develop basic skills such as addition and subtraction, they are not effective for teaching complex content and higher level skills, such as scientific inquiry and problem solving. Teacher education and teacher professional development programs should integrate more activities that provide science teachers with opportunities to explore good games designed to help students develop scientific inquiry skills and 21st-century skills (e.g., River City) beyond simple drill-and-practice games and simulations. Most participants in this study indicated that they would like to try the games before adopting them. Interestingly, teachers wanted to try games themselves rather than observing other teachers use them. This finding is consistent with previous research (Kebritchi, 2010).

Prior experience appeared to be a critical factor affecting science teachers' perceptions of educational computer games. Participants who had used computer games in teaching had more positive attitudes toward the use of educational computer games in the classroom. Specifically, they were more interested, more comfortable, and more confident about using educational computer games in the classroom. They also reported a significantly higher level of perceived benefits of educational computer games and showed more interest in receiving professional development support for the integration of games into teaching. In contrast, teachers without prior experience were found to be more concerned about the use of games than those with prior experience. These findings indicate that lack of experience might be a major barrier to adoption and integration of educational computer games into the classroom.

School level (middle vs. high) was another important factor affecting science teachers' perceptions of educational computer games. Interestingly, significant differences were found in perceptions and concerns between middle school teachers and high school teachers. Regarding the use of educational computer games in the classroom, middle school teachers were more confident and reported a higher level of perceived benefits than did high school teachers. Furthermore, high school teachers reported more concerns than did middle school teachers. One possible explanation for the differences might be that middle school teachers have more flexibility over content and teaching methods than do high school teachers. Proctor and Marks (2013) found that K-5 teachers perceived games as more useful for classroom instruction than Grades 6-12 teachers. These findings indicate that teachers may have different perceptions, concerns, and support needs depending on which grade level they teach. Further research is needed to examine the differences in science teachers' perceptions, concerns, and support needs between middle school teachers and high school teachers.

Implications for Science Teacher Education and Professional Development

The participants in this study who had prior experience had more positive attitudes toward the use of educational computer games in the science classroom. Science teacher education and professional development programs should provide future and current science teachers with opportunities to explore well-designed science games as well as effective game integration strategies. More specifically, they should allow teachers to play games themselves by providing them with access to trial versions of a variety of well-designed games. The majority of the participants indicated that they would like to try games themselves rather than observing other teachers using them.

Significant differences were found in perceptions and concerns between middle school and high school teachers. The findings suggest that middle school and high school teachers may have very different concerns and support needs when integrating computer games in their classrooms. Professional development programs should focus on their audience's specific concerns and needs and provide customized training and support.

While 70% of the participants had prior experience in using computer games in teaching, they mostly used short-form games. They were not familiar with immersive game-based learning environments. Teacher education and teacher professional development programs should increase future and current teachers' awareness of and experience with game-based learning environments designed to help students develop scientific inquiry skills and 21st-century skills (e.g., River City) beyond simple drill-and-practice games and simulations.

Implications for Game Development

Regardless of grade level, participants indicated that an educational computer game must be aligned with state and national standards (68%) and be free (50%), compatible with school computers (49%), fun (46%), challenging (44%), proven to be effective (41%), and easy to use (30%) in order to be used in their classrooms. Interestingly, the alignment with state and national standards appeared to be the single most important feature affecting science teachers' adoption decisions. The results also revealed that participants were concerned about distraction problems. The participants felt that computer games could be distracting even though they are educational. Game developers should keep in mind these features valued by teachers and their concerns in order to design educational computer games that can be used in schools.

Suggestions for Future Research

Future research should further examine the differences in science teachers' attitudes, perceptions, concerns, and support needs between middle school teachers and high school teachers. The significant differences found between middle and high school teachers in this study point to the need to understand why high school teachers have greater concerns and less confidence for using educational games than do middle school teachers.

Further research is needed to explore ways to help science teachers effectively integrate educational computer games in the classroom with a focus on standards alignment. Research could also explore science teachers' perceptions of the use of educational computer games focusing on a specific game genre, such as immersive 3D games. Most participants who had used games in teaching reported using drill-and-practice games, Jeopardy-style games, or simulations. Exploring science teachers' perceptions of 3D game-based learning environments, which engage students in inquiry and problem solving,

would be interesting and valuable. Finally, future research with teacher education programs and professional development programs should examine the value of providing experience with educational games as a way to prepare science teachers to use games for higher order thinking and problem solving.

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