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Pepperdine University

Graduate School of Education and Psychology

CULTIVATING 21ST CENTURY COMPETENCIES IN A VIRTUAL WORLDS LEARNING ENVIRONMENT

A dissertation submitted in partial satisfaction

of the requirements for the degree of

Doctor of Education in Learning Technologies

by

Terry K. Smith

September, 2011

Paul Sparks, Ph.D. - Dissertation Chairperson

This dissertation, written by

Terry K. Smith

under the guidance of a Faculty Committee and approved by its members, has been submitted to and accepted by the Graduate Faculty in partial fulfillment of the requirements for the degree of

DOCTOR OF EDUCATION

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DEDICATION

It is altogether fitting and appropriate that I dedicate this dissertation to my wife Mary. Her love and support made it possible for me to immerse myself in the challenges of 3 years of doctoral coursework. It was time I often had to be absent from our normal life, but time that enabled my learning and my research to take place. In short, she carried a huge load and managed all the details of our everyday lives so that I could concentrate on this dissertation journey.

ACKNOWLEDGMENTS

Overall, I acknowledge all of my professors at Pepperdine University for providing a diverse set of professional experiences in learning technologies. I found the rigor to be challenging and rewarding. Among my professors, I found the mix of personalities and expertise both delightful and inspiring. Readings, projects, and group assignments pushed me beyond classroom learning and out into the world where I, indeed, had to construct my own knowledge, taking responsibility for what I desired to happen in my life.

As well as my professors, I acknowledge the contributions of my doctoral cadre, a group of highly talented students who became my second family in a new learning community, one that we all entered for many different reasons. Respect, friendship, and caring were key in the cadre, which stayed determined that every member would go the distance and complete the doctoral program.

Finally and significantly, I acknowledge the extraordinary guidance, collaboration, and good humor with which Dr. Paul Sparks served as my chairperson for this dissertation. He helped refocus my original ideas for this study, and through his timely reviews and discussions, effectively contributed to my understanding of educational research.

VITA

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PROFESSIONAL EXPERIENCE

University of Saint Francis 2010–2011
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Courses taught: EDUC 385, Elementary Science & Social Studies Methods; EDUC 392, Classroom Management; EDUC 210, Teaching in a Diverse Society. Coordinated beginning and intermediate teacher education student practice teaching in local schools. Facilitated Internet projects and virtual learning programs with local schools.

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Online Instructor
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Education Consultant
Digital Projects consulting on Samuel Clemens and Mississippi River history. Integrated technology tools into middle and high school lessons and projects.

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Master of Arts Teaching Program; Courses taught: 533W, Educational Technology; Taught elementary, middle school, and high school teachers. Focus on using technology in the classroom and Internet projects.

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Classroom Teacher
Fourth grade, Project based learning; Supervised global Internet projects. Took students to Taiwan International Summer Camp in 2004 and 2007. Managed the school Web site. Extensive use of classroom technology. Assisted teachers with technology.

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Talented & Gifted Teacher
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Ellington School 1997–1998
Quincy, IL
Talented & Gifted Classroom Teacher
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Specialized in system administration documentation for Unix operating systems and networks. Project leader for online documentation strategy.

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Technical Writer
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Data General, Incorporated 1986–1989
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Specialized in system administration documentation for Unix operating systems and networks. Projects included TCP/IP, BSD Unix, Network File System and graphical user interface for X-windows.

PAPERS AND PRESENTATIONS

Smith, T., "Professor-Driven Internet Projects with Partner Schools Provides 21st Century Models for Pre-service Teachers," Conference proceedings, Society for Information Technology and Teacher Education (SITE) Conference. Nashville, TN, March 2011.

Smith, T., "Changing the Face of Traditional Education: Project-Based Learning" Conference proceedings, EDTECH 2009 Conference. National College of Ireland. Dublin, Ireland. May 2009.

Global Education Conference. Online. November 2010—Online Moderator: *Learning with Digital Natives.* Hosted webinar sessions for Argentinean presenters.

Reinventing Project-Based Learning webinar—Guest speaker with authors Jane Krauss and Suzie Boss. *Classroom 2.0 Online*, February 2010.

Virtual Worlds Best Practices in Education Conference: Second Life, panel member, March 2010.

Blogs as a Platform for Web 2.0 Tools: Hannibal Public Schools workshop, April 2010.

Laptop Leaders Academy. Online presentation: *Using Skype and Quest Atlantis*, Mitchell Technology Institute, SD, June 2010.

Guest speaker: United Kingdom education tour, Primary Schools in Burneside, Rowsley, and Reading, England: Using Technology in the Classroom, May-June 2009

EnclycloMedia, a conference of library/media specialists, counselors, and gifted and talented teachers. Online presentation: *Math Sharing Using Video Conferencing*, Oklahoma City, OK. August 2009.

SERVICE

National African American Read-In. Volunteer, organized preservice teachers in literacy sessions for students and parents at family events. Parks Multicultural Academy, February 2011. Joliet, IL.

Flat Classroom Media Judge. High school student videos on globalization, social networking, and mobile learning. Flat Classroom is an international Internet project. November, 2010.

Science Fair Judge. Volunteer Joliet Diocese, Region IL, St. Patrick's School for 7th–8th grade science fair. Joliet, IL. January 2011.

Green Earth Day Celebration. Assistant organizer and planner for elementary students participation in activities on the meaning of Earth Day 2011. University of St. Francis. Joliet, IL.

Chrysalis Education Camp. Volunteer teacher and facilitator for undergraduate students considering the teaching profession. Overnight camp environment: education stories, team building, communities of practice, and reflection on education. Camp Duncan, Ingleside, IL. August 2010.

International Summer Camp Organizer. Took elementary students to Taipei, Taiwan in 2004 and 2007 to participate in the International Summer Camp at Kang Chiao Bilingual School. This was an extension of our Internet project partner relationship which began in 2003 with the *Show Me the World* project though the University of Missouri.

MEMBERSHIPS

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Windows/MacOS/Unix operating systems, HTML, video production and conferencing, GPS caching, survey tools, virtual worlds, Internet project management, and online learning management systems.

ABSTRACT

Education reforms in recent years have pressured schools to show achievement results through testing and conformity to standards. Problems of low student engagement in the current test-heavy environment have been a serious barrier to learning in schools across the United States, especially in low socioeconomic areas. After years of unsuccessful testing programs, educators and researchers are calling for approaches that enhance student engagement and foster the 21st century competencies that students need to succeed.

Researchers have found that engagement, 21st century competencies, and learning can be enhanced using virtual worlds approaches (Arici, 2008; Barab, Dodge, & Ingram-Goble, 2006; Dede, Nelson, Ketelhut, Clarke, & Bowman, 2004; Klopfer, Osterweil, & Salen, 2009; Ludgate, 2008). Research in learning supports socialization and situated experiences in which content is learned in a meaningful, active context such as is provided by virtual worlds (Brown, Collins, & Duguid, 1989; Gee, 2003; Lave & Wenger, 1991).

This mixed-methods study used existing quantitative student data from the Quest Atlantis Project at Indiana University, and qualitative survey data from trained teachers experienced with the Quest Atlantis virtual worlds learning environment. Research questions addressed teacher observations of 21st century competencies, the degree that students were engaged with Quest Atlantis, and looked for other benefits seen by teachers. Findings showed (a) Quest Atlantis fosters 21st century competencies as reported by teachers; (b) Quest Atlantis is highly engaging for students; and (c) Academic content learned in Quest Atlantis transfers to traditional testing formats. Future

research is recommended to examine why teachers in this study reported relatively lower levels of student creativity. Additionally, because students of low socioeconomic status showed equal or better results in 21st century competencies, further study of socioeconomic variables relating to learning in virtual worlds is recommended.

The National Education Technology Plan (2010) recommends fostering 21st century competencies and new learning approaches such as virtual worlds, games, and other interactive technologies. Continued study of virtual worlds holds potential for innovative solutions for improving student engagement and learning in America's classrooms.

Chapter 1: Learning, Competencies, and Virtual Worlds

The National Education Technology Plan (NETP, 2010) states:

> Technology can inspire imagination and intellectual curiosity, help people engage actively as learners, and open new channels for success or visions of career possibilities. For example, when students use the tools of professionals to engage in real-world problems, they can begin to see themselves in productive professional roles ('I am a graphic artist,' 'I am a scientist,' 'I am a teacher'). Technology also provides opportunities for students to express themselves by engaging in online communities and sharing content they have created with the world. (p. 17)

Public schools across the United States are striving to improve under pressures from legal mandates such as No Child Left Behind and nationwide initiatives from the Department of Education such as Race to the Top in 2009, the NETP in 2010, and Common Core Standards in 2009. The prime focus of these mandates and initiatives is improving student achievement in thousands of K-12 schools, in which students range from low to middle to high socioeconomic status (SES). However, even more defined in the past few years is the call for students in the United States to improve academically, as measured against higher performing students around the world (Duncan, 2010). With a shift occurring toward new skills, proponents of this economic world view of education say that leadership and innovation are in the hands of our current students, so their quality of education will have a direct affect on the future of the United States in the global community (Duncan, 2010; Friedman, 2005).

Call For New Competencies

Academic levels of reading and math continue to be the targets of statewide standardized tests across the country. Organizations and researchers calling for school reform have begun categorizing academic skills in terms of competencies, using the term 21st Century skills (Dede, 2009; Jenkins, Clinton, Purushotma, Robison, & Weigel, 2006; Partnership for 21st Century Skills, 2011; Voogt & Roblin, 2010). Dede (2009) states, "Beyond curricular issues, classrooms today typically lack 21st century learning and teaching in part because high-stakes tests do not assess these competencies" (p. 3). Shute and Torres (in press) concur with Dede, stating:

> Learning and succeeding in a complex and dynamic world is not easily measured by multiple-choice responses on a simple knowledge test. Instead, solutions begin with re-thinking assessment, identifying new skills and standards relevant for the 21st century, and then figuring out how we can best assess students' acquisition of the new competencies. (p. 6)

Many believe that by teaching experiential skills to students as competencies instead of only isolated academics measured by test scores, then authentic improvements will take shape, improvements that can be measured in terms of what a student can do that will help in future careers, and in turn, help the economy. While many educators, writers, and researchers stand opposed to the Department of Education on students' education methods being directly tied to our economic future, there is agreement that traditional education methods need to be reformed to be more in step with the 21st century (Hanushek, 2002; Kohn, 1992). If education reform approaches can make learning more relevant and connected to the lives of students, and thereby also increase student

engagement, researchers suggest that we can expect to see enhanced learning (Barab, Dodge and Ingram-Goble, 2006; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Dede et al., 2004; Gee, 2003). A side benefit of enhancing teaching and learning could be that educators might reach a broader range of students across socioeconomic boundaries, learners who have been disengaged and underserved by efforts relying on traditional methods and standardized testing. Figure 1 shows a comparison of traditional teaching and assessment and 21st century teaching and assessment implementing a collaborative virtual world environment. These are the conditions, needed competencies, and applicable learning approaches that will be discussed in this study.

