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Video Games in Education: Why They Should Be Used and How They Are Being Used

Today's K–20 students have been called, among other names, the net generation. As they matriculate through the education system, they are often exposed to materials and manipulatives used for the past 40 years, and not to the digital media to which they are accustomed. As student scores continue to regress from Grade 3 to Grade 12 and technical jobs once housed in the United States continue to be outsourced, it is critical to expose and challenge the Net Generation in environments that engage them and motivate them to explore, experiment, and construct their own knowledge. The commercial popularity of video games is beginning to transpose to the classroom; but is the classroom ready? Are teachers and administrators ready? This article provides a practical rationale for and experiences with integrating video games into the K–20 (kindergarten through graduate school) curriculum.

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A REPORT BY THE BUSINESS ROUNDTABLE (2005) expressed "deep concern about the United States' ability to sustain its scientific and technological superiority through this decade and beyond" (p. 1). The report called for a sense of urgency and for immediate action to secure a prosperous future for this country and it's children. How can this monumental task be accomplished? How can educators reach children who have been called the *Net Generation*?

Theory (Why Video Games)

In 2003, a movement was started for using video games in teaching and training. This initiative, known as *serious games*, has changed the

way that educators viewed instruction to meet the needs of the *Net generation*. Serious games have impacted the military and firefighters (Harmon, 2003; Macedonia, 2002), medical (Cosman, Cregan, Martin, & Cartmill, 2002; Hmelo et al., 2001), and higher business education (Bos, Shami, & Naab, 2006).

Video games are one of the many ways that the Internet has changed how a generation of young people socialize and view entertainment. Today, avid game players willingly pay monthly online game fees as readily as their parents pay light bills—and anxiously wait in line for new video games the way their parents used to queue up for concert tickets (Irvine, 2004). Although video games have been around for over 30 years, it has not been until recently that technology has allowed for the metamorphosis of video games into descriptive narratives and storylines. Today's video game industry approaches yearly revenues of $15 billion and approximately 3.38 billion hr of game play (Entertainment Software Association, 2006). The game playing population falls between the ages of 10–34, with the majority of the population between 14–19. Games are not just played; they are talked about, read about, fantasized about, cheated at, altered, and become models for everyday life and for the formation of subjectivity and intersubjectivity. There is a politics, an economy, a history, a social structure and function, and an everyday lived-experience of the game (de Castell & Jensen, 2003). Craft (2004) believed that the method of instruction embodied in video games has potential for nonself-referential disciplines, particularly science; such games have been developed by Chris Dede (*River City*) and Sasha Barab (*Quest Atlantis*).

This notion has caught the attention of those inside the Washington, DC Beltway. The Federation of American Scientists (FAS, 2006) called video games the next great discovery, as they offer a way to captivate students to the point that they will spend hours learning on their own time. Most video games developed by commercial game companies focus primarily on first-person shooter and sports games, and are not educational by design. The report stated that commercial video games are not an investment that private industry is capable of taking. There is a need for the federal government to drive the movement forward with both financial and political support (FAS, 2006).

Examples of games developed as a result of this drive that can be used for educational purposes are now described. One serious educational game, *Immune Attack* (www.fas.org/immuneattack), was developed by the FAS, Brown University, and the University of Southern California. This first-person strategy educational game was created as an alternative means to teach complex biology and immunology topics to students. Here, a teenage prodigy with a unique immunodeficiency must teach his immune system how to function properly or die. The human body serves as the playing field and immune cells face off against bacterial and viral infections. Each subsequent level of *Immune Attack* features a different infection with a new type of immune cell for the player to train, and the player must scan and interact with various objects to train his immune system to fight off the invading pathogens.

Yet another example of an educational computer game is *Food Force* (www.food-force.com). Created by the United Nations World Food Program in 2005, this serious game engages users in missions to distribute food in a famine-affected country to help it recover and become self-sufficient again. The player becomes a scientist who has joined a team of United Nations experts, including a nutritionist, a logistics officer, a pilot, an appeals officer, and the director of food purchasing.

