

Serious Educational Games

From Theory to Practice

Leonard A. Annetta (Ed.)



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Edited by
Leonard A. Annetta
North Carolina State University

Foreword by
Jerry Heneghan
Founder and CEO, Virtual Heroes Inc.
www.virtualheroes.com
President, North Carolina Advanced Learning Technology Association
www.ncalta.org
Research Triangle Park, North Carolina



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For those who know me, it is probably not surprising that my research and this edited book is grounded in video games in education. As someone who always loved competition and collaboration, researching the power of video games in education was not a stretch for me. However, it is only right to acknowledge those around me who have not only gotten me to this point but those who continue to motivate me.

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JERRY HENEGHAN

FOREWORD

Serious Educational Games: From Theory to Practice

Long-term competitiveness requires a skilled work force. To compete in a knowledge economy, high-tech industries require proficiency in math, science, computer literacy and engineering -- 21st century equivalents of the three R's. The ability of our children to compete and prosper in the 21st century will depend on innovative new methods to accelerate education, increase proficiency and reduce training costs.

The convergence of education and gaming technologies represents an evolution of learning. Well-designed "serious games" (computer game technology used for training and education purposes) teach by stimulating the imagination, sparking curiosity, fostering discussion and encouraging a spirit of competitive exploration across a variety of domains.

The term "Serious Games" was first used as the title of a book by Clark C. Abt in 1970. The book illustrated the power of games to simulate a simplified version of reality and thus help people understand the variables, causes, and effects impacting decisions in the real world through role playing exercises. With the availability of commercial-off-the-shelf (COTS) interactive technologies, the credibility of serious games has grown steadily over the past decade.

The work of scholars such as Henry Jenkins at MIT and James Paul Gee at University of Wisconsin have shown that video game technologies offer the most promise for reaching, engaging and instructing our students. Recent reports such as the Federation of American Scientists' Summit on Educational Games Report (2006), the New Media Consortium and EDUCAUSE's 2006 and 2007 Horizon Reports have demonstrated that the use of video game technology for education is gaining momentum as an effective means to improve learning outcomes.

This book takes an unprecedented look at the evolving use of "serious games" for educational purposes along with some related advanced learning technologies such as Multi-User Virtual Environments (MUVes), haptics and biofeedback technology. It presents a collection of chapters that portray the theoretical and research foundation for the education use of serious games from the perspective of experts in the field who also understand the practical application of serious games. The book also provides an overview of problem-based learning as an instructional approach using the immersive characteristics of modern game technology driven by engaging narratives, character development and back-story. It provides a

breadth of perspectives that transition from ‘what we think’ to “what we know” regarding serious games and their use in education.

It is encouraging that editor Len Annetta and the authors have taken an empirical approach to the study of educational serious games – one of research and grounded theory, rather than advocacy. This book breaks new ground and is an important step in the process of moving from hype regarding serious games to a more firm foundation in the study of serious games in education. Through this important book, Annetta shows us how we can take advantage of game technologies in order to transform education in an increasingly outdated educational system. Written in a clear, lucid and direct manner, Dr. Len Annetta makes the central themes of this book easily accessible to professional as well as lay readers. It will benefit educators, school administrators, policy makers, cognitive researchers, content developers and parents regarding contemporary theory, design and use of serious games for education.

Before embarking on the exploration of this book a few definitions might be helpful:

- **STEM:** educational initiative focused on the domains of science, technology, engineering and mathematics
- **Simulation:** a representation of real life that accurately demonstrates a physical or simulated process or phenomenon
- **Games:** deliberately simplified representations of phenomenon based on goal-directed and competitive activities conducted within a framework of established rules
- **Serious Games:** Game technology used for other than purely entertainment purposes such as strategic messaging, training and education and mission planning and rehearsal. Serious games operate at the nexus of where gaming and computer graphics technology meet with instructional design and the needs of modeling and simulation.
- **Multi -User Virtual Environments (MUVEs):** MUVEs enable multiple simultaneous participants to:
 - access virtual architectures configured for learning
 - to interact with digital artifacts
 - represent themselves through graphical "avatars,"
 - communicate both with other participants and with computer-based agents
 - enact collaborative activities of various types.
- **Virtual Worlds** A virtual world is a computer-based simulated environment intended for its users to inhabit and interact via avatars. This habitation usually is represented in the form of two or three-dimensional

graphical representations of humanoids (or other graphical or text-based avatars). Some, but not all, virtual worlds allow for multiple users.

