Journal of Mason Graduate Research
Volume 1 Number 2 Year 2014

ISSN: 2327-0764
Pages: 49- 69

Using Video Games in Education

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This paper is a review of the literature examining articles related to the use of video games in education. Forty different studies were identified for inclusion based on various criteria, including, age range, date published and academic subjects studied. The review first examines positive aspects of video gaming, such as cognitive benefits and game usage in the subjects of social studies, math, science, language learning, and physical education. Potential barriers and risks associated with video games such as violence, addiction and parental and teacher attitudes, are also examined in this paper. Finally, the implications of the available research are discussed. While there are limitations, the findings show that there is some support amongst scholars for using video games in educational contexts.

Using Video Games in Education

According to a Pew Research Center study, 97% of children 12-17 in the United States have played video games (Lenhart, Jones & Macgill, 2008). With this staggering number of children involved, it is not surprising that a large body of literature surrounding video games exists. While researchers have devoted a significant amount of attention to negative aspects of video games, such as violence and addiction (Bushman and Anderson, 2002), they are also beginning to examine potential benefits of video games, such as in the context of education (Nie, Roush, & Wheeler, 2010; Steinkuehler & Duncan, 2008) and cognitive flexibility (Colzato, Leeuwen, van den Wildenberg, Hommel, 2010).

Steinkuehler (2007) immersed herself in a two-year ethnographic study on a massive multiplayer online game. She noted that the full guide for the game was almost 300 pages long, yet many players were able to operate the game capably within a few hours. How many teachers dream of students absorbing educational information that quickly? What is it about video games

that make this kind of intuitive learning possible? Gentile and Gentile (2007) argued that video games display many hallmarks of an ideal learning environment. These include establishing clear objectives, offering multiple difficulty levels, and consistent feedback.

Considering the significant number of children from various ages that do play video games, the following review of literature is meant to identify the possible barriers, as well as benefits that using video games in the classroom may present.

Video Games

What is a video game? Juul (2005) explains, "a game is a rule-based system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels emotionally attached to the outcome, and the consequences of the activity are negotiable" (p. 36). This definition allows for a variety of different types of games including simulations such as the *Sims* series of games and *Second Life* (SL). While neither of these simulations have defined goals assigned by the game designers, players may create goals for themselves, and are certainly invested in the outcome.

Methods

The initial literature search was conducted in three databases: Academic Search Complete, ERIC, and PsychINFO. The reference lists from initial articles were used to identify further articles of interest. Search terms included computer game, video game, serious game, learning, education, motivation, engagement, classroom, academic achievement, and violence.

The initial search on Academic Search Complete using the listed search terms and no qualifiers resulted in over 3,000 articles. Additional restraints, such as changing search terms in title, peer reviewed journals only, full text, published from 2005 to present, resulted in 54 articles. This created a more manageable list. The same restraints in ERIC resulted in 26 matches and 22 from PsychINFO (with a date range from 2007 to present).

Using the abstracts and author supplied key-words, articles were sorted into six categories: education, general benefits, addiction, violence, implementation, and outside scope of review. The articles dealing with education were then further sorted into subcategories of math, science, physical education, language, social studies/history, and art. Research focused on pre-elementary school aged children or children with special needs (e.g. learning or emotional

disabilities) were excluded. Previous literature reviews (Young et al., 2012) on this topic have identified a lack of quantitative research in this field, so qualitative and mixed methods studies are included. While the general date limit for published studies was 2005, older works identified during bread-crumb searches were included for important authors and seminal research.

Results

This review will examine research investigating the positive aspects of video games, including general benefits and possible educational uses. All resources have been compiled into a table for reference (Table 1). It will then examine potential barriers and risks associated with video games. Finally, the reviewed benefits and risks will be used as a framework for discussing future use and implementation of video games in classrooms.

Benefits

General. Several studies have reported cognitive benefits in relation to the fast-paced nature of video games. Dye, Green and Bavelier (2009) found that video game players as young as seven responded more quickly than non-players during an attention task, but did not make more errors. Colzato et al.'s (2010) study found similar benefits. Video game players showed stronger cognitive control skills during a task-switching paradigm activity. The authors "speculate that VGPs [video game players] are more efficient in controlling episodic memory structures and, thus, in selectively activating and updating task sets" (Colzato et al., 2010, p. 3).