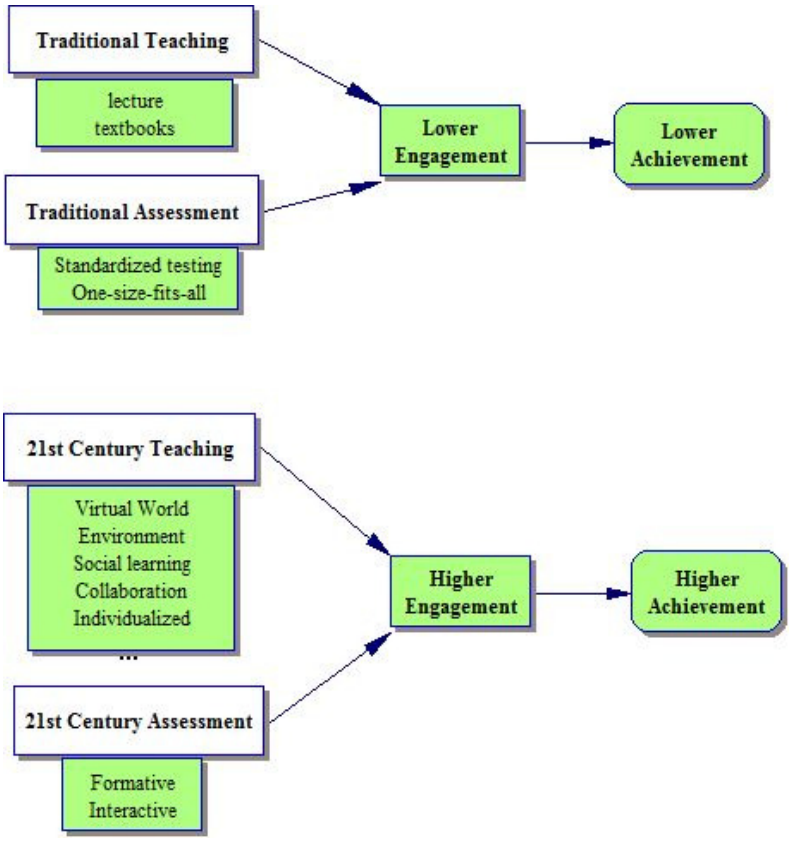


Figure 1. 21st Century teaching and assessment in virtual worlds.

Engagement as part of the reform process. High student engagement in school is considered one prerequisite for success across the range of K-12 students, whether they

are of low or high SES. Engagement can diminish with traditional teaching modes and be even worse among students from low socioeconomic conditions. Doherty and Abernathy (1998) stated:

> Low-performing schools are often located in communities where families live in concentrated poverty; there are usually low expectations for students; students are not encouraged to take demanding courses; many teachers are burnt out; and school facilities are run-down, overcrowded, and disorderly. (p. 25)

According to Willms (2003): "When students are segregated along social-class lines into different schools or educational programmes, students from disadvantaged backgrounds tend to have markedly worse outcomes" (p. 10). Earlier, Willms (2002) used the phrase double jeopardy to describe low SES students who are in schools of predominantly low SES populations; there is a much higher probability of these students being disengaged and exhibiting low performance in school with these double factors. Because engagement is connected to activity level, concentration, and student performance, increasing engagement has the potential to lead to higher scores, improve student attendance, and address high student dropout rates (Bridgeland, Dilulio, & Morrison, 2006; Finn & Voelkl, 1993; Fredricks, Blumenfeld, & Paris, 2004; Ingels et al., 2005; Willms, 2003).

However, disengagement is not confined to low socioeconomic schools. Yeh (2008) found that low student engagement exists across the U.S. educational system and noted that creating situations of engagement for students should be an important goal in education. In other research, longitudinal studies of student engagement in early elementary years showed that problems with engagement have negative long-term effects on achievement. The Beginning School Study (as cited in Alexander, Entwisle, &

Dauber, 1993; Alexander, Endwise, & Horsey, 1997) showed that student engagement in first grade was related to achievement test results as they progressed through Grades 1, 2, 3, and 4, as well as subsequent decisions to drop out of school (Fredricks et al., 2004).

New methods yield higher engagement: Games attract students. Changing how learning happens in schools requires new ways of thinking, changing old ways, and acting in new ways (Doherty & Abernathy, 1998). Educational games have been one strategy tried in schools, as educators strive to push students toward higher achievement. This direction shows great promise (Gee, 2003). In a study of elementary students ages 9 to 12 in Boys and Girls Clubs, Dr. Sasha Barab examined social likes and dislikes, favorite magazines and books, and preferred video games that students chose in their leisure time (Barab, Thomas, Dodge, Carteaux et al., 2005). From what he learned about the students' involvement with video games, he argues that video games represent a learning form that engages students and deserves attention from educators. Vandeventer and White (2002) concur with Barab in findings from their study of 10- and 11-year-old students whom the authors called highly proficient video game players, in which the subjects displayed expert behavior in teaching adults how to play video games. The researchers observed proficient behaviors in self-regulation, qualitative thinking, and decision making, all desired characteristics of successful students.

Computer learning approaches in elementary, middle, and high schools have typically been video games designed for factual content and explicit test practice (Klopfer et al., 2009). Multiple-choice and fill-in-the-blank software for standardized test practice in math, reading, and other subjects has been available to schools for years, while outside of schools, noneducational commercial video games continue to rise in popularity and

sales. Video gaming among youth in elementary through high school years, from the 1980s through the present, provides educational benefits even though the majority of video games are not specifically designed for education (Barab, Thomas, Dodge, Carteaux et al., 2005; Gee, 2003; Herz, 1997; Shaffer, 2006). Given that youth spend significant time with video games, Barab and others argue that commercial gaming companies are, in a sense, educating young people (Barab, Thomas, Dodge, Carteaux et al., 2005). Additionally, although commercial games with educational potential do exist, there remain too few examples that would satisfy teachers and parents, and support engaging academic learning (Barab, Dodge, Turzun et al., 2007).

Educational Technology, 21st Century Competencies, and Engagement

Finding new methods and technologies that can enhance student achievement, boost test scores, and foster student engagement has become an important focus and direction for the U.S. Department of Education as elaborated in the National Education Technology Plan. The focus has become concentrated on describing a set of competencies and literacies known as 21st century competencies (Partnership for 21st Century Skills, 2011; Voogt & Roblin, 2010). Teaching and providing authentic experiences for students to learn and use 21st century competencies are key goals of the National Education Technology Plan. These competencies underpin the broader learning goals for students across the United States, particularly for how they measure against students from other countries.

New assessments yield higher engagement. Current uses of technology to meet the mandates and challenges of No Child Left Behind laws and the Race to the Top initiative from the Department of Education, as well as the current raise-the-bar strategy

of increased standardized testing is not improving the situation (Bracey, 2009; Dede, 2009). Innovative applications and approaches that combine learning theories of situated and distributed cognition with high interest, educationally research design curriculum are explicitly called for in the National Education Technology Plan.

Since the advent and expansion of the No Child Left Behind Act of 2001, there have been pressures to increase student achievement through various means, including standardized testing, increased teacher effectiveness, fostering alternative or charter schools, and most recently, implementing technology strategies specified in the National Education Technology Plan. It is from the educational technology, social learning, virtual worlds perspective that this study seeks to add to the knowledge base of effective, equitable technology learning situations that can be implemented in schools to meet needs of a variety of SES students. This deviates significantly from current technology approaches that focus on repetition on isolated skills for so-called content mastery represented by increasing test score numbers. This study aims to cast light on learning research in authentic situations aided by virtual environments in which students are immersed in 21st century competencies, integrating reading, writing, thinking, navigating, and negotiating in modules of science, social studies, math, language arts, and character education. Demographics play a role in this study because of the high degree of disengagement in schools found in low socioeconomic groups (Willms, 2002). Information gained from this study could be potentially useful as educators make selections among educational technology software; that is, understanding that some kinds of software are more effective at engaging the wide array of demographics found in public schools. Then educators can make informed choices among a variety of software

solutions being marketed to schools: those that authentically engage diverse groups, and those that drill on skills specifically to raise test scores.

Immersive virtual worlds change instruction and assessment. Since popular commercial video games generally do not meet educational requirements, researchers argue that new games designed in the fashion of popular commercial games, but integrating academic content, would be welcomed and endorsed by educators and parents, and such games could help with the problem of diminishing engagement in schools (Barab, Arici, & Jackson, 2005; Dede 2009). However, more than engagement is needed; educators need to see academic results. The U.S. Department of Education (as cited in National Education Technology Plan, 2010) contends that using technology and teaching 21st century competencies can lead to the academic results educators seek.

While skills-based drilling games are the predominate type available in schools, the landscape is changing. With technology advancements and the rising popularity of Internet-based multiuser games, skills-based educational games are no longer the only option. Educators have more sophisticated choices. Among those choices, teachers can help students become proficient at problem solving and inquiry skills if conditions are simulated properly. One effective way is by having students assume the role of the experts working in an authentic virtual circumstance; that is, the students are working in similar conditions as real-world experts (Blumenfeld et al., 1991; Dede, et al., 2004). Gerstein (2009), in her study of students using virtual worlds, observed evidence of the participatory culture of the 21st century as labeled by Jenkins et al. (2006), a situation that also illustrated Lave and Wenger's (1991) tenet of novices and experts working together in a connected community. Dede et al. (2004) wrote that subpopulations of students

unmotivated by traditional classroom practices, as well as special needs students, could benefit from learning in an immersive virtual environment because of the accommodating benefits for both groups.

With the advent of the immersive virtual environment, students have a sophisticated range of interactive opportunities, providing educators with choices that go beyond exercising explicit skills and practicing for tests (Dede et al,. 2004). Klopfer et al. (2009) argued that the design of many popular virtual worlds have "engaging game mechanics that are ripe for both formal and informal learning environments" (p. 6). "These next generation ideas are already inspiring educational innovation, and demonstrating that educational games have learned a lot" (p. 6). Significant examples of educational virtual world learning environments include Indiana University's (Quest Atlantis) Harvard's (River City and EcoMUVE), and the California Institute of Technology's (Whyville). Each of these incorporates avatars in a virtual world, social networking among players, using tools, simulations, and academic content. Also central to these virtual worlds is the concept of play, where students are free to take risks with learning and try new identities or roles (Arici, 2008; Barab et al., 2006; Lave & Wenger, 1991). Vygotsky (1978) sees play as an important part of learning, observing that children at play, in assuming new roles, exhibited levels of thinking and performance beyond their age levels. Gee (2003) and Klopfer et al. (2009) argue similarly that games provide students with opportunities in risk-free scenarios to explore and experiment as both novice and expert, engaging in activities that are key to being a successful student, activities which that develop the abilities described as 21st century competencies (Partnership for 21st Century Skills, 2011; Voogt & Roblin, 2010).

Learning and Virtual-Worlds Terms

The following is a brief listing of basic terms relevant to this study pertaining to learning theory and virtual worlds. This section is intended to be useful to the reader, while not an exhaustive set of definitions for the study.

1. *Situated cognition or situated learning*: learning is inseparable from doing, that knowledge is situated in activity as it occurs in social and cultural contexts. Learning is deeper when the content to be learned is situated in a meaningful, useable context for the learner (Brown et al., 1989).
2. *Distributed cognition*: a way of looking at learning such that knowledge is not confined to an individual, but is instead spread or distributed across human beings involving personal memories, objects, and tools of the culture or environment. This concept points toward socialization as important for learning as opposed to solitary learning (Lave & Wenger, 1991).
3. *Community of practice*: describes a social learning situation in which people create an ongoing community focused on a common interest. The community is composed of experts and novices and provides for varying levels of interactions and input. A well-developed community of practice continues on as members join and leave the community over time (Lave & Wenger, 1991).
4. *Transfer of knowledge*: content leaned in one context may be used in another context, such as a concept learned in school would be intended for use elsewhere (Brown et al., 1989).
5. *Decontextualization*: in descriptions of learning, this describes when content is delivered or taught in a context in which it is not actually used or experienced.