Enjoy!

Jerry Heneghan

Founder and CEO, Virtual Heroes Inc.

www.virtualheroes.com

President, North Carolina Advanced Learning Technology Association

www.ncalta.org

Research Triangle Park, North Carolina

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<http://www.fas.org/gamesummit/>

EDUCAUSE's 2006 Horizon Report (2006)

<http://www.nmc.org/pdf/2006HorizonReport.pdf>

New Media Consortium

<http://www.nmc.org/pdf/2007HorizonReport.pdf>

CHAPTER 1

Why Educational Video Games?

We don't stop playing because we grow old, we grow old because we stop playing~ Oliver Wendell Holmes

INTRODUCTION

A 2005 report by the Business Roundtable entitled *Tapping America's Potential: The Education for Innovation Initiative* 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 our country and our children. How can this monumental task be accomplished? How can we reach children who have been called the *Net Generation* and *Digital Natives*? One potential explanation could be through Serious Educational Games. In 2003, the Serious Games movement was started as an approach to empower people with video game technology in teaching and training. This chapter provides brief explanations for the questions: 1) Why use educational video games?, 2) What are 21st Century skills?, 3) What is play and should it be in schools? and how educational games are being used at North Carolina State University.

WHY USE EDUCATIONAL GAMES?

Video game industry today approaches yearly revenues of \$15 billion and approximately 3.38 billion hours of game play. 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, “cheated”, fantasized about, altered, become models for every day life, and for the formation of subjectivity and intersubjectivity. There is a politics, an economy, a history, social structure and function, and an everyday lived-experience of the game (de Castell, 2003). Craft (2004) believes the method of instruction embodied in video games has potential for non-self-referential disciplines, particularly science.

The Federation of American Scientists 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. Their report stated that educational 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 (Federation of American Scientists, 2006). *Immune Attack* (<http://www.fas.org/immuneattack>), *Food Force* (<http://www.food-force.com>), *Discover Babylon* (<http://www.discoverbabylon.org>), and *Quest Atlantis* (<http://atlantis.crlt.indiana.edu/start/index.html>) are examples of games developed as a result of this drive that can be used for educational purposes.

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.

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). Video games motivate learning by challenging, providing curiosity, beauty, fantasy, fun, and social recognition. They reach learners and passive students who don't do well in conventional settings (Tanner & Jones, 2000; 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).

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 you learn 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. Gee (2003a) stated 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 calls 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. 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, 2004). Virtual learning environments allow for development of higher levels of learning and collaboration skills (Gibbs, 1999), and improved practical reasoning skills (Wood & Stewart, 1987).

WHAT ARE 21ST CENTURY SKILLS?

If we are to reach tomorrow's leaders today, it is crucial we design curricula around the foreseen skills needed to be successful in the 21st Century (see chapter 2 of this book for clear examples of 21st Century skills). Income and wealth in the 21st century 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, 2004). Why is this so important? Jobs once located in the United States are now being outsourced or off-shored. The National Committee on Science, Engineering and Public Policy (2006) reported some alarming statistics:

- For the cost of one engineer in the United States, a company can hire eleven in India.
- 38% of the scientists and engineers in America holding doctorates were born abroad.
- Chemical companies closed seventy facilities in the U.S. in 2004. Of 120 new chemical plants being built around the world with price tags of \$1 billion or more, one is in the U.S. while fifty are in China.
- In 1997 China had fewer than fifty research centers managed by multinational corporations. By 2004 China held over six hundred.
- For the first time, the most capable high-energy particle accelerator on earth will reside outside the United States.
- In a recent international test involving mathematical understanding, U.S. students finished in 27th place among participating nations.
- About two-thirds of the students studying chemistry and physics in U.S. high schools are taught by teachers with no major or certificate in the subject. In the case of math taught in grades 5-12, the fraction is one-half.
- In one recent period, low-wage employers like Wal-Mart (now the nation's largest employer) and McDonald's created 44% of all new jobs. High-wage employers created only 29%.
- In 2003 foreign students earned 59% of the engineering doctorates awarded in U.S. universities.
- In 2003 only three American companies ranked among the top ten recipients of patents granted by the U.S. Patent Office.