In addition to increased attention, research shows video games offer a potential learning environment. One study examined a *World of Warcraft* (WoW) discussion board and found evidence of authentic opportunities for empirical thought (Steinkuehler & Duncan, 2008). Players discussed the pros and cons of different types of characters and magic available in the game, sometimes even using complex mathematical formulas or outside resources to support their arguments. The authors noted only one in five Americans are proficient at this type of empirical thinking.

Also, studies have shown positive results in utilizing *Second Life* (SL) as a virtual learning environment. Atkinson (2009) believes that a strongly constructed learning environment in SL may increase deeper learning. In one study, professors assigned a project in SL for an interdisciplinary graduate course. Students found that they could go beyond the bounds of a simple fifteen-minute PowerPoint presentation that instructors assigned in previous

courses. The authors explained that "the affordances of the 3-D virtual world learning environment led to experiential activities that not only helped achieve learning outcomes but also surpassed course objectives" (Jarmon & Mayr, 2008, p. 166). Utilizing opportunities to expand supported learning outside the classroom walls could help motivate student participation in the learning process. The broad reach of online games such as SL also offers a unique opportunity for students to interact with people outside of their immediate area. Nie and colleagues (2010) reported that their participants, digital photography students, appreciated the increased exposure their work received in SL compared to if they had displayed their work locally.

Social Studies. One case study examined this idea of taking learning outside of the traditional classroom setting by analyzing a high school history class using a video game called *Making History* (Watson, Mong, & Harris, 2011). The teacher in this case study used this game in previous classes and had developed clear learning goals and a strong methodology for integrating the experience with the course material. Groups of students played the game, each controlling a country during World War II. The authors noted that while not all students benefited from the time spent playing the game, the class environment went from a teacher-centered lecture to one that focused more on the learners. Students could interact with each other and ask the teacher questions while thinking critically about decisions made leading up to WWII by being there in the video game. Watson et al. (2011) emphasized the excitement students felt at participating in the game: students actually discussed strategies for the next round outside of class! Some students often lack this kind of excitement and motivation to learn in traditional classrooms.

Squire, DeVane and Durga (2008) found similar results using *Civilization III* during an afterschool program. The popular *Civilization* series of games allows players to take over a civilization at varying points of history. Players are able to "explore the relationships between geography and politics, economics and history, or politics and economics" (Squire et al., 2008, p. 242). Many of the students involved in the program were generally apathetic about school work, and had mediocre grades. After playing the game with their peers, students were able to recognize and define academic language associated with the ancient cultures in the game, such as "hoplite" a military unit in ancient Greece. Some of the students even began actively seeking out information outside of school, watching documentaries and reading books on their favorite

cultures. Students for whom grades had been reported saw an increase in not only their history grade, but across all subjects.

While the students playing *Making History* and *Civilization III* reported having fun and enjoying the game, another video game focused on social studies, *Pax Warrior,* does not seem to have the same level of enjoyment. *Pax Warrior* was designed for high school students and was used by Carpenter, Lundell and Rubin (2007) in a graduate level public policy course. This game allowed students to act as participants in the United Nations decision making during the genocide in Rwanda. Students seemed frustrated by the game because it was unwinnable; no matter what decisions they made as UN officials, many people still died. However, the researchers noted that the simulation did allow students to discover novel solutions they had not thought of in previous decisions of the topic. This research shows that a game does not necessarily have to be fun to enhance learning.

Each of these studies suggest strong motivational effects of video games in social studies classrooms. Rather than simply listening to a lecture or viewing a power point presentation, these video games can allow students to immerse themselves in a different world. They become invested in understanding this world, as seen when the students pursued outside material to improve their *Civilization III* skills (Squire et al., 2008). While the evidence is limited that this increased motivation translates to higher academic achievement, the evidence does suggest that it encourages deeper learning. Unfortunately, because academic achievement is often measured in test scores and grades, instead of depth of understanding, further research is required to appreciate the full impact of video games on social studies learning.