Discover Babylon (www.discoverbabylon.org) is the result of the collaboration among the University of California—Los Angeles's Cuneiform Digital Library Initiative, the FAS Learning Technologies Project, Escape Hatch Entertainment, and the Walters Art Museum in Baltimore. This multiplayer serious game is characterized by historically and scientifically accurate information, 3D photorealistic simulations, as well as question and answer management tools intended to foster learning. The game is designed to engage children ages 8–14 in challenges and mysteries that can only be solved through developing an

understanding of Mesopotamian society, business practices, and trade.

Quest Atlantis (http://atlantis.crlt.indiana.edu/start/index.html), a National Science Foundation (NSF) funded-project developed by researchers at Indiana University, serves as one final example of 3D multiuser virtual environments created to immerse children (ages 9–12) in educational tasks. Users travel to virtual places (e.g., Unity, Ecology, Culture, and Healthy World) to perform educational activities (Quests). Students conduct environmental studies, research other cultures, interview community members, and develop action plans to complete their quests (Barab & Luehmann, 2003). Further examples include *Environmental Detectives,* developed by the Education Arcade, and *River City,* developed by Chris Dede from the Harvard Graduate School of Education. Both of these games strive to teach research-related inquiry skills.

These educational games commonly require the use of logic, memory, problem-solving, critical thinking skills, visualization, and discovery. Moreover, the use of these gaming technologies requires that users manipulate virtual objects using electronic tools and develop an understanding of the complex systems being modeled. Generally speaking, these educational games seem to be effective in enhancing motivation and increasing student interest in subject matter, yet the extent to which this translates into more effective learning is less clear. The lack of empirical data, due primarily to the scarcity of systematic investigations into the cognitive impact of serious games, forces us to turn to prior work investigating the impact of interactive computer simulations for hard evidence.

21st Century Skills

If educators are to reach tomorrow's leaders today, it is crucial that they design curricula around the foreseen skills needed to be successful in the 21st century. Competitive advantage for a region, state, or nation is now built on the skills of its general workforce as opposed to its geography, trade laws, research labs, and patents. And critical to that competitive advantage are the education and skills that adults acquire in primary and secondary schools (Organization for Economic Cooperation and Development, 2001). In the 21st century, income and wealth will come from applying technology and new ideas to create new products and processes. Adding value to products and processes is the key to growing jobs and income in this new economic environment (Aubert & Reiffers, 2004). Why is this so important? Because jobs once located in the United States are now being outsourced or off-shored.

The workers of the 21st century must have science and mathematics skills, creativity, information, and communication technologies skills, and the ability to solve complex problems (Business-Higher Education Forum, 2005). The transformation of learning in many other countries provides models to consider how linking education and the economy might benefit students, businesses, and society (Kozma & Voogt, 2003). The use of sophisticated information technologies in every aspect of education has the potential to provide a powerful lever for this transformation (Jones, 2003).

The United States has benefited greatly from being the global innovation leader in the development and use of advanced technologies, and video games and game play can facilitate the development of 21st century skills. The United States is not developing its workforce with skills in expert thinking and complex communications to meet the needs of the 21st century, global, knowledge-based economy (Levy & Murnane, 2004). Jenkins (2007) described what some of the new literacies that contribute to 21st century skills might look like (Table 1).

Play

The idea of playing to learn is not a new concept. Sociologists and anthropologists have tended to treat play as a human activity in which they analyze the principal characteristics observed in the age of the player (Caillois, 1961). This stems from Groos's (1898) theory of pre-exercise, which led him to affirm that people do not play because they are young, but people have

Table 1
New Media Literacies

New Media Literacy	Description
Play	Capacity to experiment with one's surroundings as a form of problem-solving.
Performance	Ability to adopt alternative identities for improvisation and discovery.
Simulation	Ability to interpret and construct dynamic models of real-world processes.
Appropriation	Ability to meaningfully sample and remix media content.
Multitasking	Ability to scan one's environment and shift focus as needed to salient details.
Distributed cognition	Ability to interact meaningfully with tools that expand mental capacities.
Collective intelligence	Ability to pool knowledge and compare notes with others toward a common goal.
Judgment	Ability to evaluate the reliability and credibility of different information sources.
Transmedia navigation	Ability to follow the flow of stories and information across multiple modalities.
Networking	Ability to search for, synthesize, and disseminate information.
Negotiation	Ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms.

a youth because they must play to practice. Play systematically confronts the child with a learning situation that could only be located within his or her area of close development. That is, it would involve a task located slightly above the acquired skills (Vygotsky, 1967).