- In Germany, 36% of undergraduates receive their degrees in science and engineering. In China, the corresponding figure is 59%, and in Japan it is 66%. In the U.S., the share is 32%. In the case of engineering, the U.S. share is 5%, as compared with 50% in China.

The workers of the 21st century must have science and mathematics skills, creativity, information and communication technologies (ICT) 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 benefits 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 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).

WHAT IS PLAY AND SHOULD IT BE IN SCHOOLS?

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 theory (1898) of pre-exercise, which led him to affirm that we do not play because we are young, but we have a youth because we must play to practice. Play systematically confronts the child with a learning situation that could only be located within his/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 implied by 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 (Brougere, 1999). Learning to play is learning to master situations marked by the second degree, the necessary metacommunication (Bateson, 1973). We 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 from child to adult (Bruner, 1983). These lines are becoming blurry, as more adults are engaging in video games.

Rieber, Smith, and Noah (1998) argue 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 increasingly better understand the logic behind rules and express themselves as individuals through the roles they portray within a game. If we are able to successfully participate in video games and simulation, it is because as children we 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).

PRACTICE (HOW)

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

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, 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 Games¹, introduces inservice science teachers to the game creation process.

Using much of the aforementioned theory as a framework for the construction of this course, the *Wolf Den* originally set out to find a way to deliver online learning synchronously and to investigate if practicing teachers could create their own role play science games.

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. This makes sense since we have been programmed through the preK-12 schooling to interact with our peers and teachers in real time. *Wolf Den* not only provided a quality distance-learning platform, but also through the inclusion of a Voice over Internet Protocol (VoIP) solution, real-time conversations were exchanged while 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 easy as, or sometimes easier than, in the real world.

An example mini game 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 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.



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

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). In addition, students with high overall perceptions of social presence scored high in terms of perceived learning and perceived satisfaction with the instructor.

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). 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 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 as it has been delivered most recently through asynchronous course management tools.



Figure 2. Avatars representing students in the Wolf Den.

The second question asked whether or not teachers could learn to design video games as a teaching and learning tool. Not only were teachers able to learn the game design and creation process, but they successfully constructed games that engaged students, built a community of peers, and helped students learn difficult science content (Annetta et al., 2006). This ability and success was a springboard to the *HI FIVES* project.

*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. Moreover, over 200 students will learn the games design process and work closely with teachers to add the fun element to the content rich games the teachers create.

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 they may create video games for their individual classes. Further, students will learn the game design and creation process so they can construct video games as a form of performance assessment. Through a drag-and-drop Graphical User Interface (GUI) 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*, will be made

available to the public in October 2007 and can be ascertained from the project website³.

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 digital natives participating in the project. As opposed to watching videos, students are actively, not passively, learning content. Further, through an integrated database, teachers are able to ascertain real-time data from student decisions in the game they created.

A game create by a teacher, titled *Invicta The Invader*, was designed to teach six grade students about invasive species; specifically the red fire ant in this case. During the first phase of development, the teacher created a robust story about how fire ants made their way in the United States (figure 3). The game was merely a passive walk through of the invasion from the perspective of a fire ant. When the students took the role of developer, they obtained the vision of the teacher, researched the history of the fire ant invasion, and created a more engaging, fun educational virtual environment (figure 4).