Math. Also, video games have been used successfully in mathematics classrooms. *Deal or No Deal* is a popular TV show where contestants choose a briefcase which could be worth anywhere from one cent to one million dollars. As the show progresses, the contestant opens the other briefcases to show which amounts they have not chosen and the "banker" offers the player money to quit, which may or may not be higher than the value in the chosen briefcase. A control group received a lecture and worksheets about statistics, specifically the definition and formula for expected value. The experimental group played *Deal or No Deal* as an in-class activity after the same lecture, calculating the expected value of the chosen briefcase (Chow, Woodford & Maes, 2011). A week later, 95% of students who played the game were able to calculate the expected value on a post-test versus only 59% of the control group. The students in the

experimental group were able to apply their knowledge of statics by playing a game rather than simply completing paper worksheets. This seems to have allowed for better recall of the material, perhaps because the students learned it in a more meaningful way.

It is important to note that playing an educational video game more often does not necessarily result in stronger educational gains. Kim and Chang (2010) found that non-English language learners and female English language learners (ELL) students who played a math game every day showed lower performance compared to students who played math games sometimes (once a month to twice a week), or not at all. Interestingly, this pattern did not hold true for male ELL students, who showed the same performance when playing math games sometimes or every day.

Not only do video games improve math performance and aid in knowledge retention, but also there is evidence that these games can improve student attitudes towards the subject. For example, students playing a video game designed to teach math reported a more positive attitude to math than the control group (Huang & Ke, 2009). Ke (2008) found that students with lower socioeconomic status displayed more positive math attitudes after playing a cooperative math game compared to competitive or individual game situations. For students that were not in the lower socioeconomic category, all three math game conditions showed gains in positive attitudes towards math.

Science. Significant attention has been given to the game *Quest Atlantis* (QA), an educational video game created by researchers at Indiana University funded by the National Science Foundation (Barab, Sadler, Heiselt, Hickey & Zuiker, 2007). In QA, students navigate through different worlds interacting with other players and non-player characters (NPCs) to complete educational activities called Quests. The scripted responses from NPCs give students information needed to help them complete their Quests and, hopefully, learn the intended academic lesson. Some of the worlds in QA focus on science content, but other worlds emphasize different content areas. Barab et al. (2007) found that 4th grade students completing Quests in a science-focused QA world "demonstrated rich insights in terms of their submitted work, were clearly engaged, and participated in rich scientific discourse. Further…students developed a rich perceptual, conceptual, and ethical understanding of science" (p. 76).

When Hickey, Ingram-Goble and Jameson (2009) first implemented the same Quests in a 6th grade science class with a teacher who had never used the game before, they found that

students who played QA did show improvement in the post-test measures. However, these gains were not statistically significant when compared to the gains of students using a traditional curriculum. After revising the teaching procedure to provide students with more formative feedback during the Quest process the experimental group gains increased, but were still not statistically larger than the control group gains. In the second stage of their study, the researchers saw that even though they provided detailed feedback to assist students, not all of the students bothered to utilize their assistance. In the QA environment, students had to navigate away from the main game environment to view the Quest feedback. This could be one reason students did not access the feedback as many popular video games embed feedback directly into the game. Student engagement with the learning aspect of the video game is vital. Lim, Nonis and Hedberg (2006) note that students in their study who reported the highest engagement also showed the most significant improvement from pre-test to post-test scores. By ignoring the feedback, it seems the participants in Hickey et al.'s (2009) study were not engaged enough with the academic content to realize greater benefits.

Other games have been studied for use in science education, such as *Dr. Friction*, a game developed to teach fifth graders about forces and motion (Annetta, Mangrum, Holmes, Collazo & Cheng, 2009). In this game, students needed to complete puzzles to regain their stolen building blocks, with hints from an in-game avatar assistant, Fulcrum, if needed. Fulcrum offered hints if the students requested them and they did not need to navigate away from game play to access Fulcrum's help, unlike the feedback system in QA. The researchers found that the male students were more likely to seek help from Fulcrum during the game than the female students. Though a few students scored lower on the post-test, overall the participants showed significant gains on post-test scores about friction and motion after playing *Dr. Friction*. All but one student reported feeling that playing the game had helped them learn about the topic.