Traditional classroom teaching in schools has been described as decontextualized.

6. *Virtual world*: a computer-based simulated environment, sometimes called a 3-D virtual environment. Users, in the form of computer-simulated characters called avatars, can enter the virtual world using login and password information and interact with other avatars as well as exploring the computer-generated physical attributes of the environment. Depending on the design, avatars can travel, communicate with each other, and modify the environment. Virtual worlds are used for educational training purposes as well as for commercial entertainment purposes (Malaby, 2009).
7. *Game-based learning*: refers to embedding intentional content into an interactive attractive game format for students. Real-world contexts are depicted and clear learning outcomes are designed as part of the process of playing the game. User advance in the game depending on their successes in solving the problems and interacting with challenges of the game (De Freitas, 2006).

The Purpose of this Study

Educators agree that engagement is critical to learning, but most of the prior engagement studies in schools have been done broadly in regard to teaching methods, generic technology use, and drop-out rates (Bowen, 2002; Finn, 1993). However, the question of learning coupled with the acquisition of 21st century competencies has not been specifically addressed. To that end, this study uses a framework of situated and social learning theory (Brown et al., 1989; Lave & Wenger, 1991) to examine engaged

students working in immersive virtual worlds, practicing and learning 21st century competencies. Quest Atlantis was chosen as an exemplar virtual environment for this study because, among virtual approaches, it has had the widest acceptance in the United States and around the globe with more than 60,000 students using it worldwide.

Defining 21st century competencies. Voogt and Roblin (2010) conducted a theoretical analysis of existing literature regarding the definition of 21st century skills. They looked at how 21st century skills were defined by different organizations, as well as how organizations recommend that 21st century skills be implemented and assessed. The theoretical frameworks studied were the National Education Technology Standards, the National Assessment of Educational Progress, the Partnerships for 21st Century Skills, EnGauge, and the Assessment and Teaching of 21st Century Skills. The authors reported that the "frameworks seem to converge on a set of 21st century skills (namely: collaboration, communication, ICT literacy, and social and/or cultural competencies, including citizenship). Most competencies also mention creativity, critical thinking, and problem solving" (p. i). A set of 21st century competencies gleaned from this literature review will be used in a survey of Quest Atlantis classroom teachers to see which skills were observed in students as a result of working in the virtual worlds environment.

Research Questions

Researchers contend that immersive virtual environments are highly engaging and present students with chances for deeper learning and problem-solving opportunities not typically found in school classrooms (Arici, 2008; Barab, Arici, & Jackson, 2005; Gee, 2003; Klopfer et al., 2009; Prensky, 2001). This study seeks to answer the following questions:

1. To what degree do the teachers of students who use Quest Atlantis observe 21st century competencies acquisition?
2. To what degree are students engaged while learning with Quest Atlantis?
3. What other benefits do teachers and practitioners see from students working in Quest Atlantis?

Existing data was used to help answer these questions. Fifteen elementary students, ages 9–10, all knowledgeable Quest Atlantis players, were studied in their usual classroom as they worked on virtual worlds genetics missions, facilitated by a trained Quest Atlantis teacher. Students were given pre- and posttests on genetics, their actions were recorded on video, and their cognitive state while working was examined using a Likert-style engagement survey (see Appendix E). A follow-up survey was conducted of selected, experienced Quest Atlantis teachers to discover the degree to which they observe their students exhibiting 21st century competencies as a result of working with Quest Atlantis.

Significance of the research. The research questions position Quest Atlantis as a possible approach for addressing low engagement and learning in general, including lower socioeconomic groups and schools, as a way to reach beyond ineffective drilling and testing, while implementing learning theory research of Brown et al. (1989) and others. Learning theory concepts include personal identity, using tools, cultural connections, and simulating situations (a kind of virtual situated cognition), which lead to deep learning.

Data gathering and assessment is still a high priority for the Department of Education. Included in the recent National Education Technology Plan are references to

differentiated learning, simulations, and social learning. Quest Atlantis gathers data constantly on student performance (an e-portfolio approach), but not in a testing manner that gets in the students' way of learning experiences. Information gathered can then be used to assist in decisions about, for example, the best course to take or the best method to use when approaching low performing schools.

Organization of the Study

The remainder of this study is organized as follows. Chapter 2 is a literature review of student engagement, situated learning theory, the relationship of 21st century competency acquisition by students in virtual worlds, and a review of research on the immersive-worlds learning environment, Quest Atlantis. Chapter 3 describes the triangulation mixed methods design of the study: data collection methods, instruments, the subjects, and timeline of the study. Chapter 4 presents the results and analysis of the data. Chapter 5 presents conclusions, recommendations, and implications for educational game designers and for future research.

Chapter 2: Review of the Literature

"Learning is a deep human need, like mating and eating, and like all such needs it is meant to be deeply pleasurable to human beings." (Gee, 2005, p. 29).

Student learning in K-12 schools has been under scrutiny in recent years, as evidenced by rigorous state and federal efforts to increase achievement through testing and accountability. Educators acknowledge that student engagement is a prerequisite for meaningful learning and achievement to occur in schools, which has led to studies on how, why, and under what conditions students are engaged. As technology use increases in K-12 education to foster student engagement and achievement, one strategy receiving attention in recent years is a computer approach known as the virtual environment. Research has shown that substantial levels of sophisticated learning occurs in commercial style games, and recently, more research indicates the same for educationally designed games with embedded academic curriculum. While studies with elementary students have indicated that engagement is occurring, there has been little in-depth research on engagement as it intersects with social learning in virtual worlds to foster competencies called 21st century skills.

This purpose of study is to examine specific learning experiences of elementary students who are engaged and using 21st century competencies in problem-solving missions while exploring virtual worlds. Other researchers have examined students in virtual worlds (Annetta, Mangrum, Holmes, Collazo, & Cheng, 2009; Arici, 2008; Dede, Ketelhut, Clark & Bowman, 2003; Gee, 2003) and noted positive responses and increased engagement, but this study seeks to extend and add to that research by focusing on the acquisition of 21st century competencies. As the remainder of this literature review will

show, the intersection of engagement, social learning, and virtual worlds can provide an effective approach to learning by increasing student engagement in terms of classroom learning and assessment. As the National Education Technology Plan (2010) states, "Assessment: Measure What Matters" (p. 25). This researcher strives to understand if higher engagement occurs when students practice 21st competencies and are assessed formatively and frequently instead of participating in high-stakes, once-per-year assessments.

Engagement and Learning

While research has been done on student engagement in schools, much of it has been broad examinations of student behavior and time on task, or studies that relate engagement to classroom teaching methods, interest in textbooks, dropout rates, or technology use. It is generally agreed that engagement is critical to the achievement and success of all students (Arici, 2008; Barab, Thomas, Dodge, Carteaux, et al., 2005; Dede et al., 2003; Newmann, Wehlage, & Lamborn, 1992).

This literature review seeks to (a) define the various meanings of engagement, (b) provide a situative learning framework for understanding engagement in virtual environments, (c) define the meaning of the phrase 21st century competencies, and (d) examine the possible benefits to students and schools who are the main targets for reform under the U. S. Department of Education initiatives.

Encouraging Engagement

Engagement in school is thought to be a solution to declining test scores, student attendance problems, quitting school, and lack of effort in the classroom—in short, a fix for many of the missing qualities in students (Fredricks et al., 2004). Creating

engagement in students is, therefore, a standard goal for all teachers. Longitudinal studies of student engagement in early elementary years have shown that problems with engagement can affect achievement over the long term. The Beginning School Study (Alexander et al., 1993; Alexander et al., 1997) showed that the engagement of first grade students was related to achievement test improvement during years 1 through 4, and later decisions to drop out of school (Fredricks et al., 2004). Clearly, then, if engagement is low in early years, and is not positively modified during this time, the subsequent years of middle and high school may be expected to show continuing diminished student achievement.

Finding new methods and materials to foster engagement, as well as upgrading teacher skills to use these new materials and methods, has become an important goal for educators. With the growth of Internet applications and tools, the increase in broadband availability, and the spread of new Internet tools for education, an increasing number of K-12 teachers are expected to incorporate technology into classroom instruction. For each grade level or subject, teachers are increasingly being asked to implement optimal learning experiences (De Freitas, 2008). An optimal learning experience defined by an educator focused on standardized test scores is different than the same phrase defined by an educator implementing a situated learning approach. Optimally engaging experiences are those that connect with the lives of students and have meaning that is embodied (Lave & Wenger, 1991) and in which students can be observed as being in the flow, or lost in their learning experience, much the same way as readers express that they are lost in the reading of a good book. The engagement in a flow situation also works to replicate itself in that, as the participant completes or finishes an experience of flow, the level of flow

(good feeling) can subside, resulting in a participant's renewed effort or search to reestablish the feeling of flow (Csikszentmihalyi, 1990). By contrast, an educator concentrating on raising standardized test scores will position most learning sessions in a decontexualized mode; that is, the content is covered outside the life connections of the student, the result being a nonflow experience and diminished retention of knowledge (Barab et al., 2006; Brown et al., 1989; Lave & Wenger, 1991; Perkins, 1993).

Terms and Meanings of Engagement

The term engagement has been defined in many ways by many different researchers, depending on the context of the study. Engagement may be viewed in terms of functional descriptors such as emotion, behavior, or cognition (Fredricks et al., 2004). Emotional engagement can be thought of as a student's reactions to peers, teachers, and connectedness to the school environment. Emotional engagement might be how a student feels in school—either welcomed by teachers and peers, or feelings of remoteness. Behavioral engagement is considered to be related to dropping out, social activities, and thought to be a critical factor of academic success. Students who act out aggressions or withdraw purposely, or separate themselves from known accepted groups are examples of nonengaged or disengaged behavior. Engagement in terms of cognition relates to a student's inclination and effort toward comprehending and learning academic topics, self-regulating his or her actions, and exhibiting academic strategies. When students are observed exhibiting extended time on task requiring careful thinking and are focused on authentic, meaningful tasks, this, according to Corno and Mandinach (1983), is evidence of engagement. In looking at the definitions here from different studies, a problem of distinction exists because some studies combine emotional, behavioral, and cognitive

engagement, while others may focus on a subset. An engaged, authentic learning situation, as described by Jones, Valdez, Norakowski, and Rasmussen (1994), will include challenging work, immediate feedback, learning choices, and social interactions. Still, there are more ways of defining engagement.

Some researchers have looked at student interviews and data on staying in school or dropping out as a perspective on engagement (Wehlage, Rutter, Smith, Lesko, & Fernandez, 1989). Connell (1990) and Eccles and Midgley (1989) studied how engagement is affected positively or negatively based on individual student needs in a given context. Studies looking at engagement in terms of students' intellectual responses to instruction methods and assigned tasks were done by Newmann (1992) and Newmann et al. (1992). There is crossover in these studies as follows. For example, Eccles and Midgley's study did not address drop out potential, but looked at similar variables as did Finn (1993). On the same line of reasoning, Newmann's observations of intellectual responses were done in similar environments as Connell's examination of student needs compared to context. These overlaps are pointed out to show how engagement is clearly not an easily defined concept among educators and defining it can be highly dependent on what the researcher seeks.