Childhood is a time for constructing the relationship between the world through play. The decision, the initiative of the player who organizes the activity, the rule, whatever its origin, the absence of consequences (gratuity or futility), and the uncertainty of the results scaffolds learning (Brougere, 1999). Childhood is a period during which people learn to play and when they progress in mastering the structure of the surrounding world. Learning to play is learning to master situations marked metacommunication (Bateson, 1972). If early childhood already witnesses the use of play for educational purposes, it is also the time for building this structure. Older children and adults will continue to use this structure to entertain themselves and to learn. This sends us back to the dual logic of play, entertainment/education from early childhood (Myers, 1999).

Individuals must relearn to pretend—learn that things are not as they seem but within the context of a controlled and negotiated action between players. This is most noticeable in the disconnect between role play and game play from child to adult (Bruner, 1983). These lines are becoming blurry, as more adults are engaging in video games.

Rieber, Smith, and Noah (1998) argued that digital games engage players in productive play, which gives reason for renewed optimism for using games to support learning in leveraging the increasing power of the computer to immerse the player in interactive simulated worlds. Games allow the player to better understand the logic behind rules and express themselves as individuals through the roles that they portray within a game. If individuals are able to successfully participate in video games and simulation, it is because, as children, they learned to master rules through play (Corbeil, 1999).

Clegg (1991) argued that the instructional context that envelops gaming is a more important predictor of learning than the game itself. Specifically, how the game is contextualized, the kinds of cooperative and collaborative learning activities embedded in game play, and the quality and nature of debriefing are all critically important elements of the gaming experience. Engaging simulations provide an environment for the cycling of assimilation and accommodation, which is referred to as cognitive disequilibrium and resolution. Simulations succeed as teaching tools when they initiate cognitive disequilibrium and resolution while allowing the player to be successful (Piaget, 1975).

Learning

Students of the Net generation live in media-saturated environments as they spend an average of 6.5 hr per day engaged with various media (Roberts, Foehr, & Rideout, 2005). Educators and scientists repeatedly return to the conclusion that one advantage of educational games is that games tend to generate a much higher level of students' positive emotional engagement, thus making the learning experience more motivating and appealing (Rieber et al., 1998), improving participation and achievement (Jayakanthan, 2002). Games can motivate passive students to contribute more than they would in a traditional learning environment (Tanner & Jones, 2000). Video games motivate learning by challenging and providing curiosity, beauty, fantasy, fun, and social recognition. They reach learners who do not do well in conventional settings (Dede, 2004).

By representing the simulations through gaming conventions, educators can potentially increase engagement while fostering deeper learning, as learners engage in critical and recursive game play whereby they generate hypotheses about the game, develop plans and strategies, observe their results, and readjust their hypotheses (Gee, 2003b). The stereotype that video games solely contribute to antisocial, obese children was debunked through research on the Computer Games in Education project of the United Kingdom. The motivating power of games and their ability to encourage cooperation were felt to support the work of schools in developing independent, but social individuals (Kirrirmuir, 2002). Simply put, students are more likely to achieve if attempts are made to make the learning environment more congruent with that preferred by students (Faser & Walberg, 1991).

Stealth learning, coined by Douglas Crockford in 1987, is designed at making a fun game with no overt teaching involved but to have the enjoyment enhanced as one learns more about the subject matter (Falstein, 2005). It can be argued that learning takes place best in story-based, human-centered circumstances (Cognition and Technology Group at Vanderbilt, 1993).