Figure 3: The game start of Invicta The Invader

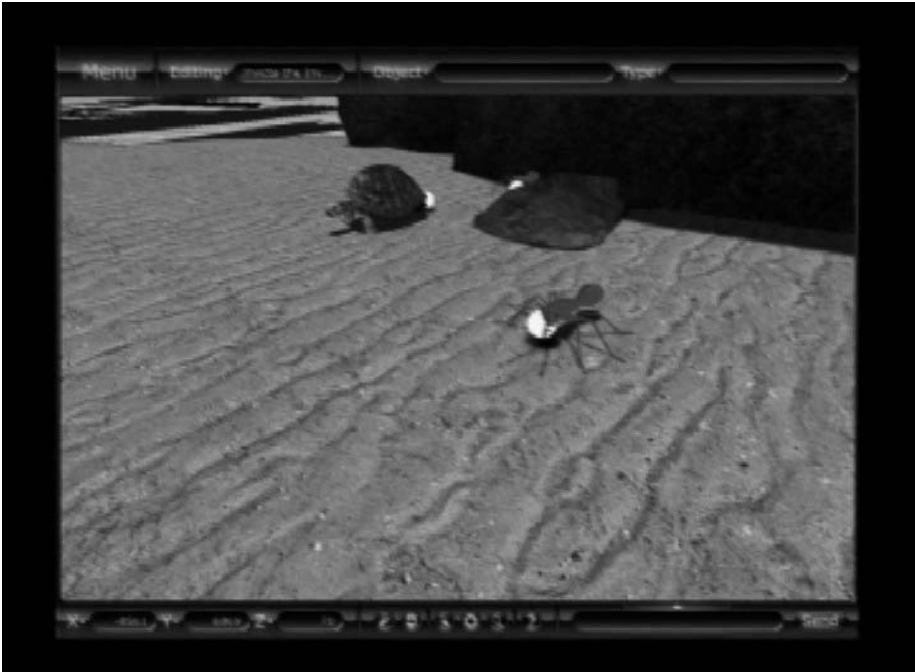


Figure 4: A screen shot of student development of Invicta The Invader depicting fire ant feeding on turtle eggs.

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 accustomed.

CONCLUSION

There is still much to be done in this arena. 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. The remainder of this text will provide you with a theoretical framework and concrete examples from which to begin your quest for answers on educational video games.

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Leonard A. Annetta
North Carolina State University

Meng-Tzu Cheng
North Carolina State University

NOTES

¹ <http://courses.ncsu.edu/ems594/common/ignite/index.html>

² NSF Project ESI-0525115

³ <http://ced.ncsu.edu/hifives>

HILLER A. SPIRES

CHAPTER 2

21st Century Skills and Serious Games: Preparing the N Generation

If it were possible to define the mission of education, it could be said that its fundamental purpose is to ensure that all students benefit from learning in ways that allow them to participate fully in public, community, and economic life (New London Group, 2000, p. 9).

INTRODUCTION

Ensuring that all students have the opportunity to participate fully in society is a daunting challenge for educators. Central to this challenge in the 21st century is changing how we view learning. Serious games, an area that is gaining momentum in education, has potential to transform how we view learning as we meet the fast-paced, ever-changing demands of modern life. Forging a conceptual bridge between serious games and highly-valued emerging skills, this chapter: 1) defines evolving characteristics of the 21st century learner, 2) synthesizes proposed 21st century skills from different disciplines, and 3) analyzes how certain features of serious games can promote the highly valued 21st century skills of *expert problem-solving* and *complex communication*. The chapter closes with a call for more thoughtful empirical studies in order to establish a research base for the emerging field of serious games.

THE 21ST CENTURY LEARNER

Today's students, commonly referred to as the N generation, millennials, or digital natives, were born into social and educational environments where digital technologies are pervasive. The emergence of this first technologically savvy generation creates new challenges for parents (e.g., monitoring time devoted to digital interactions and appropriate content) as well as for educators. Digitally native students bring different skills, interests, and needs to the classroom and educators are grappling to understand these unique attributes in order to design instruction accordingly. Many educators decry the violence and inappropriateness of content both on the web and in games, while others look past the immediate problems and see potential for educational applications. The learning principles that are embedded within games and to which they owe much of their popularity

are often overlooked. As the numbers of game players increase it becomes even more important that educators find ways to harness this phenomenon for educational purposes.

Young people's enthusiasm for the Internet and video games is not a trivial trend. Over one billion people, one sixth of the world's population, were accessing the Internet in 2005 (Internet World Stats: Usage and Population Statistics, n.d.). Even a conservative estimate would suggest that nearly half of the world's population will be online within the next five years. In the U.K., 74% of children and young people aged nine to nineteen have access to the Internet at home, and most of these are daily or weekly Internet users (Livingstone & Bober, 2005). In Japan, 98% of homes have access to the Internet with broadband 16 times faster than that found in the U.S. In the US, the Pew Internet & American Life Project has conducted surveys on children and teens technology use since 2000. In the most recent survey Lenhart and Maddan (2007) reported that 93% of teens use the Internet. More than half of online teens indicated that they were creating content in the form of blogs, videos, or music.