Learning Theory Framework - Situated Learning

Researchers examining situated cognition (Arici 2008; Brown et al., 1989; Klopfer et al., 2009; Lave & Wenger, 1991) have argued that a major reason for student dissatisfaction in schools and why students may perform below expectations is partly because the curriculum is disconnected from their lives. Gardner (1999) points to years of research showing that although students may score acceptably in a curriculum designed

for testing, they remain operationally disconnected from the topic areas and show little success in putting the knowledge to real use. In other words, many classroom skills acquired, based on a rote approach, fail to transfer to real life, especially in Gardner's research, which points toward a lack of matching of learning styles with one-size-fits-all classroom approaches.

According to situated cognition research, the disconnection lies in the compartmentalizing or separation of curriculum content apart from the situations or context in which that content would normally be used. The researchers argue that meaning is lost in this decontextualization of content—ultimately engagement, learning and student achievement are minimized (Barab et al., 2006; Brown et al., 1989; Lave & Wenger, 1991; Perkins, 1993). In an effort to find ways in which to reconnect content with context, there is growing interest in the study of virtual environments, which are thought to stimulate engagement in academic learning (Gee, 2003) while immersing students in situations for distributed cognition. Greeno, Collins, and Resnick (1996) concur with Gee from a constructivist point of view; it should be recognized that students have natural tendencies to be engaged in learning when the environment is conducive, and by contrast, a diminished tendency in a less conducive environment. Why do students pursue some activities? Intrinsic motivation to pursue an activity, according to Malone (1981), is evident when students engage in it for its own sake, not for external reasons such as grades. In addition Malone indicates that intrinsically motivated students are more likely to concentrate longer on the activity, and to transfer what they are learning to uses beyond the activity, demonstrated in their real lives.

Dede's (2009) work concurs with Malone (1981) on the transfer and usability of knowledge, and agrees with Barab et al. (2006) and Arici (2008) that intentionally designing immersive experiences that are situated in activity, the human senses, and symbolism can increase the participant's feeling of presence, of being in the virtual setting, and interacting with its characters, its challenges, and its rewards. Dede (2009) extends the case for immersion in digital environments for deeper learning to include the idea of multiple perspectives: learning that is enhanced when a student is able to change his point of view or frame of reference at will. This can be accomplished by seeing an object or location from the inside, such as a village in a virtual world, or viewing that same object or location from a distant point in the virtual world, which additionally speaks to the idea of distributed knowledge located throughout the environment, available for exploration and choice, rather than the being isolated in prearranged lessons. The student has control of what lies ahead, can change direction, and can adjust progress - opportunities not found in a regular classroom situation.

Gee (2003) uses the term semiotic domains to describe an area in which a learner achieves, as a result of his or her immersion and engagement, a level of mastery among a number of related and associated concepts or knowledge areas. He describes a semiotic domain as "a set of principles or patterns in terms of which materials in the domain are combined to communicate complex meanings" (p. 1). The semiotic domain is not one of rote memorization, but one of meaningfully synthesized concepts and skills that a learner can freely use in the activity of the domain. Gee points to examples such as literary criticism, biology, theology, advertising, modernist painting, midwifery, and video

games. In any of these, the participant is situated in a combination of culture, language, experience, identity, and participation on different levels.

Arici (2008) agreed with Gee's (2003) and Corno and Mandinach's (1983) arguments regarding engagement as a phenomenon of sustained attention, but Arici (2008) added that engagement "extends beyond cognitive boundaries, and includes additional elements such as play and even altruism" (p. 41). Arici ties engagement to the notion of embodiment of the student's experiences while in a virtual learning world in which a student speaks of actions completed on a computer with avatars, as though those actions and their associated emotions were enacted in the physical world. In Arici's observations, she reports that students felt they had played, worked, and helped others in the virtual world of Quest Atlantis, as though they were there. Being in the virtual world was real to students, like a lived-in place, a situation for context and content to come together. Engagement was obviously happening, but it was not clear what effect the engagement had on learning, specifically on abilities called 21st century competencies.

Virtual Worlds Versus Test-Based Computer Games

How students interact with computer technology and especially with video games has attracted the attention of many education researchers and writers in recent years (Arici, 2008; Barab, Dodge, Thomas, Jackson, & Tuzun, 2007; Gee, 2003; Ketelhut, Dede, Clarke, Nelson, & Bowman, 2007*;* Laurel, 1998; Lucas & Sherry, 2004; Prensky, 2001; Shute & Torres, in press; Woodard & Gridina, 2000). At Indiana University, researchers and designers (Barab, Dodge, Thomas, et al., 2007) have taken this interest forward in design research with the creation of their educational virtual world called Quest Atlantis. The educator-researchers who designed Quest Atlantis were interested in

making a virtual world that took advantage of kids' attraction to video games, while facilitating differentiated learning and empowerment. Included in the goals were ideas to use a multiuser environment in which students worked on missions in social commitment scenarios designed to help them value their communities and understand that they have meaningful ways to contribute to their communities, and to their world, to develop global awareness. By providing a context of community and purpose first, the researchers then had a structure in which to begin integrating knowledge, skills, and competencies.

In another educational virtual environment called River City (Ketelhut et al., 2007), researchers embedded academic content in a science-based virtual world. Both Quest Atlantis and River City were introduced into pilot schools, offering opportunities for students and teachers to experience the new learning worlds, while providing researchers with easy access to user data. Data gathered from student interactions shows students consistently communicated on topics related to actions or doing tasks, as well as on communications focused on conversation and issues in social relationships (Arici, 2008; Ketelhut et al., 2007). They were talking to each other while they were doing science tasks and internalizing science concepts—and doing so in a combination of electronic communication and face-to-face conversation.

In recent years, as schools have felt pressure to focus on test scores, most computer usage in labs and classrooms has been in the form of practice and drill programs designed to support facts and sequential skills (Jonassen, 1988; Klopfer et al., 2009; Prensky, 2001). Drilling software is vastly different from recent virtual-world designs that utilize simulations, rich graphics, detailed narratives, interactive characters, changing consequences per user input, embedded academic content, and have the social

network component of multiple users on the Internet, as opposed to a stand-alone local computer installation. Klopfer et al. (2009) have written about the overwhelming appeal of virtual games as compared to the static, sequential nature of educational drilling software. Clearly, virtual worlds are more thought provoking, more engaging. Virtual world environments present a completely different experience than the stand-alone computer learning programs typically installed on school computers for drill and memory retention. Testing-based, drilling software programs concentrate on step-by-step repetition, repeating and quizzing on previous patterns, and are usually figured out quickly by elementary students. For example, students running a stand-alone math or science program are generally interacting with preset screen order, simple multimedia feedback, and multiple choice functions. This is a nonsocial interaction of a student with an isolated machine.

Other examples of Internet-based virtual worlds not designed for school-based education, but that are highly popular among elementary students, are member Web sites such as Club Penguin and NeoPets, both evidence of young students' attraction to virtual-world communities. These virtual worlds are considered typically just playing and, therefore, not found as a part of classroom learning. Clearly, virtual worlds offer something completely different: they offer a sense of place, of new worlds to explore. They offer a venue in which many users from multiple locations are in-world actively exploring, moving about in virtual spaces, involved in scenarios, and all while assuming new identities, socializing, manipulating a personal avatar, solving problems, helping each other, and making choices that affect the direction and outcome of the game.

Educators have mixed responses as to the usefulness or appropriateness of games. However, research indicates that participation in a virtual gaming environment aligns with constructivist-based learning: it offers students opportunities for trial and error experimental learning in real time and at a pace of their choosing (Annetta et al., 2009).

Researchers also argue that video games are an excellent medium for formal academic education using situated learning theories (Arici, 2008; Barab et al., 2006; Barab, Thomas, et al., 2005; Squire, DeVane, & Durga, 2008), and video games can provide effective informal learning (Annetta et al., 2009; Gee, 2003). In a situated learning instance, a person interacts with content as it is used in a given context, which differs from traditional schooling in which content is delivered outside of a meaningful context.

Dickey (2005) argues that students are engaged in games because of "role playing, narrative arcs, challenges, and interactive choices within the game, as well as interaction with other players" (p. 1). Role playing takes the learner beyond himself or herself and into a kind of participation that allows for being in a new identity, which is especially true in virtual worlds when students interact with the virtual environment through a personal avatar. The new identity, in an educational perspective, can place the learner in a context where he is the scientist, the mathematician, the artist, the writer, the traveler, the detective, and so forth. Lave and Wenger (1991) view this identity as part of legitimate peripheral participation, a changing learner's role among various levels of expertise from novice to expert. Barab, Zuiker, et al., (2007), Arici (2008), and Soderberg and Price (2003) have addressed the identity concept as key to deeper learning, an

approach where students can virtually become people in realistic situations in the acts of problem solving, socializing, and sharing knowledge.

Other researchers (Gee, 2003; Van Eck, 2007; Vandeventer & White, 2002) argue that video games do more than just motivate, they help foster specific content acquisition and skills needed in real-life situations. Gee (2003) argues that learning in a gaming situation provides a practice field that is not normally seen in a school classroom: "Learners can take risks where real-world consequences are lowered" (p. 207). Land's (2000) arguments for using a blend of learning methodologies aligns with the gaming model because the player is central in the environment and a main actor in the construction of meaning.

Commercial multiuser virtual worlds games such as World of Warcraft and Final Fantasy are well known among video game players and are also recognized by researchers as having significant learning benefits (Gee, 2003), but these virtual-world examples have not been generally accepted in schools as viable methods for K-12 teaching and learning because of the use of weapons, violent character interactions, and inappropriate language. The dynamic aspects of video games make them ideal interactive learning environments, complete with narrative, challenges, characters, tools, and collaboration with peers. In sum, the engaged learner, using a well-designed video game, is demonstrating the high-level skills expected of a successful student (Squire et al., 2008).

Educational Virtual World Environments

To go beyond the perceived noneducational aspects and to highlight the learning aspects, some educator-researchers have worked with designers and virtual world

programmers to create environments designed for education. Their ideas incorporate academic content, develop collaboration skills, appeal to students socially, and allow new forms of learning while engaging students to take on challenging, meaningful work, and while practicing collaboration. Barab, Thomas, Dodge, Newell, and Squire (2004), with the Quest Atlantis Project at Indiana University, and Dede et al. (2003), with the River City Project at Harvard University, are in the forefront of educator-researchers who are embedding academic content, based on distributed and situative learning theory, into multiuser virtual environments for student engagement and learning.