Designing human-centered educational games that have rich storylines is not a magic bullet, nor is it an easy undertaking. The implications for designing educational games include blended motivation and self-regulated learning (Rieber et al., 1998). Today's gamers learn differently within the context of virtual worlds. How they learn and what they learn is often mutually exclusive. Gee (2003a) stated that the practice of learning a video game is an enculturation practice that involves not only learning the mechanics of game play, but learning how to negotiate the context of play, the terms and practices of a game's players, and the design choices of its developers. These levels of engagement are what Gee called internal and external *design grammars* for a given domain. These design grammars are consistent in any competitive or collaborative play environment.

A player learns to think critically about the simulation while at the same time gaining embedded knowledge through interacting with the environment. By allowing the player to take on new identities, solve problems through trial and error, and gain expertise or literacy, video games have potential for nonself-referential disciplines, particularly science (Craft, 2004). Games provide learners the opportunity to learn by doing, experience situations first-hand, and role-play. This establishes the proliferation of gaming in today's learners (Rickard & Oblinger, 2003). Virtual learning environments allow for development of higher levels of learning and collaboration skills (Gibbs, 1999), and improved practical reasoning skills (Wood & Stewart, 1987).

The video games in education conversation can be couched in developmental psychology (play), learning theory (constructivist), and 21st century skills. The power of these teaching and learning tools is not readily apparent in the literature. What follows explains how video games are being used at one institution.

Practice (How)

The power of video game technology can be embraced in many ways. Two such applications

are now described. The first use of video games is as a platform for distance learning. The second application is as an instrument for teaching and learning course material.

The Wolf Den

Popular commercial video games follow a rigid storyline where a plot thickens through varied scenes and game players interact with computer agents that aid in the movement through a narrative toward a common goal. Today's video games, not unlike their Hollywood counterparts, have various genres. What seems to get the most attention are first-person shooter games. However, the most popular games, especially for girls, are role-play/action-adventure games.

Because of their rich storylines, video games easily lend themselves to established instructional practices such as problem-based learning. At North Carolina State University's College of Education, a virtual world was created as a platform for distance learning and video game creation for practicing teachers. The *Wolf Den*, as it is called, is a virtual leaning environment where synchronous (real-time communication and interaction), online courses are taught and where students engage in the design and creation of role-play games. Specifically, a course entitled Introduction to 3D Multiuser Online Role-Play Games[1] introduces inservice science teachers to the game creation process.

A driving force of the pervasiveness of the Internet is the convergence of voice, data, and video networks and the deployment of converged services (Lazar, 2004). Katz (2005) argued that convergence is less a technical exercise than a social one. It promises technology-mediated collaboration and community. As high-speed connectivity becomes more pervasive and service converge increases, students enrolled in distance courses desire synchronous interaction without leaving the comfort of their home. Synchronicity can be valuable for virtual communities, provided that members actually take advantage of the synchronous technology design by interacting (Blanchard, 2004). *Wolf Den* not only provided a quality distance-learning platform, but also through the inclusion of a Voice over Internet Protocol solution, real-time conversations were exchanged and both the instructor and student were visually captivated in the 3D world. Moreover, students enrolled and taught in the *Wolf Den* are exposed to immersive artifacts that can be manipulated as easily as in the real world. An example minigame created in the *Wolf Den* allows students enrolled in the distance course to enter the laboratory and test water samples through microscopes and use the chemicals that they would have used in the traditional setting (Figure 1). This not only is a safe way of performing potentially dangerous science activities, but also begins to answer the question of how science can be delivered from a distance while giving the students authentic laboratory experiences.

The students exposed to *Wolf Den* had very positive attitudes toward the delivery method and the interactions within the virtual learning environment (Annetta, Murray, Gull-Laird, Bohr, & Park, 2006). This is consistent with results from Richardson and Swann (2003), where social presence is also seen to influence not only online activities generally designated as group projects, but also those usually designated as individual projects. In addition, students with high overall perceptions of social presence scored high in terms of perceived learning and perceived satisfaction with the instructor.