At the state level, a recent survey was conducted of 4000 middle grades students (sixth, seventh, and eighth grades) who were in a North Carolina statewide after-school program (Spires, Lee, Turner & Johnson, 2008). This mixed-methods study included the survey as well as a sample of 48 students drawn from the larger group who participated in one-hour focus group sessions. Students reported high frequency usage of video and online games, music services as well as email, instant messaging, and cell phone services out of school. There was a difference between what students said about in school and out of school technology uses. In school students reported high levels of computer-based skills work and moderate levels of Internet-based research. Students were also asked about where they found information for completing their work and 86% of respondents indicated that they used the Web as opposed to printed materials. When asked about activities they enjoyed in school, students listed doing research on the Internet above working on projects in a group, listening to the teacher explain things, and doing worksheets. Analysis of survey data revealed no significant differences in computer usage in and out of school among ethnic groups as well as rural and non-rural students' uses of computers.

The main distinctions that emerge between in and out of school technology use relate to the intent of the technology use and the actual devices being used. Outside of school students are using technology for communication and entertainment purposes. They also are more likely to use smaller handheld and gaming devices outside of school. Inside school students are using desktop computers for web-based research, word-processing and other productivity purposes (spreadsheets, PowerPoint, etc.). The surveys suggested that students' technology use inside school is often less creative and meaningful than their technology use outside of school. Students expressed strong opinions in all the surveys about what technologies they thought should be in school and how they thought these

technologies should be used, and they viewed technology skills and understandings in general as essential for their success in adult workplaces. Interestingly, research suggests that while they are frequent users of technology tools, Net-Generators typically lack information literacy skills, and their critical thinking skills are often weak (Oblinger & Oblinger, 2005). They may be digital natives, but they do not necessarily understand how their use of technology affects their ways of learning.

WHAT KNOWLEDGE AND SKILLS ARE ESSENTIAL FOR THE 21ST CENTURY?

In 1900 in his seminal essay, *What Knowledge is of Most Worth?*, social theorist Herbert Spencer stated that this question needed to be answered before designing curriculum or instruction. As we make our way into the 21st century, Spencer's provocative question is still front and center but this time in the midst of fast-paced technological changes that are driving the global economy. With ongoing advancements in information technologies creating much of the change we experience, different groups are thinking hard about the new knowledge and skills that are needed for workplace productivity. Even though it is impossible to predict the future, based on current expectations from the business community trends are emerging in terms of new skills that are needed. The Partnership for 21st Century Skills (P21) (2005) is the latest in a series of business-education consortia that have delineated core content, skills, and processes that are deemed critical to the twenty-first century workplace. P21's perspective is consistent with that of many economists and nonprofit organizations that address workforce-capacity issues (Levy & Murnane, 2004; Dede, Korte, Nelson, Valdez, & Ward, 2005). Arguing to "bridge the gap between how students live and how they learn" (p. 4), P21 has identified six key elements for 21st century education including, core subjects and learning skills as well as 21st century tools, contexts, content, and assessment. These six elements shape an educational reform agenda that P21 argues will enable young people to develop a wide range of skills (e.g., media, communication critical thinking, creative, problem solving, interpersonal, collaborative) while using information and communication technologies in real world contexts. To help education leaders and policymakers implement 21st century teaching and learning, P21 recently launched Route 21 (P21, 2007), an online, one-stop shop for 21st century skills-related information, resources and tools. Interestingly, P21's claims are similar to the SCAN report that emerged in the 1990's.

P21 suggests that technology plays an important role in educational change and much of the proposed change is tied to the tools and resources students use in their everyday lives. As reported earlier, students are becoming increasingly dependent on technologies to communicate, gather information, extend social experiences, and be entertained. Obviously, as students move into the workplace their interest in technologies transfers with them; the workplace, however, often expects workers to have even more sophisticated technological skills and know-how and a disposition receptive to change.