Harvard researchers (Dede et al., 2003) concur with Gee (2003), Van Eck (2007), and Shute and Torres (in press) in studies of student interactions in a virtual science environment called River City. The development team for River City utilized the talents of education researchers, instructional designers, computer programmers, museum archivists, graphic artists, scientists, and middle school science teachers from public and private schools. The structure and approach of River City was based on media similar to what was already engaging students outside of school. In process with River City, Dede et al. (2003) turned their attention on,

> …students [who] are disengaged from schooling and typically are difficult to motivate even by good teachers using inquiry-based pedagogy. We are studying whether educational MUVEs with deep content and challenging activities that resemble the entertainment and communication media these students use outside of school can reengage them in learning. (p. 2)

Quest Atlantis is of prime concern to this study because, different from River City, which is not currently in a developing mode, Quest Atlantis is an ongoing research design

project that is growing in its distribution in schools in the United States and in other countries. As a research design project, current data from installed school sites are constantly being examined by educators, programmers, and designers at Indiana University to advance and improve the experience for effective student learning. The existing data for this study came from interventions done by researchers specifically to inform the quality of the developing Quest Atlantis program.

Quest Atlantis: Details of the Learning Environment

Quest Atlantis is a research project focusing on learning and teaching. It is a virtual environment designed for students, ages 9 through 16, and is available from Indiana University's Learning Sciences Department on the Internet at www.questatlantis.org. Figure 2 displays the opening screen of the Quest Atlantis Web site. It provides access for educators, students, and interested parents to download the program and learn about Quest Atlantis. In contrast to commercial games, Quest Atlantis offers an overview of the program, related text materials to download, links to educational research papers, and connections to related educational resources intended for continued teacher collaboration and learning (Barab, Dodge, Thomas, et al., 2007).

Figure 2. Introduction screen of Quest Atlantis.

Quest Atlantis, though referred to as a game, is a multileveled program with different entry points and user interfaces for students and teachers. The program is currently in use on six continents by teachers and students in Norway, Croatia, Canada, New Zealand, Israel, Australia, Italy, Turkey, China, Denmark, Britain, Japan, and the United States - the number of users is estimated to be more than 60,000. The project is based in the Learning Sciences department of the School of Education at Indiana University, and has received funding from the MacArthur Foundation, National Science Foundation, NASA, Institute of Educational Sciences, BIOGEN, and Food Lion. Most recently, in December 2010, the Bill & Melinda Gates Foundation provided a grant of $2,366,734. To address perceptions of declining student achievement, a stated goal of the grant was to attract students who are disengaged with regular classroom situations, and to

offer them engaging experiences in literacy, science investigation, and math. Additionally, outcomes were identified that aim at the following: common core standards, a teacher software toolkit, teacher professional development modules, studying results in classrooms, producing publications on results, and investigating commercialization and sustainability of the Quest Atlantis program (Quest Atlantis: QA Grant Support, n.d.).

Quest Atlantis in schools. Quest Atlantis requires that classroom teachers complete a training course, online in the virtual world, before they can install the program in their classrooms, add students to the roster, and begin instruction. Teacher training in Quest Atlantis is a four-class session. Teachers go online and meet as avatars in a training area called Teacherville. The teacher instructor conducts a demonstration of navigation, using menus, chat screens, telegrams, and setting up home pages. Teachers are shown links to comprehensive documents that describe the narratives into which missions are designed, and also the academic content and competencies that students will practice. Teachers are shown that missions are laid out in full, step by step, listing what students will have to do in order to complete a set of tasks. Students are involved in decision making, scientific experiments, collaborating to solve public problems, entangled in dilemmas, asked to deal with bullies, and many more examples in which their critical thinking abilities are challenged. In subsequent classes, teachers are shown how to use the Teacher Toolkit to enroll students, to obtain student permission forms, to assign missions, and to provide meaningful formative assessment-feedback on student work. Teachers are encouraged to become part of an ongoing community in which they can join a special blog and wiki for ongoing discussions, sharing, and questions. As teachers

develop more expertise and technology skills, some become trainers and extend the community. All students and teacher participants become part of the design research process and sign Institutional Review Board releases in order to use Quest Atlantis in school or homes (Barab, Dodge, Thomas, et al. (2007).

The designers leveraged commercial role-playing gaming formats to make learning spaces, in what they call a metagame context, without violent interactions, positioning students in identities where they manipulate content in real contexts by being scientists, writers, recyclers, counselors, artists, and other responsible roles. Quest Atlantis is based on a set of research-based core components: a multiuser virtual environment, a background narrative, story-embedded social commitments, units and missions facilitated by a trained classroom teacher, and an avatar interface in which a student's abilities and knowledge evolve within the world as missions and quests are experienced. Students learn the backstory of Atlantis through an animated video before beginning any of the missions. The power of engaging storytelling is leveraged throughout the design of Quest Atlantis, and the designers have referred to the experience as a playable fiction. Students interact at deeper levels of understanding in focused situated learning as they become part of the story (Barab, Dodge, Thomas, et al., 2007).

When they login, students and teachers arrive in the virtual world at a common location know as Emissary Island, where default-prompted actions guide participants toward learning how to navigate and understand this new world. Through a personal avatar, students navigate virtual villages and natural settings and communicate with other students as well as with scripted nonplayer characters. For example, Lara the Fairy helps new students begin the process of being in the virtual world. Lara welcomes the new

students using text screen conversations. The new student, in avatar form, is given directional coordinates (seen at the top of every screen) to go talk to a gnome named Maq in his tower. Maq picks up the where Lara leaves off and explains the backstory of Atlantis, describes a special group of characters called Emissaries, and sends the new quester off on the first mission. Choice is important in Quest Atlantis. When Maq sends a quester to find Sam, the quester uses a special machine and is offered choices of what to do next. The design of Quest Atlantis is such that the actions and choices of students determine the consequences of their journeys and adventures in the virtual world (Barab, Dodge, Thomas, et al., 2007).

During the orientation to the virtual world, students have the option to choose skin color and clothing for their avatar, the first step in asserting a new identity. As part of existing in this new world, students are shown how to use the directional guides at the top of each page, how to teleport to different worlds, and gradually as they progress, they go through the process of completing missions for which they receive lumins for successful efforts. Lumins are part of the backstory and represent the acquisition of competencies and understanding in the seven social commitments: compassionate wisdom, creative expression, environmental awareness, personal agency, healthy communities, social responsibility, and diversity affirmation. A special ceremony occurs each time a quester gains enough lumins to luminate in that particular social commitment. The more lumins a quester accumulates, the more his or her understanding and abilities and knowledge grow. Compete teacher instructions and information on getting started and using Quest Atlantis are located on the Indiana University Web site (Quest Atlantis: Home Page, n.d.).

Global awareness in the virtual world. Students, often referred to as questers once they begin their journey in the virtual world, are not only in this world with the rest of their classmates, they are in a space that is populated by students and teachers worldwide. As described earlier, users from six continents have accounts in Quest Atlantis. This means that students from Missouri can encounter students from California or just as easily from England or Japan. This adds yet another dimension to this virtual world—besides completing activities that require critical thinking, problem solving, creativity, empathy, and collaboration, questers can communicate with other questers from around the world. This is made possible through the text screen at the bottom of the main display, and also through a mechanism called Telegrams. Questers can find other user names in a common list and send telegrams to those users to inquire how to find a particular landmark, to seek help in answering a questions, or just simply to greet a new friend.

Experiencing specific content. This study is concerned with student learning. Content knowledge has been the major focus of testing in schools, but the education experts who authored the National Education Technology Plan (2010) concede that content is not enough. Learning is a complex phenomenon; it includes more than just exposing a person to facts and expecting those facts to be retained. Deeper learning requires connections among the learner, the context of the learning, and the content of the learning (Brown et al., 1989; Gee, 2003; Lave & Wenger, 1991).

Most fourth grade students are unlikely to understand the biological processes and gene activities foundational to the creation of color and size in the reproduction of organisms. Existing data on students in Quest Atlantis describe how they were invited to

take on the identity of a scientist, and to complete tasks that involved learning how to use scientific tools and concepts in order to breed virtual dragonflies of a specific size and color, and to understand the probability of such occurrences given the starting elements; that is, the characteristics of the mother and the father. Students began the quest by teleporting to a virtual world called Healthy World, and there they were asked to locate certain characters at specific directional locations. The students were experienced Quest Atlantis players, so teleporting and navigating in virtual worlds was already a competency they possessed. As the mission progressed, the students talked with Dr. Uther, Dr. Selina, and Ekon as they learned about genetics and breeding dragonflies. The nonplayer characters helped tell the story, and offered choices and tasks to students who moved throughout the environment delivering packages, collecting dragonflies, using mating tanks and genetics machines, and solving complicated trait matrices called Punnet Squares to produce specific genotypes of dragonflies. Figure 3 shows the Punnet Square tool for designing a specific dragonfly offspring.

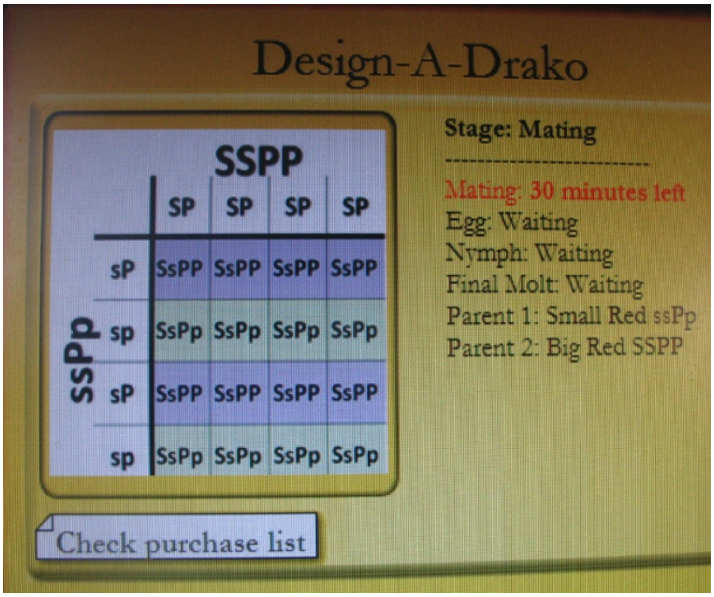


Figure 3. Punnet Square for parent dragonflies.

For example, Dr. Uther might ask a questing student to match dominant and recessive characteristics among red and blue dragonflies to produce at least one small blue dragonfly. In the process, students were involved with cloning, natural breeding, and finding cures for diseases. As tasks were completed, students were asked to submit written responses and descriptions of their activities. In exchange for a successful response, students were awarded a form of in-world money called cols and were also awarded lumins, which are associated with the seven social commitments. Stories and missions in Quest Atlantis are based on these commitments, as listed earlier, which are: (a) creative expression, (b) diversity affirmation, (c) personal agency, (d) social responsibility, (e) environmental awareness, (f) healthy communities, and (g) compassionate wisdom. As students made in-world choices, they charted pathways within the narrative, and their individual learning trajectories began to unfold, a design feature intended to allow players' actions to have consequences on the environment as well as on their own learning. By their actions having a consequence, the students could understand that what they did had an effect on the world and on what happened next in their own experience. Students were reading for meaning, comparing ideas with other students, socializing via texting and telegrams, deciphering puzzles, operating scientific machines, making choices based on time and resources, and writing and reflecting on the content and meaning of each mission using response screens.