The research on video games in science education seems promising, but there are still issues. Consistent feedback is one of the ways video games create a strong learning environment (Gentile & Gentile, 2007). If students are not accessing this feedback, it may limit the game's effectiveness as a learning environment. However, game designers need to be careful not to give the answers away. When Annetta et al. (2009) asked one student why he used Fulcrum's hints so often, he replied "He's there to help so why not" (p. 1101). This shows that there needs to be a balance between providing students the support they need versus doing all the work for them.

Language. Think about the number of ways you can greet a person in English alone: hello, hi, hey, how are you, etc. As Johnson (2010) points out, a language learning game must be able to distinguish between all of the possible variability in the language to provide useful feedback. This is one reason researchers have begun examining the effectiveness of simulations and other types of games in language learning.

In *The Sims*, players control a virtual family through day-to-day situations. While the characters do not speak English, the everyday nature of the game brings players in contact with common objects and situations that could offer a useful opportunity for language learning. Ranalli (2008) provided students with supplementary material, such as a list of target vocabulary, and notes about culture and weekly quizzes. Students were grouped in pairs of different native languages in order to encourage communication in English. While most students felt the game and supplemental materials were helpful for developing their English skills, one student noted that they did not have to understand English to be able to play the game. This student reported enjoying the game and not paying much attention to the learning aspect. While simulations like *The Sims* could be useful, it seems the focus should be on games that require players to engage with the language. It is important to note, however, this sort of virtual immersion experience could limit the usefulness for those in the early stages of language learning who may not have enough vocabulary to interact with the game effectively.

The game QA, described earlier, does require this engagement with language. Zheng, Young, Wagner and Brewer (2009) studied the interaction between two English speaking students and two Mandarin Chinese speaking students completing co-quests through QA in English. The authors explain that "rather than focusing on practicing language for the sake of practicing a language, learners…collaborate in achieving a goal, thereby learning the language by using it" (Zheng et al., 2009, p. 502). Both native Chinese speakers reported that the co-questing in QA improved their English skills.

Classrooms are not the only place language learning takes place. Johnson (2010) examined the Tactical Language and Culture Training System (TLCTS). This system is being investigated for use by the U.S. government to teach native languages to military personnel preparing for deployment. TLCTS is an extremely complex learning system designed to handle the ambiguity and variance in language. One group of Marines used the TLCTS system before deployment and was interviewed regarding the effectiveness of the system after returning. The

officers of the unit felt the language skills learned through TLCTS improved the unit's effectiveness. Of the Marines interviewed, 76% percent reported using their new language skills on a daily basis and 50% believed those skills contributed to their ability to carry out their missions (Johnson, 2010). Although one Marine scored the training as "worthless" because the system, originally designed for the Army, did not teach participants to say "I am a U.S. Marine," overall, TLCTS appears to be an effective learning tool.

Physical Education. A new wave of motion-controlled games may allow video games to increase physical activity in gamers. Three well-known game systems utilize active game controls: Nintendo Wii and PS3's Move use motion sensitive controllers, while Xbox's Kinect uses a camera to input player movement into games. A pilot study compared the physical activity of children provided with an active video game package to that of a control group (Ni Mhurchu, Maddison, Jiang, Jull, Prapavessis & Rodgers, 2008). Participants provided with the active game package showed higher levels of physical activity and smaller waist circumferences than the control group.

Vernadakis, Gioftsidou, Antoniou, Ioannidis, and Giannousi (2012) examined college students using the Nintendo Wii during a balance-training program. Thirty-two physical education majors either completed a traditional balance training program or used the game *Wii Fit Plus*. Both groups showed increases in balance measures, with the experimental group showing better scores on many post-test measures. The Wii game allows users to track daily progress and activities as well as set progress goals. The authors suggested that the "Nintendo Wii gaming console allowed students to become active participants in the training process" (Vernadakis et al, 2012, p. 203). This engagement along with the specific feedback the system offers to players may have been factors in improving their balance. This is supported by preliminary results from Manley and Whitaker (2011), which suggested that students in a sport psychology course found class sessions which included a Wii game more fun and engaging than sessions with physical games than class sessions without such games. (e.g. a Wii dart game versus a dartboard).