Coming from a popular press perspective and being more global with his concepts than P21, Daniel Pink in *A Whole New Mind*, (2005) boldly claims that “the future belongs to a very different kind of person with a very different kind of mind—creators and empathizers, pattern recognizers, and meaning makers. These people . . . will now reap society’s richest rewards and share its greatest joys.” (p.1). Arguing that we have already passed from the informational age to the conceptual age, Pink claims that in addition to left brain-directed reasoning, which was dominant in the information age, right-brain approaches are also essential in the conceptual age in order to be successful. Table 1 depicts the six senses that Pink asserts must prevail to be successful in today’s society.

Table 1. A Whole New Mind: Moving from the Information Age to the Conceptual Age. (Pink, 2005).

<i>Right-Brain Senses</i>	<i>Description</i>
Design	Creating something aesthetically appealing, whimsical or emotionally engaging.
Story	A tool that is enriched by emotion, a deeper understanding of how we fit in the world and why that matters.
Symphony	The ability to put together the pieces; to synthesize rather than to analyze; to see relationships among unrelated fields, to detect patterns; to invent something new by combining elements nobody else thought to pair.
Empathy	Being able to discern what makes a fellow woman or man tick to forge relationships and to care for others.
Play	Ample evidence points to the enormous health and professional benefits of laughter, lightheartedness, games, and humor.
Meaning	Our abundance has freed millions of people to pursue significant desires: purpose, transcendence, and spiritual fulfillment.

Another group that has done advanced thinking in the area of 21st century skills is MIT Professor Henry Jenkins (2007) and his colleagues. The skills that Jenkins promotes are more localized to media literacies than the global skills that Pink and the P21 group target. Prompted by the rich media landscape that exists today, Jenkins has articulated a new skill set that involves social skills developed through collaboration and social networking. These skills build on the foundation of traditional literacy, research skills, technical skills, and critical analysis skills taught in the classroom. Table 2 depicts these new media literacies, which are

contextualized within digital media environments. Note that both Pink and Jenkins point to “play” as a 21st century skill, although they define it in different ways (see Chapter 4 of this text for a discussion of educational play). Pink points to the health and professional byproducts of play; Jenkins, on the other hand, claims play is as an approach to problem solving. Interestingly, both authors use “empathy” and “negotiation” as very similar concepts.

Table 2. New Media Literacies (Jenkins, 2006)

<i>New Media Literacy</i>	<i>Description</i>
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 & compare notes with others toward a common goal.
Judgment	Ability to evaluate the reliability & 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.

Dede (2007) astutely argues that proposed skills and knowledge are not robust enough to encompass what is needed for the future; but rather *understandings* and *performances* will better serve our transition into 21st century work and life. Levy and Murnane (2004) suggest that expert thinking and complex communication are

essential for contemporary work, since these are the two areas in the workplace that computers cannot replace human beings. Expert problem solving involves effective pattern matching based on detailed knowledge, metacognition, and the set of skills used by the perplexed expert to determine when to end one strategy and try the next. Complex communication involves managing multiple information streams as well as the capability to interpret subtleties and present convincing arguments. In an economy flooded with new concepts and invented language, communicating complex information effectively is an increasingly valued skill. Complex problem solving, quick and intuitive decision-making ability, collaboration skills, and resourcefulness are the keys to success in the workplace. The rapid pace of change and the need for continuous learning makes the capacity to learn a highly valued competency as well.

If we synthesize across the various taxonomies that have been described, it appears that the bottom line for 21st century life and work is that we need, first, continuous learners who can forge understandings in ambiguous and complex problem solving landscapes. Second, we need learners who can collaborate with multiple information and communication streams. In an era of high stakes testing, schools do not typically place these two performances at the center of education. The question that many educators are asking is, “How do we turn the educational corner to nurture these dispositions in our schooling process?” Multiple agendas are emerging in order to answer this question; one area that shows promise but still needs much research is the area of serious games.

HOW CAN SERIOUS GAMES ENABLE 21ST CENTURY SKILLS IN EDUCATIONAL SETTINGS?