The importance of teachers. Many classroom computer games are intended for isolated student interaction; that is, the student goes to the computer and runs through the program working on usually rote content related to testing objectives. The interaction with these programs is unchanging: students start the same, the path is the same, and the

rewards and output are the same. For such skills practice games, the teacher is rarely needed, as the game outputs a score or numeric assessment of some kind. If this drilling process is repeated again and again, it is hard for one to conjure the image of an engaged student. Rather one might see a mechanistic sequence played out repeatedly—perhaps some content might be learned, but the conditions for learning in this situation are far from optimal (Gardner, 1991; Gee, 2003; Klopfer et al., 2009; Shute & Torres, in press). On the other hand, in a Quest Atlantis classroom, the teacher maintains prime importance. The teacher is both administrator and peer learner in this situation. Missions, quests, and special selections of units are all done by the teacher using the teacher toolkit as displayed in Figure 4. The teacher toolkit is the main point of program interaction for the classroom teacher. Teachers are trained in the use of the toolkit prior to starting their own Quest Atlantis classes. With this dashboard style interface, teachers have access to all of the documents, help screens, rules, and available missions. Student names are listed in roster format and teachers can quickly see the progress of each student. The toolkit also provides the teacher with notification when students have submitted input to their missions. It is the teacher's job to read each submission, similarly to how a teacher might read a traditional classroom assignment, and then to comment on the student's work. At this point, the teacher has the power to accept the work as well done and appropriate, or to click the Revise button, which sends the submission back to the student for corrections. With each accepted mission, students receive lumins, a running account of which is displayed on their home page.

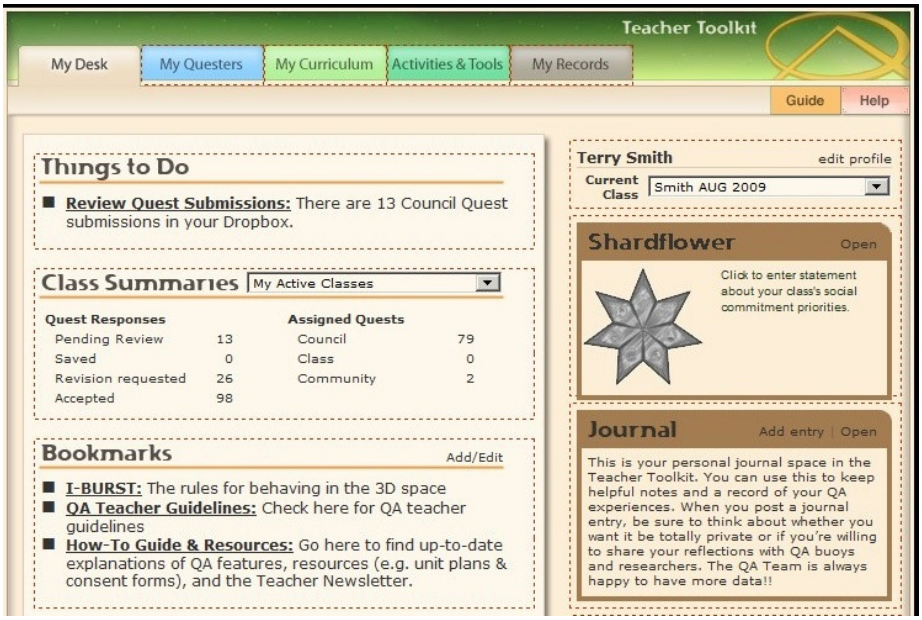


Figure 4. Quest Atlantis teacher toolkit.

Note that in Figure 4, there are 13 submissions awaiting review. The teacher must read this work and respond accordingly, which is an opportunity for the teacher to communicate and model constructive criticism in an online communication format with the student. Additionally, the teacher has ready access to the rules of behavior in the virtual world, known as the I-BURST; the teacher guidelines; and the various guides and resources for teaching in this virtual world (Quest Atlantis: Home Page, n.d.).

In the day-to-day Quest Atlantis classroom situation, different students are working on different missions. Student A might be on a character education mission, student B on a water quality mission, student C working on a recycling campaign, and student D calculating the genetics of dragonflies. The classroom teacher has selected and assigned all of these activities and is responsible for checking and responding to input from the students on their respective missions. For teacher and students, this is a substantial departure from a typical classroom scenario in which all students normally complete the same assignment, in the same time frame, and are graded and returned by

the teacher. In a Quest Atlantis classroom, differentiation is the norm, students are pursuing academics along personal choice lines, and the teacher adapts to the overall work flow. The adaptive disposition of the teacher changes how the teacher approaches the students; that is, since the teacher cannot easily know what every student is doing at every instant, the methodology of assessment is changed. An air of mutual trust is inherent in the classroom; teachers interact conversationally, probing for details and progress, and assessing anecdotally while learning alongside the students. In this teacher-student environment, barriers fall away as teacher and students converse in the manner of peers, finding their way through a challenging puzzle together, and building a different kind of relationship based on shared experiences and discussions. The Quest Atlantis teacher is significantly different than a traditional teacher in how technology is used to assign and assess, how students interact in a more exploratory-project fashion with teacher and peers, and how the classroom environment invites collaboration, socializing, sharing, and helping, all of which contribute to a more engaging school experience (Barab, Gresalfi, Dodge & Ingram-Goble, 2010).

Examples of Student Engagement in the Virtual World

"There is simply no other way to engage students as virtual reality can" (Sykes & Reid, 1999, p. 11).

In Arici's (2008) study of elementary students using Quest Atlantis, she provided a view of student engagement in a virtual world she describes as one that "shares the genre of video games, computer games, simulations, and other immersive and interactive contexts" (p. 15). The students were seemingly naturally attracted to the environment. To study student engagement in this instance, she used a tool based on Csíkszentmihályi's (1990) study of what he called flow. The idea of flow can be thought of as that condition

when a person is involved with a problem or challenge to such as degree that the outside world may seem to fade away, as he or she is totally immersed in the current experience.

Comparing virtual worlds to traditional methods. Arici's (2008) study involved two groups of elementary students working on an inquiry science unit focusing on water quality. One group was described as a traditional classroom curriculum using textbooks, lecture, and activities, while the other group used a Quest Atlantis mission with which students entered the virtual world to explore, gather data, and reach conclusions about water quality. Arici (2008) states that the student group using the virtual world "had deeper engagement, higher learning, and sustained memory over time" (p. 146). While the study showed that Quest Atlantis enhanced engagement in a general group of students, it did not address 21st century competencies.

Virtual Worlds: Reaching Low Performing Students

This study called attention to how students can be deeply engaged in virtual world activities and reap a variety of significant learning experiences from their immersion (Arici, 2008; Barab, Thomas, et al., 2005; Dede et al., 2003; Gee, 2003; Prensky, 2001; Shute & Torres, in press; Strangman, Hall, & Meyer, 2003). The relevance of the student experiences in terms of current perceived inadequacies and failing schools is our next area of interest for this study. Efforts continue nationwide to address low performance, low engagement, and low test scores by a combination of competitive (Race to the Top) and punitive (No Child Left Behind) initiatives from the U.S. Department of Education. In addition, a major effort is underway in a majority of states to establish common core standards. A long line of education experts such as Bracey (2009), Gardner (1999), Kohn (1992, 2000), Kozol (2007), Ohanian (1999), and Papert (1980) have analyzed the

standardized testing approach, pointing out what they saw as the negatives, the inappropriateness to learning, the harm to students and teachers, the overextension of the Federal government, the over focus on worldwide student competition, the waste of billions of dollars to manage a test-driven environment, and the decline of education in general as a result of testing. Amrein and Berliner (2002) concur, citing the Heisenberg Uncertainty Principle: "The more important that any quantitative social indicator becomes in social decision-making, the more likely it will be to distort and corrupt the social process it is intended to monitor" (p. 5). The over focus on testing has resulted in a diminishing of environments conducive to learning by stripping away important experiences that have been deemed lower priority because they are not targets of high-stakes testing, and therefore, not as valuable. On this phenomenon, Henry (2007) calls attention to the fact that on average across the United States, 71% of schools have made cutbacks in time allotted for physical education, fine arts, and music in order to create time for test focus in math and reading.

Experts who stand opposed to a testing mentality do not argue the fact that schools need some kind of reform. Schools are operating on guidelines that fit past needs, not needs of today and requirements of the future. Identifying the majority of school locations and populations is also not a matter of disagreement between those who see testing as the answer and those who see testing as ineffective and wasteful. We know that low performing schools are overwhelmingly found in areas of poverty and economic decline, among diverse populations, where expectations for students are typically low, that school facilities are in poor physical shape, and staff are too often teaching in areas for which they are not certified (Doherty & Abernathy, 1998). Not only do schools in so-

called lower-class environs have significantly poorer conditions, but measurements of achievement in these schools continually fall well behind measurements of students in higher-class situations (Willms, 2003). As stated earlier, Willms (2002) called this phenomenon double jeopardy to describe the situation of low socioeconomic students who also attend schools composed predominantly of low socioeconomic populations. Looking back to our earlier discussion of engagement, Willms found that there is a much higher probability of these double jeopardy students being disengaged and showing resultant low performance in school. Because engagement is connected to activity level, concentration, and student performance, increasing engagement can potentially lead to improvements in these areas (Finn & Voelkl, 1993; Fredricks et al., 2004; Willms, 2003). We know that in these low-performing schools, the downward trend in achievement is observable at all grade levels, even down to warning signs appearing in the very early grades (Alexander et al., 1993; Alexander et al., 1997). Bracey (2009) calls out the connection between low socioeconomic students and assessments as follows:

> The strong relationship between poverty and test scores seen in the PIRLS [2001 Progress in International Reading Literacy] data are replicated in the Scholastic Achievement Test (SAT), in the Trends in International Math and Science Study (TIMSS), and in the National Assessment of Educational Progress (NAEP). (p. 2)

Current testing methods and affected groups. In short, we know there are serious problems in education, and we know basically where those problems are to be found—largely and significantly among low socioeconomic populations. The common scale for rating student performance on standardized tests across the United States is as follows: Below Basic, Basic, Proficient, and Advanced. Every student receives a ranking

in one of these categories associated with math and reading, and in some states with science and social studies. As schools seek to avoid the punitive measures of not meeting Adequate Yearly Progress, they logically focus energy on the students whose low test scores could be raised just enough to go from Below Basic to Basic. Efforts to raise test scores then are aimed squarely at low socioeconomic populations. This means practicing, tutoring, and drilling for those borderline students, the group for which test scores could mean the difference between meeting Adequate Yearly Progress requirements and punitive, negative measures taken against the school, the teachers, and principal for not meeting the requirements. This kind of policy is not only ineffective, but is destructive on the low socioeconomic populations more so than on any other population in America (Amrein & Berliner, 2002).

If we align with Amrein and Berliner (2002) and accept that low socioeconomic groups are, even though unintentionally, being harmed even more by current policies, what then is an option for improvement? If drilling and practicing for tests is not the answer, then in what learning improvement activities should all students be engaged? Bracey (2009) writes that we need look no further than the school where the current president's children attend. Sidwell Friends School operates using interdisciplinary studies, inquiry and problem solving, and promotes learning that addresses the whole child. It encourages artistic expression, provides opportunities for collaborative scientific investigation, fosters an attitude of serving others, and values individual choice. It is upon examining the Sidwell Friends School and the educational approaches there, that we can make the connection to the competencies that result from the experiences at this school to

the competencies needed by all students: creativity, communication, critical thinking, collaboration, problem solving, and awareness of others in the world.