Vernadakis et al.'s (2012) study lasted 8 weeks and Ni Mhurchu et al.'s (2008) lasted 12 weeks, so the question of long-term effects remains open and needs further research. However, the results are certainly promising considering that 89% of teen gamers play video games on console systems such as the Wii, PS3 and Xbox (Lenhart, Jones & Macgill, 2008).

Barriers

So far, the studies reviewed have shown video games to be strong potential tools for increasing engaged learning or, at worst, harmless yet ineffective. However, some research has suggested a darker side to video games.

Violence. Several studies examined violent video games through the lens of the General Aggression Model (GAM) developed by Bushman and Anderson (2002). According to the GAM, exposure to violent media, such as video games, results in increased aggression due to stored aggression-related scripts in an individual's memory. In support of this theory, Bushman and Anderson (2002) found that students who played a violent video game supplied an aggressive ending more often when asked to complete a story. However, the authors do not specify their criteria for classifying an ending as aggressive. One story is about Jane, who spent almost an hour waiting for food at a restaurant after a long day. Some of the aggressive responses listed in their appendix included Jane feeling "frustrated with the service" and thinking that she should "write to the newspaper about this place" (Bushman & Anderson, 2002, p. 1685). Neither response seems unusual for a rational person to make when forced to wait for service. In comparison, another aggressive response was "I should set this table cloth on fire" (Bushman & Anderson, 2002, p. 1685). A large gap exists between the levels of aggression in these two responses. The fact that the researchers simply classify both as "aggressive" during data analysis could severely skew their results to demonstrate more aggression than actually exists. Also, Gentile, Lynch, Linder & Walsh (2004) also reported results supporting the GAM, including a relationship between violent video games and physical violence. However, Ferguson (2010) noted that if Gentile and colleagues (2004) had controlled for gender, the correlation between violent games and aggression would have been significantly smaller.

In addition, researchers have investigated the different effects of virtual violence versus real violence. Another study used the GAM model in relation to participants' heart rate and galvanic skin response to test for desensitization to violence (Carnagey, Anderson, and Bushman, 2006). They found that participants who played a violent video game showed a lower physiological arousal in response to a video tape of real violence than participants who played a nonviolent game. On the other hand, Barlett and Rodeheffer's (2009) research suggested that playing an unrealistic violent video game results in lower aggression than playing a video game with realistic violence.

In direct contrast to the GAM studies, Unsworth, Devilly and Ward (2007) found that some participants with low starting anger and a pliable personality did show short-term increases in anger; these small increases were not enough to warrant concern. Additionally, participants with strong personalities did not show any increase in anger and those participants with pliable personalities and high start anger actually demonstrated a cathartic effect with reduced anger after playing a violent video game. Despite Anderson et al.'s (2010) urging that the debate over whether violent video games cause aggression has ended, such divergent results show that more work needs to be done on this topic.

Addiction. Addiction is a large concern surrounding newer technology such as video games. One study examining addiction in WoW players used a go/no-go behavioral measure similar to one validated with alcoholics (Decker & Gay, 2011). In this study, researchers asked participants to distinguish between traditional English and WoW related words with positive or negative connotations. For example, if a participant has a target of "good," he would click a button whenever a positive word (target) appeared but refrain from pressing the button for a negative word (distracter). WoW players showed faster reaction times than non-players in this task. WoW players also better distinguished between targets and distracters on both neutral English words and WoW related words. This contradicts findings in other addiction studies where the addicts showed a bias towards words related to their addiction. Other video game studies supported the findings that playing action video games increase speed, cognitive response times etc. (Dye et al., 2009). However, Decker and Gay (2011) cautioned that the WoW players also showed more bias toward responding in general, which may indicate poor impulse control.

There seems to be a fine line between definitions of gaming addiction and high levels of game engagement which may have resulted in an overly pessimistic view of the number of people afflicted with video game addiction. Charlton and Danforth (2010) examined personality factors in conjunction with addiction scales to determine if certain personality traits are related to addiction versus engagement for individuals playing a massively multiplayer online role playing game (MMORPG) *Asheron's Call*. They found that factors such as lower levels of attractiveness, emotional stability, agreeableness, and extraversion were indicators of video game addiction. The authors reported that these traits have also been found to be predictors of other types of addiction (e.g. gambling and alcoholism). However, high levels on the engagement scale did not show any correlation to these characteristics.