With growing numbers of people around the world playing computer games, the economic and social implications of this phenomenon are profound. A single definition of serious games does not appear to exist, although typically the term depicts games that are used for training, advertising, simulation, or education. Educators are attempting to find ways to appropriate the best features of game-based learning and bring them into the formal classroom. Not surprisingly, the two 21st century skills of complex communication and expert problem solving are dominant features that cut across most game genres. For the most part, traditional schools are not set up to provide learning contexts that promote these two skills. Problem-based learning scenarios have been used for years to try to approximate real life problems and have met with some success in education. But typically problem-based learning modules have not approached the cognitive complexity and fast-paced processing that game contexts afford. Additionally, there is a gap between what students have a growing demand for, what our global economy requires, and what traditional schools can afford. While game-based learning will not be a singular answer to filling the gap, it can provide movement in the right direction.

The modern work environment is about managing complex information streams, which increasingly is a critical part of job performance. Games can provide a context for situated learning in which players are immersed in complex, problem solving tasks that require expertise. Examining the role of expertise in modern culture, John Bransford and his colleagues (e.g., Schwartz, Bransford, & Sears, 2005) distinguish between routine and adaptive expertise. Routine experts are adept at solving routine problems every day; adaptive experts exhibit flexibility, which is highly valued in today's workplace since knowledge and skill requirements change significantly over the course of a career. While routine experts may be efficient and technically skillful, they may not be able to flexibly adapt to solve new problems; adaptive experts are able to adapt to as well as seek out new learning situations (Hatano & Oura, 2003). Adaptive expertise is clearly a key feature of game environments.

Becker & Wade (2004) deconstruct complex communication and expert problem solving further and assert that the following characteristics of gamers map on to the needs of the 21st century workplace. Gamers are able to:

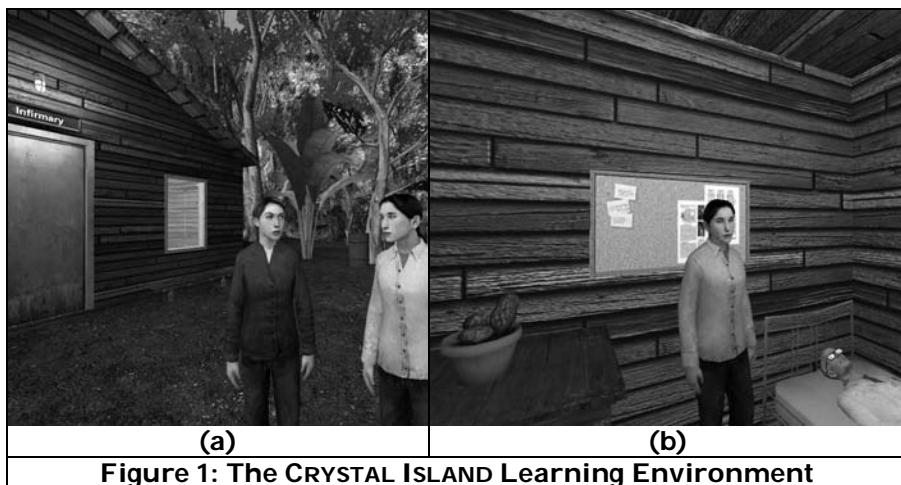
- Rapidly analyze new situations
- Interact with characters they don't really know
- Solve problems quickly and independently
- Think strategically in a chaotic world
- Collaborate effectively in teams

These characteristics are evident in commercial massively multiplayer online games (MMOGs) like *World of War Craft*, or *Everquest 2*. MMOGs share many of the same features of other games except they are played online. Steinkuehler (2004) asserts that these games can be cognitively demanding, requiring exploration of complex, multi-dimensional problem spaces, as well as empirical model building systems. These environments require the negotiation of meaning and values within the online community as well as the coordination of avatars and multiple forms of text. *Civilization III* is an example of a commercial entertainment game that provides extensive experience in problem solving. As players lead a civilization from 4000 BC to the present, they seek out geographical resources, manage complex economies, and hold diplomatic summits with other nations. Squire (2003) conducted a study to see what students learned about social studies from *Civilization III*, even though the game is designed primarily for entertainment. Students understood the concepts of monotheism and monarchy as well as learned how to synthesize disparate periods of history.