Changing Focus at the Top: National Education Technology Plan

In a classic dichotomy, the U.S. Department of Education maintains a dual position on education recommendations and initiatives. On one hand, it promotes test pressures, punishments, and reconstitution of schools with its mentality of raising the bar and enforcing test scores. On the other hand, in a stroke of innovation, it has recently released a major educational document, a framework positioned in 21st century competencies, which makes the claim for something entirely different than concentrating solely on standardized testing. The National Education Technology Plan (2010) clearly references learning research and the idea that educators should "measure what matters" (p. ix). The National Educational Technology Plan references the work of Vendlinski and Stevens (2002), stating:

> Through multimedia, interactivity, and connectivity it is possible to assess competencies that we believe are important and that are aspects of thinking highlighted in cognitive research. It also is possible to directly assess problem-solving skills, make visible sequences of actions taken by learners in simulated environments, model complex reasoning tasks, and do it all within the contexts of relevant societal issues and problems that people care about in everyday life. (p. 26)

In a section titled "What We Should Be Assessing," the NETP refers to measuring complex thinking competencies based on cognitive research. It discusses combining research in learning theory with technology applications. Virtual environments are

referenced in regard to understanding how students communicate and learn while immersed in a virtual world based on the work of Dede (2009), who contributed to the NETP. As described earlier in this study, Dede and others created a virtual world called River City designed for studying and understanding science concepts. Students were empowered with the identity of a scientist and given the challenge to conduct scientific investigations in the virtual world. Such simulated explorations and simulations focus not on basic skills, and not specifically on testable standard concepts, but instead place the student in a practice situation. Competencies are practiced as the students make progress in the virtual world, so that a kind of embodied cognition can take place, a form of learning that is based on interacting with the artifacts and conditions of the lived-in world (Lave & Wenger, 1991); however, this is a virtual world.

Students and assessment. Clearly, as described in the NETP, the ability to simulate educational environments and experiences, to place students in roles in which choices are available, and with which students largely direct their own learning paths can be a viable route to engaging experiences, then to increased student achievement. In a virtual world, where data can be gathered constantly on the student work, assessment can take on a new form, perhaps one that is less intrusive and more in line with the process of learning. Typical standardized testing assesses summatively; that is, it measures what is perceived to be learned at an end point. However, a virtual world, with constant data gathering, can enable educators to do more formative assessments, which allows for adjustment, review, and guidance toward a desired success during the learning process. In addition, a virtual world offers another advantage, one that addresses the needs of those students who might not be as vocal as other students; teachers have the ability to see what

all students are learning by observing the work captured by tools in the virtual world (Gee & Shaffer, 2010; Shute, 2008).

Reaching a wider range of students. The range of students able to interact with content is broadened in the virtual world—physical handicaps can become invisible as students move about as avatars climbing, running, swimming, teleporting, and building 3-D structures. Peer teams of varying academic abilities can work together, allowing for differentiated learning, much as learning buddies work together in traditional classrooms. The NETP (2010) states using the virtual environment to learn requires "rethinking the use of time-based measures of attainment rather than competency-based measures" (p. 46). The NETP calls for using the Universal Design for Learning (UDL) principles, not only to challenge diverse learners, but to supply learning situations that tap into their interests, and that can lead to improved outcomes. UDL is typically defined as a departure from one-size-fits-all curricula, instead being an approach to allow multiple forms of expression by students thereby addressing many learning styles as well as many variations in mental and physical ability. Ways that can accomplish this, according to the NETP, include providing choices among different learning scenarios each of which promotes competencies instead of only factual knowledge. The UDL principles promoted in the NETP are:

- "Provide multiple and flexible methods of presentation of information and knowledge.
- Provide multiple and flexible means of expression with alternatives for students to demonstrate what they have learned.

- Provide multiple and flexible means of engagement to tap into diverse learners' interests, challenge them appropriately, and motivate them to learn" (p. 18).

Student engagement can be increased by providing options, for example, to choose virtual world locations in which they explore, undertake missions, and interact with content in a situated context; in other words, demonstrating competencies while manipulating content.

Strangman et al. (2003) concur with the UDL concepts outlined in the NETP, particularly in relation to meeting the needs of students by removing barriers to instruction for at-risk students and students with disabilities. A major advantage of a UDL combined with virtual-worlds learning is the same as recurs in the work of many other researchers—that students have the ability to go beyond limitations of the classroom, limitations of themselves, and explore and operate in a wide variety of environments (Arici, 2008; Dede, 2009; Gee, 2003; Gee & Shaffer, 2010; Klopfer et al., 2009; Shute, 2008; Shute & Torres, in press).

Competencies of the 21st Century

Strangman et al. (2003) wrote:

> The introduction of virtual reality and computer simulations into the classroom will greatly improve teachers' ability to offer choices of content and tools because their nature is so vastly different from those typically made available in the classroom. The non-print, interactive, multi-sensory, 3-dimensional, and in some cases hands-on nature of these tools can be highly engaging for students. (p. 17)

The standardized test movement in recent years has focused on those skills that most easily lend themselves to testing, which are facts and knowledge. Facts and knowledge, the lowest level of Bloom's taxonomy, are easy for testing companies to convert into booklets of multiple-choice and short-answer assessments. Every question is closed; that is, students will be correct or incorrect in most instances of standardized testing assessments. And as educators continue to define the successful student by test scores, a sizeable population is not represented—the low-performing population. There are many societal conditions that have a serious impact on students' learning, and current political efforts to raise the bar, increase the standards, toughen the rigor, and so forth have had little effect (Bracey, 2009).

Identifying what should be assessed. The NETP, released in November 2010, takes a different course than is typically associated with the U.S. Department of Education and its continuing focus on standardized testing. The term 21st century skills is used throughout to place emphasis not only on content, but on competencies; that is, on what students can do in specific circumstances. Ladwig (2010) has referred to competencies as the critical nonacademic outcomes students need. A recent study of the literature on 21st century skills (or nonacademic outcomes) by Voogt and Roblin (2010) reports a variety of sources and definitions for what 21st century skills means. The report synthesized information defined by different organizations, as well as how organizations recommend that 21st century skills be implemented and assessed. The authors examined theoretical frameworks including the National Education Technology Standards, the National Assessment of Educational Progress, the Partnerships for 21st Century Skills, EnGauge, and the Assessment and Teaching of 21st Century Skills. The authors' analysis

found that ideas clustered around similar phraseology of 21st century competencies, which included technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness. Social skills development was assumed within the other skills. Implementation recommendations of 21st century competencies by these organization also converged into areas of "(a) curriculum and instruction; (b) professional development; and (c) strategies and conditions for the implementation of 21st century skills at both the national and school level" (p. 27). The frameworks that were examined all pointed to needs for significant changes in how curriculum is designed in schools. Ideas across the frameworks call for new ways of assessing and new ways of teaching. These competencies of the 21st century can best be supported if our institutions begin favoring methodologies such as project-based learning and experiential learning, and rely more so on assessment principles that are formative instead of summative. Addressing the role of the teacher, the study found expectations of teachers beyond teaching 21st century competencies. Not only are teachers expected to assess these skills, but teachers are expected to be familiar with these skills and competencies and to demonstrate them as part of their ongoing practice. Finding strategies and methods for modeling and implementing 21st century competencies should be part of the professional development of teachers if students are to acquire these competencies (NETP, 2010).

Dede (2010) clarifies the term 21st century skills in terms of what people need to function as citizens, to be productive members of a changing economy, and to interact with a variety of socially networked entities. Old skills, which may have relied on individual ability, are diminishing and disappearing while collaborative-based competencies are needed more and more (Karoly, 2004). K-12 teaching methods that

treat knowledge as matter to be delivered in containers to be remembered and used later ignore the important needs of a knowledge-based society, which means solving problems as they arise based on interactions with others, and sharing solutions and information.

Competency Practice in Quest Atlantis

Voogt and Roblin's (2010) analysis provides a world-view set of 21st century competencies, with differences in implementation and recommendations for assessment. This study is concerned with a practical cross section or representative set of competencies culled from Voogt and Roblin's work. These competencies are technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness. Active practice of these competencies is embedded throughout the missions of Quest Atlantis. The next sections give examples of these competencies.

Technology skills. Questers work through several missions learning about the possible hazards of being on the Internet, using chat rooms, and giving out personal information to strangers. Students have to give advice to another player about someone who is planning to meet a stranger. Students analyze stories and descriptions of situations, and then are asked to speak to different characters and give advice on what to do. Besides discussing the dangers of technology, students use technology. Being in the virtual world has required students to maintain their login and passwords, track information being stored in virtual bookbags called Q-Paks, update their home pages, and use the text chat facility and the telegram facility to speak to others. Students travel in the virtual worlds using a teleport device, and then navigate specific locations using the directional tool on every screen. When questers visit Q-Ville, they encounter a Building School, a place where they can browse among instruction sets, choose one, and follow

directions to learn how to construct 3-D structures on their own plots of rented virtual land. Students come to realize that the worlds in which they are traveling are simulations running on computers, and that the sense of presence they are feeling is a complex interaction between them and the technology. An added feature of Q-Ville is that questers have the power to fly, which is often useful when constructing structures that hover in the virtual sky.

Critical thinking. Ingolstadt is a virtual village in Quest Atlantis where a horrible disease has spread among the citizens. Many villagers have died already, and many more are sick. This quest is based on Mary Shelley's *Frankenstein*. Dr. Frank, a resident of Ingolstadt, is conducting experiments in his home laboratory, experiments on a living life form known as the Creation, and his work may be helpful in finding a cure for the disease in the village. Students are placed in situations requiring critical thinking about the ethics of experimenting on a living thing, work on developing a thesis statement of their beliefs, and find themselves placed in situations of having to tell the truth or not. Students use critical thinking throughout their stay in Ingolstadt, interacting with the local newspaper editor, the constable, the postmaster, and others.

Problem solving. Opportunities to solve problems are presented in every mission. Scenarios for solving problems can vary among sorting out social situations, friend disputes and disagreements, deciphering a code to continue on a journey, loading a mating tank with the proper insects to produce a specific offspring, determining if water quality has improved or declined based on the kinds of life living in the water, rating the mechanical efficiency of two different bicycles, and so on. Problems are solved in an open-ended fashion; that is, there is not a specific correct answer in most cases, but

instead, an interpretation and an explanation that justify the usefulness of an answer must be offered by the quester. In many cases, several solutions can work, reinforcing the idea that just finding an answer is not the only reason for solving problems.

Collaboration. Ludgate's (2008) study of collaboration in Quest Atlantis found that the students often collaborated by choice, even when collaboration was not required, clearly a social function of students being together and focusing on a common task and of experiencing what Ludgate calls a play-space environment. Collaboration skills are needed throughout the missions, sometimes with only a few players, and sometimes on a larger scale. Elementary students in two separate schools in Florida demonstrated a large-scale example of collaboration using Quest Atlantis. Working with teachers, students responded to the British Petroleum oil rig explosion in the Gulf of Mexico. The resultant mass pollution and destructive effects on plant and animals life in the Gulf of Mexico presented an important challenge. Students studied the impact of the spreading oil, studied the affected animal life, and collaborated to create a special virtual area to care for the wildlife harmed by the oil. Using 3-D virtual building techniques learned while in Quest Atlantis, students designed and built tanks, and cleaning and medical areas to care for the injured fish and fowl. Teachers also shared videos of the project on YouTube.