It is easy to see how playing an MMORPG could lead to addiction when coupled with these traits. Playing a game online would allow people with low levels of attractiveness, agreeableness and extraversion to interact with others from the safety of their own home, displaying the face of the character, or avatar, they choose to portray in the game world. Additionally, the ability to escape into a fantasy world would certainly appeal to individuals with lower emotional stability. These traits are also common in individuals with other addictions. Video games, like gambling, can be enjoyed by many responsibly, but can have negative consequences if done in excess.

Some researchers suggest that understanding the motivation behind addictive gaming behavior could help prevent that addiction. Przybylski, Ryan and Rigby (2009) looked at harmonious versus obsessive engagement using self-determination theory (SDT). Obsessive engagement was defined as interfering with one's regular life, while with harmonious engagement an individual is able to enjoy the activity without disrupting other aspects of his or her life. SDT suggests that motivation stems from the opportunity to satisfy basic needs for competence, autonomy and relatedness (Ryan & Deci, 2000). The authors found that individuals who felt these needs were satisfied by video games were more likely to show harmonious engagement. Also, the reverse was true, with participants who reported low need satisfaction showing evidence of obsessive engagement. Przbylski et al. (2009) suggested that knowing this relationship can help researchers develop ways to support the needs identified in SDT and perhaps prevent obsessive engagement with video games.

Attitude. The final barrier to the use of video games in classrooms is the attitude parents, teachers and administrators have towards those games. For example, teachers in the Republic of South Korea identified a number of reasons why they were unable to effectively integrate video games in the classroom, including inflexible curriculum and limited budgets, negative effects of gaming, students not being ready and lack of supporting material (Baek, 2008). Kenny and McDaniel (2011) found that only 42% of pre-service teachers in their study played video games regularly. According to Kenny & McDaniel (2011), this number seems small when compared to a 2008 report from the Entertainment Software Association (ESA), which estimates that 80% of people in the same age range play video games regularly.

A number of things influence parental attitudes toward video games. Bourgonjon, Valcke, Soetaert, de Wever and Schellens (2011) examined some of these factors such as gender,

experience with and preference for video games, and perception of the negative effects or learning opportunities provided by video games. The researchers found that "parents express rather negative beliefs about video games and are reluctant when it comes to using video gaming in educational settings" (Bourgonjon et al., 2011, p. 1440). Experience playing video games was negatively correlated with perceived negative effects of gaming, however, only 13.9% of respondents reported playing and enjoying video games.

It seems that few parents and teachers have experience with games, making them less likely to be open to the potential value video games have as learning tools. Not much can be done to remedy this situation if these decision makers are not willing to expose themselves to video games. According to a report by the ESA (2011), 45% of parents play video games with their children occasionally. Gee (2003) notes that his own introduction to gaming was trying to learn a video game so he could help his son play. After having some difficulty mastering a game his four-year-old could handle, Gee began to investigate video games more closely. Perhaps more parents and teachers will have similar revelations as they are exposed to more video games.

Conclusion

While there are still hurdles to overcome, this review shows that video games have the potential to be strong learning tools in the classroom. There are several limitations to the studies reviewed here with sample size and research design being the most notable. Additionally, ethical concerns, such as socioeconomic status and gender differences, as well as implementation difficulties contributes to limitations on realizing the full potential of video games in the classroom.

One of the biggest problems with many of the studies reviewed is sample size. Many of the studies included fairly specialized populations and small sample sizes (see Appendix. For example, Zheng et al.'s (2009) study on language learning in QA only included four participants. Also, while Squire et al.'s (2008) study began with 12 participants, attrition led to in depth analysis for only 2 students. These small, focused samples limited the researchers' ability to say that video games would be beneficial to students in general rather than just video games were beneficial to this particular type of student. Additionally, the majority of children in the age ranges examined would have been exposed to video games prior to participating in these studies. While a few of the games used are only available in educational settings, many of them are

popular games available for purchase by anyone. The participants could have been exposed to the games prior to study, making it difficult for true control and experimental conditions.