Becker and Wade's characteristics are also evident in non-commercial games, such as Dede's long standing *River City*, an immersive simulation for middle school students. This MUVE (Multiuser Virtual Environment) is an example of an academic enterprise that was created using designed-based research and promotes both complex communication and expert problem solving. Following the path of *River City*, with the addition of intelligent tutors, *Crystal Island*, is being developed at North Carolina State University by a team of computer scientists and educational

researchers. This NSF funded project (Lester, Spires, & Nietfeld, 2007) is an example of an academic innovation that targets science education for 8th grade middle students. Taking their cues from Jerome Bruner (1990, p. 35), who observed that the way people organize their experience and knowledge with the social world “is narrative rather than conceptual,” the creators used a narrative centered learning environment to explore concepts related to microbiology (Mott & Lester, 2006).

The learning environment (see Figure 1) is set on a recently discovered volcanic island where a research station has been established to study the unique flora and fauna. The user plays the role of the daughter (or son) of a visiting scientist who is attempting to discover the origins of an unidentified illness at the research station. The environment begins by introducing the student to the island and the members of the research team for which her father serves as the lead scientist. As members of the research team fall ill, it is her task to discover the cause of the outbreak. She is free to explore the world to collect physical evidence and interact with other characters. Through the course of her adventure she must gather enough evidence to correctly choose among candidate diagnoses including botulism, cholera, salmonellosis, and tick paralysis as well as identify the source of the disease relying on her knowledge of genetics to solve the mystery.



The task-oriented environment of *Crystal Island*, its semiautonomous characters, and the user interface are implemented with Valve Software’s Source™ engine, the 3D game platform for Half-Life 2. The user can perform a broad range of actions including performing experiments in the laboratory, interacting with other characters, reading “virtual books” to obtain background information on diseases, and collecting data about the food recently eaten by the members of the research

team. Throughout the mystery, users can walk around the island and visit the infirmary, the lab, the dining hall, and the living quarters of each member of the team. In the current test bed, there are 20 goals users can achieve, three hundred unique actions the user can carry out, and over fifty unique locations in which the actions can be performed. As a narrative centered learning environment, *Crystal Island* satisfies Malone & Leper's (1987) criteria of challenge, curiosity, control and fantasy; learning includes competence and direction in the face of novelty, complexity, and ambiguity. A series of experimental studies are underway that will assess the effects that using *Crystal Island* has on student problem solving and affect. Additionally, the research is examining how well performance in the environment predicts a range of academic dispositions (Spires, Turner, McQuiggan, & Lester, 2008; McQuiggan & Lester, 2008).

CONCLUSION

As educators continue the quest to ensure that all students have the opportunity to participate fully in society, multiple paths for learning must be explored. Although in its infancy, game-based technologies hold promise in forging new models of learning and teaching for the formal schooling process. Central to this challenge in the 21st century is finding cross-sector partners who are willing to take up the research and development mantel in order to shed more light on the educational benefits of games. Gee (2003) identified 36 learning elements embedded within games that he analyzed. He concluded: "Better theories of learning are embedded in the video games many children in elementary and high school play than in the schools they attend. Furthermore, the theory of learning in good video games fits better with the modern, high-tech global worlds of today's children and teenagers live in than do the theories (and practices) of learning they see in school" (p.7). Gee's assertion, no doubt, is designed to be provocative; but his statement holds some truth. As games become more popular, however, generalized, non-substantiated statements will not serve the field well. We need a systematic way to analyze the learning features of games and conduct educational research that will help articulate the cognitive, affective, and social benefits for education.

Gaming technology will need to overcome the same types of resistance that, in recent years, other technologies have confronted, (e.g., computers as tools for analysis and the Internet as a primary form of communication within business). As the field moves forward, essential questions for the educational research community are: What are the critical factors built into game-based environments and how can they inform our current theories of teaching and learning? How can we appropriate the very best of what games have to offer for educational purposes in the 21st century? In the best interest of the N generation and future learners to come, we need to answer these questions thoughtfully and thoroughly—and we need to answer them sooner rather than later.

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AFFILIATIONS

*Hiller A. Spires
Professor and Senior Research Fellow
Friday Institute for Educational Innovation
College of Education
North Carolina State University*