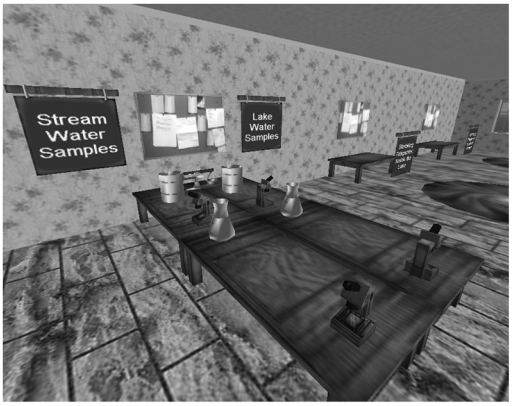

Figure 1. Laboratory in the *Wolf Den* virtual world at NC State University.

Garrison and Anderson (2003) defined social presence as the ability of participants in a community of inquiry to project themselves socially and emotionally as real people through communication. Online learning environments that feature mainly asynchronous text-based computer-mediated communication have been criticized for their lack of support for social presence, and this lack of support for social presence may impact the sense of belonging and acceptance in a group (Rovai, 2002). *Wolf Den* provided a rich setting for online social presence. The ability to work collaboratively is at the heart of social presence theory (Garrison, Anderson, & Archer, 2000). Social presence is a strong predictor of satisfaction with computer-mediated communications (Gunawardena & Zittle, 1997).

Annetta and Holmes (2006) reported that using avatars, digital representations of oneself, increased social presence and built a stronger community of practice. Students who had a choice of which avatar they would like to be reported greater course satisfaction and felt closer to their classmates and instructor than students who only could choose a male or a female avatar (Figure 2). The theme that arose as to why students with avatar choices reported greater satisfaction was one of individuality. Those students with choices could be unique, giving them a sense of individuality. Deindividuation is a state in which people lose their individuality because group members do not feel that they stand out as individuals and/or individuals act if they are submerged in the group (Festinger, Pepitone, & Newcomb, 1952). This is a major detraction in online learning.

Individuality is arguably what makes the traditional classroom successful in that students can be themselves. This is never more important than at the college ages where students blossom into adulthood and create the personalities that will propel them through life.

HI FIVES (Highly Interactive Fun Internet Virtual Environments in Science)[2]

HI FIVES is a joint effort of researchers in science, distance education, and computer science who are partnering with the Kenan Fellows Program (an elite teacher group) to harness the untapped potential of inexpensive, online multiuser video games to improve the IT skills and science achievement of students in grades 5–9. Fifteen teacher leaders and 60 participants (including seven guidance counselors) are learning how to use this technology to increase student science and math achievement and motivate their students to enter STEM-related careers.

Much of the literature describes the potential of games or how off-the-shelf software can be used in the classroom (Gee, 2003a, 2003b; Prensky, 2001; Squire, 2001). *HI FIVES* is unique in the sense that it is providing a tool for teachers so that they may create video games for their individual classes. Further, students learn the game design and creation process so that they can construct video games as a form of performance assessment. Through a drag-and-drop graphical user interface wrapped around the Half-Life2™ game engine, participants in *HI FIVES* are creating immersive, multiuser games without knowledge of 3D art or computer programming. The development software, called *Virtuoso*, was made available to the public in August 2007 and can be attained from the project Web site.[3]

All of the attributes garnered from the *Wolf Den* are being incorporated into *HI FIVES*. The idea of community of practice and social presence are at the forefront of the research being conducted. Active learning through the immersion of games is showing positive impact on the Net generation participating in the project. As opposed to passively watching videos, students are actively learning content. Further, through an integrated database, teachers are able to ascertain real-time data from student decisions in the game they created.