Many of the studies included primarily qualitative analysis. While qualitative studies are useful in some circumstances, qualitative results do not generalize well to the larger population. Both the small sample sizes and primarily qualitative study of educational video games, limits the field's generalizability. It is difficult to firmly declare that video games are effective learning tools with these limitations. Unfortunately, it seems this field will continue to struggle with this limitation as it is not well suited to quantitative, generalizable analysis. If a researcher conducts a large, quantitative study on *Quest Atlantis'* effect on science grades, that research may still only be generalizable to that particular game in that particular subject.

Cost is another factor that can greatly limit video game implementation in schools. Limited resources afflict many schools and interested teachers may lack the funds to purchase copies of a video game or appropriate technology to play the game. Even assigning students video games as homework or long-term projects could present an issue, as students with a lower socioeconomic status may not have access to a compatible computer or game console. Students that do not have regular access to such technology, or students who are just not "tech-savvy," may also feel uncertain using such tools. When assigning a video game as a long-term project, teachers should ensure that students have sufficient opportunities to use school-based resources in case they do not have access to such resources at home. In addition, a strong support system must be in place to assist students with technological difficulties. The instructor should have enough experience with the game system to answer questions and help students overcome problems. As mentioned earlier, many teachers do not have enough familiarity to help students navigate educational games effectively.

In Manley and Whitaker's study (2011), one student commented that it was boring waiting for the other students to take their turn at the Wii game. While cost may prohibit being able to provide each student their own console, there are few possibilities to keep students engaged. Depending on the number of machines available and the type of games, teachers could put students in small groups to work together. Teachers could also provide alternate, supportive activities for students not actively participating in the game. These activities should contribute to the learning goal, but require minimal supervision so the teacher would still be available to assist students needing help with the game.

Many seem to consider video games a largely male domain; however, according to the ESA (2011) almost half of regular game buyers (48%) are female. The female students in Annetta et al.'s (2009) study reported spending more time on computers than their male counterparts, though the boys did report more time playing games on the computer. The authors argue that the way these two groups use computers differs in that boys use the systems more for gaming and girls more for relationship building. It is interesting to note the 2006 ESA report cited in Annetta et al.'s (2009) study states that only 38% of game players are female. It is possible that the gender gap in video games is closing, but it is still necessary for teachers to be aware that this gap still exists. It would be beneficial to incorporate a paradigm like "universal design" when designing educational video games. While universal design generally deals with creating products that are accessible to both people with or without disabilities, a similar concept could be applied to incorporate game features that could be beneficial to both genders. While girls may generally use social features more, boys could also benefit from a collaborative social learning/gaming environment.

A significant challenge when designing games for the classroom is finding the right balance between the learning content and the game. Shelton and Scoresby's (2011) student game designers chose to remove some "neat" effects in their game to make the educational content more prominent. On the other hand, the students felt that it was important to include all of the short stories in the book their game was based on. They chose to remove some of the stories from the main content of the game so players would not be distracted from the primary learning goals. Instead, they included the unused stories in a bonus level that they could access after completing a final puzzle.

This balancing act is important to keep in mind when designing educational games. If a designer takes out too much of the game aspect, the motivational potential decreases. However, taking out too much learning content and the game loses its educational value. Educational game designers should have experience in the realm of education, or work closely with someone who does. Fortunately, more schools are offering instructional technology training programs, which could help close the gap between teacher and game designer. The current research seems to point to the fact that the most important aspect in serious game design is to keep the learning goals in mind to ensure you do not go too far with "neat" features that add nothing to the learning experience without losing the motivational enjoyment of gaming.

There are still a number of barriers to overcome before video games will see widespread acceptance as educational tools. Violence, addiction, gender and socioeconomic differences are serious issues that need to be fully addressed before parent and teacher attitudes towards video games will improve. Despite the issues, this review suggests that using video games in education offers strong potential for learning. Though there are limitations with the current body of research, the results show that further investigation in this area is warranted. Future studies will need to address these limitations to further explore the effects of games on education and allow serious games to become more fully integrated in today's classrooms. While these games may not be effective learning environments for all students in all subjects, they can provide teachers with an additional tool for motivating and engaging students.