Games created in *HI FIVES* have been used in multiple ways. Because of the rich storylines, teachers have been creative in how the stories portrayed in their games can be a microcosm of a theme from a teaching unit. For example, a fifth grade teacher in the project created a game about simple machines. The game, entitled *Dr. Friction's Lair*, was about an evil professor who came into the classroom and stole the simple

Figure 2. Avatars representing students in the *Wolf Den*.

machines. The students were excited about doing a lab on pulleys, levers, wedges, etc., but when they arrived to class the next day, the teacher told them their equipment was stolen. A note was left behind explaining why the simple machines were gone and how the students could get them back—if they were brave enough. The note was signed by Dr. Friction. The students had to go on the computers and find the six simple machines that had been stolen. After the students played the game, they used the traditional simple machines the next day in class.

Other teachers have used their games as homework assignments, test and unit reviews, and even virtual labs. The critical piece could be the students constructing games as the teacher takes on the role of pedagogical and content expert. It is well documented that people learn best by doing (e.g., the Constructivist paradigm) so why not allow students to construct games? In the summer of 2007, students were introduced to the game creation in *HI FIVES* and that line of research has the potential to be the most powerful use of video games in education.

Video games in the classroom are not a replacement for good teaching. They are merely a supplement that engages students in the content and provides an avenue for them to learn difficult concepts of the real world in an environment in which they are comfortable.

Conclusion

If this is the present of how video games are being used in education, then what is the future? There is much to be done in this area and what follows is an outline of potential future research on video game technology as it pertains to education.

Haptics

Using the five senses behaviorally impacts working memory. Video games generally incorporate only sight and sound. However, with such hardware devices as the Novint Falcon™,[4] the ability to integrate force feedback into virtual environments is not only becoming more possible, but also more cost-effective. Research done on haptic (embracing the sense of touch) feedback can serve as a framework for work on how touch enables memory from a video game narrative.

Textbook Replacement

For various reasons, such as cost and student health, in the form of documented back problems from carrying large quantities of books, school systems are moving away from using textbooks. Textbooks are being replaced by photocopies and in some cases, Podcasts, wikis, blogs, Web

sites, and audio books. Text in video games is what often drives the narrative within the game. If expository text, graphics, and video could be embedded within an environment of virtual missions, then students and teachers would have a virtual one-stop shop.

Distance Education

Although *Wolf Den* shed light on the potential of using video game environments for distance learning, the research thus far is just the tip of the iceberg. Although massively multiplayer online (MMO) games are the most played computer games, large lecture classes lend themselves to be replaced by these worlds and delivered from a distance. As large courses are often just lecture, virtual environments can place hundreds of students and an instructor in a virtual environment where classes can be taught in a synchronous learning environment. Also, rather than giving students an avatar from which to choose, creating one's own avatar might allow for more individuality and great social presence.

Home School/Virtual School

The home school and virtual school market is growing exponentially in the United States. As parents and virtual school administrators look for strategies to help students learn, video games in the form of a distance learning platform and mission-based content can be the vehicle that engages and creates a social atmosphere.

Game Components

What is it about these games that excites and engages students? Although most agree that games can be both engaging and instructive, there is little consensus regarding the essential characteristics of instructional games. Implicit in the research literature is the notion that if one pairs instructional content with certain game features, one can harness the power of games to engage users and achieve desired instructional goals. Using the framework set forth by Garris, Ahlers, and Driskell (2002), these questions can start to be answered. Garris et al. presented an input–process–output model of instructional games and learning that elaborates (a) the key features of games that are of interest from an instructional perspective; (b) the game cycle of user judgments, behavior, and feedback that is a hallmark of engagement in game play; and (c) the types of learning outcomes that can be achieved.

As video games in education are gaining attention, it becomes more and more critical that empirical research be done on why and how games can impact students. There is much to be learned and it is crucial that anyone interested in making games for educational purposes band together to answer these questions. Revisiting the report, *Tapping America's Potential: The Education for Innovation Initiative* (Business Roundtable, 2005), there is a sense of urgency for immediate action to secure a prosperous future for this country and it's children. Video games might be the call to action.

Notes

1. http://courses.ncsu.edu/ems594/common/ignite/index.html
2. NSF Project ESI–0525115.
3. http://ced.ncsu.edu/hifives
4. http://www.novint.com/

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