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Appendix

Table 1

Research design, sample size and data collection

Author(s)	Research Design	Sample Size	Data collection
Annetta, Mangrum, Holmes, Collazo & Cheng (2009)	Mixed methods	74 students 20 students	Content knowledge pre-test/post-test, observation Focus groups
Baek (2008)	Quantitative	444 teachers	Survey
Barab, Sadler, Heiselt, Hickey & Zuiker (2007)	Mixed methods	28 students	Field notes, observations, interviews Classroom assessment
Barlett & Rodeheffer, C. (2009)	Quantitative	74 participants	Questionnaires, Word Completion Task, physiological arousal
Bourgonjon, Valcke, Soetaert, de Wever & Schellens (2011)	Quantitative	858 parents	Survey
Bushman & Anderson (2002)	Quantitative	224 students	Story stem completion task
Carnagey, Anderson & Bushman (2007)	Quantitative	257 students	Heart rate, galvanic skin response
Carpenter, Lundell & Rubin (2007)	Qualitative	41 comments	Blackboard discussion
Charlton & Danforth (2010)	Quantitative	388 video game players	Addiction scale, engagement scale, personality measure
Chow, Woodford & Maes (2011)	Quantitative	2 classes, about 30 students in each	Classroom assessment
Colzato, van Leeuwen, van den Wildenberg & Hommel (2010)	Quantitative	34 total; 17 video game players, 17 non players	Task switching paradigm

Table 1 Continued

Author(s)	Research Design	Sample Size	Data collection
Decker & Gay (2011)	Quantitative	12 WoW players, 30 non players	Go/no-go task, questionnaire
Dye, Green & Bavelier (2009)	Quantitative	131 total; 56 video game players, 75 non game players	Questionnaire Attentional Network Test
Gentile & Gentile (2007)	Quantitative	430 elementary school children, 2048 adolescents	Survey
Gentile, Lynch, Linder & Walsh (2004)	Quantitative	607 students	Survey
Hickey, Ingram-Goble & Jameson (2009)	Mixed methods	6 classes over 2 semesters with 1 teacher; about 170 students	Content knowledge test, class assessment, open-ended problem solving assessment
Huang & Ke (2009)	Quantitative	64 students	Content knowledge test, attitude measure, student teacher interaction observation system
Jarmon & Mayr (2008)	Qualitative	5 students	Student journals, focus groups
Johnson (2010)	Mixed methods	385 total participants	Content knowledge pretest/posttest, open ended surveys
Ke (2008)	Quantitative	160 students	Pre-test/posttest on math attitudes and math knowledge
Kenny & McDaniel (2011)	Quantitative	58	Pre-test/post-test Video Games Preference Inventory
Kim & Chang (2010)	Quantitative	170,000 students	Survey
Lim, Nonis & Hedberg (2006)	Mixed methods	8 students	Science concepts pretest/posttest, observation, interviews
Manley & Whitaker (2011)	Qualitative	74 students	Student essays, open ended survey

Table 1 Continued

Author(s)	Research Design	Sample Size	Data collection
Ni Mhurchu, Maddison, Jiang, Jull, Prapavessis & Rodgers (2008)	Quantitative	20 students	Accelerometer & activity questionnaire
Nie, Roush & Wheeler	Qualitative	6 students	Personal interviews, focus group
Przybylski, Ryan & Rigby (2009)	Quantitative	6 studies, 2977 total participants	Surveys on Player Experience of Need Satisfaction, game enjoyment and trait aggression
Ranalli (2008)	Mixed	9 students	Language pretest/posttest, open ended survey
Shelton & Scoresby (2011)	Qualitative	7 graduate student game designers, 2 ninth grade English classes	Game-play transcripts, observation, interview
Squire, DeVane & Durgas (2008)	Qualitative	12 total, in-depth analysis for 2 students	Observation, interviews
Steinkuehler & Duncan (2008)	Qualitative	1984 forum posts	Content analysis of online *World of Warcraft* discussion forum
Unsworth, Devilly & Ward (2007)	Quantitative	107 participants	Gaming and personality trait questionnaires, trait anger pretest/posttest
Vernadakis, Gioftsidou, Antoniou, Ioannidis & Giannousi (2012)	Quantitative	32 students	Balance assessment pretest/posttest
Watson, Mong & Harris (2011)	Qualitative	98 students	Observation, focus groups, student essays
Zheng, Young, Wagner & Brewer (2009)	Qualitative	4 students	Chat logs, interviews, observation