Communication. Reading and writing skills are needed to move forward in the virtual world. Talking to characters in Quest Atlantis is done by reading displayed comments of the nonplaying characters. For example, Lara the Fairy might greet a student by saying: Hey there, quester! I love the smell of the flowers here! The student quester always has options in answering. Among the possible answers a student might choose to click are: I need help finding somebody; or See ya later, I'm off to quest!; or

I'm curious about the super-committed mission. These responses follow different trajectories for what happens next. The student may go off on his or her own, might engage in a conversation about a location, or might be directed to start a new mission. As students proceed through their missions, they always have a home screen where they can check their current status. For example, if a student started the "Sally's Journal" mission, but only completed a portion of the steps and had to logout of the program, the status screen displays exactly where the student stopped the next time the student logs in. Writing and reading skills are needed as well when students respond to missions that have to be reviewed before lumins will be awarded. If writing is well thought out, clear, and meets the requirements of the mission, then the reviewer (the classroom teacher) accepts the work. However, if a student does an incomplete job or submits a poorly written response, the reviewer can select Revise, which requires the student to fix errors and resubmit the work.

Creativity. A Peppler and Solomou (2011) study analyzed the emergence and growth of creativity among students working as a group in Quest Atlantis. The study sought to uncover how creative ideas happen within a group and are then shared throughout the community. In the virtual world, students worked as apprentices in an architecture unit, which followed a narrative based on Ayn Rand's *Fountainhead* novel. Researchers found not only demonstrations of student creativity, but also found a highly social component to the emergence of creativity within the group.

Global awareness. Membership in Quest Atlantis is worldwide, currently with participants on six continents and an estimated number of users near 60,000. With this scale of membership, the viewpoints, customs, languages, and ideas from around the

world can converge in one place—a virtual location available across the time zones, 24 hours a day (Barab, Arici, et al., 2005). Teachers have the capability to network with other teachers, plan in-world meetings, share curriculum, organize coquesting, share languages, and so forth. The number of ways to interact is entirely a function of teachers' creativity, time input, and personal growth. The virtual world meeting space provides opportunities for making social studies connections, creating new projects outside the virtual world, bringing other technologies such as blogging and video conferencing, and collaborating with other cloud-based tools.

Barab, Gresalfi, et al. (2010) express learning in Quest Atlantis this way:

> I regard games as offering a new pedagogy for the 21st Century, one that has the potential to not merely fill individual minds but empower whole persons. And one that can transform learning from a rote acquisitional process, to a transactive one in which conceptual understandings have transformational significance. (p. 16)

Summary

The state of the education system in the United States is most easily described as still in the 20th century; that is, educators exercise a high regard and focus on methodologies and facts that were required for success in earlier industrialized periods of our country and that no longer predominate our economy (Dede, 2010). In this climate, during the past 30 years, test score data show that achievement by American students has fallen, and the U.S. Department of Education has taken action to reform or turn around this trend by implementing rigor and raising standards, by requiring standardized testing, and by meting out consequences to low-performing schools and school personnel. Most education experts agree that the efforts at rigor have become more punitive than effective

and significant groups of students living in poverty continue to suffer the inequities of their environments and emerge in the data stream as low performing. Increased efforts at targeting these low socioeconomic groups have not substantially improved academic achievement.

This chapter highlighted the problem and accompanying characteristics of disengagement, and presented a contrasting method of education using virtual worlds. Virtual worlds allow students to step beyond the restrictions of their schools. Students can act as experts in areas of science, math, information technology, social studies, fine arts, and other academic areas. They can assume the roles and identities of experts, which allow the joining of content in a real context. Competencies can be practiced in virtual environments that are typically not possible in the confines and schedules of a traditional classroom (Sykes & Reid, 1999). Virtual worlds have been shown to be engaging and to foster 21st century competencies such as technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness. Research gathered across a wide socioeconomic range of students using Quest Atlantis has shown increased engagement and satisfaction, and has aligned closely with social learning theory tenets of how deeper learning occurs in meaningful situations in which learners are connected with the culture in which they construct knowledge. Given current conditions across the United Stated in which schools are under fire for low performance, a new, nonpunitive approach should be welcomed by educators and politicians. With the worldwide user base of Quest Atlantis at more than 60,000 and growing, and its recent significant funding coupled with the emphasis by the U.S. Department of Education's NETP, solutions and strategies may be on the horizon for positive changes in all schools,

but especially in turning around those double jeopardy low-performing schools with predominantly low socioeconomic populations. Above and beyond the test performance goals sought by No Child Left Behind, President Obama's Race to the Top, and common core standards proponents stands a larger goal, one that requires future citizens to have competencies to function in what more and more is being called the digital age (Gee, 2003).

Chapter 3: Methodology

As learning and teaching approaches continue to be modified to increase student achievement in the current competitive standards climate, there is research-based argument for introducing learning situations that will foster significant gains in abilities known as 21st century competencies (or skills)—in other words, learning that goes beyond the academic content of today's standardized tests (Dede, 2009; Shute & Torres, in press). The purpose of this mixed-methods study is to shed light on effective virtual worlds learning choices recommended in the U.S. Department of Education's NETP (2010) for educators to use in schools, and to introduce challenges for educational software designers to build innovative systems that educators can approve.

Research Questions

The research questions guiding this study are as follows:

RQ1. To what degree do the teachers of students who use Quest Atlantis observe 21st century competencies acquisition?

RQ2. To what degree are students engaged while learning with Quest Atlantis?

RQ3. What other benefits do teachers and practitioners see from students working in Quest Atlantis?

Research Design

A triangulation mixed-methods design fits this study's approach because the researcher is investigating data from different levels of the overall population, and seeking to use both quantitative and qualitative data. To paint a clearer picture, triangulation mixed-methods design is typically conducted in one phase in which one data set is supportive of another data set, such as a qualitative measure embedded in a

quantitative intervention (Creswell & Clark, 2007; Lasserre-Cortez, 2006; McMillan & Schumacher, 2010). In contrast to a concurrent one-phase nested mixed-methods model, a two-phase model can also be applied. The two-phase model places qualitative data gathering before or after an intervention in which quantitative data was gathered (Creswell & Clark, 2007). Depending on the circumstances of the study, quantitative and qualitative methods may be used with greater or lesser emphasis, sometimes heavier on one than the other. In the case of this study, existing quantitative data precedes qualitative data. Creswell and Clark stated:

> These sequential approaches are useful when a researcher needs qualitative information before the intervention, to shape the intervention, to develop an instrument, or to select participants, or after the intervention, to explain the results of the intervention or to follow up on the experiences of participants with certain types of outcomes. (p. 69)

A study of low-income working mothers (Weiss, Mayer, Kreider, Vaughn, Dearing, Hencke & Pinto, 2003) used a mixed-methods triangulation method, incorporating quantitative data followed by qualitative data. They concur with Creswell and Clark (2007) and Lasserre-Cortez (2006) on the value of this approach—that it produced better triangulation of the data.

Data Sources

Sources of data for this study are both quantitative and qualitative. Table 1 shows the three data sources for this study and the research question associated with each source. Indiana University supplied existing data from pre- posttests, and existing data from engagement surveys of students who worked with Quest Atlantis. The researcher

gathered additional survey data from experienced Quest Atlantis teachers.

Pre- and posttest results were generated by students familiar with the Quest Atlantis virtual worlds learning environment and who knew how to navigate steps to complete academic missions. Content of the pre- and posttests matched that of a virtual worlds mission studied by Indiana researchers in the classroom. The mission on which students worked presented them with concepts of genetics, including genotypes, phenotypes, Punnet squares, alleles, dominant traits, and recessive traits. After the pretest, students worked on a Quest Atlantis virtual world mission in which they assumed the identities of scientists and used scientific tools and procedures of geneticists for 5 days breeding specific genetic designs of virtual dragonflies. Following the 5 days in the virtual world, students were given a posttest on genetics content learned from experiences in the virtual environment. Additionally, students were surveyed to determine their level of engagement while working in the virtual world and interacting with genetics academic content. Student activities described in the mission included problem solving, collaboration, communicating (with text, telegrams, and response tools), critical thinking, understanding the in-world scientific community, using technology, and appreciating the global impact of genetics and cloning.

Table 1

Data Sources

Data Sources	
RQ1	Survey of Quest Atlantis Teacher Observations of 21st Century Competencies
RQ2	Likert-Style Engagement Survey Pre- and Posttests of Content
RQ3	Teacher Open-Ended Responses

Existing test data. In one test, students were introduced to six hamsters with varying descriptions of fur length, presence of a tail, and color of fur. Matching genotypes were provided for each of these. For example, test directions showed students that BB or Bb represented a long tail, while bb was a short tail. RR or Rr was presence of a tail, while rr indicated no tail. Directions instructed students to use the genotypes in identifying specific hamsters that would be associated with changing genotypes. A graphical organizer, typically used in genetics courses, called a Punnet Square was incorporated to show how genotypes can be paired to result in specific traits. Finally, students were introduced by test examples to the fact that some phenotypes such as color and size were dominant and some recessive, thus further affecting possible offspring combinations. After 5 days of work in the virtual world, where students talked to virtual scientists, learned about breeding processes, captured virtual dragonflies, and used scientific breeding tools to create certain sizes and colors of dragonflies, a posttest was given (See Appendix A).

Engagement measure. Understanding engagement is important to this study based on research findings stated earlier tying performance and general satisfaction to engaging educational experiences (Alexander et al., 1993; Alexander et al., 1997; Arici, 2008; Barab, Thomas, Dodge, Carteaux, et al., 2005; Dede et al., 2003; Fredricks et al., 2004; Newmann et al., 1992). For this study, an existing Likert-style engagement survey shows student responses to 15 statements as follows: Agree a Lot, Agree, Agree a Little, Disagree a Little, Disagree, and Disagree a Lot. Some examples used in the survey were: (a) This activity was challenging; (b) I felt in control of the situation; (c) I was succeeding at what I was doing; and (d) I felt as if the environment were real.

Quest Atlantis teacher survey. To support the existing data from the pre- and posttests and the existing engagement survey, additional qualitative data regarding 21st century competencies were obtained. These data were derived from teachers, all of whom were experienced using the Quest Atlantis virtual world learning environment in public school settings with elementary students. The researcher, after examining available surveys from previous research, did not find an existing survey suitable for the purposes of this study. A survey was needed that could tease out specific competencies drawn from practitioner observations. Since none was available, the researcher designed a survey to address this study's needs. The survey questions were developed based on definitions of 21st century competencies offered by other educators and researchers (Dede, 2009; Jenkins et al., 2006; Partnership for 21st Century Skills, 2011; Voogt & Roblin, 2010). The survey was formulated to uncover behaviors of the following 21st century competencies in students who have been using Quest Atlantis. These competencies are technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness. Because this survey was newly developed, it required validation. Experts in educational technology, multiuser virtual environments, and game design were consulted on the validity of the survey tool administered to Quest Atlantis teachers. They reviewed all survey statements compared to the targeted 21st century competencies associated with each survey statement. After their review, expert feedback on content, as well as adjustments to the survey, was implemented. The survey is attached as Appendix B.

Data Collection and Purposeful Sampling Procedures

Purposeful sampling is when the researcher has specifically selected participants known to be experienced in the main topics of the investigation (Creswell & Clark, 2007). Participants for this study were selected in part by Indiana University, and in part by the researcher. For the teacher survey, participants were identified with the assistance of an international Quest Atlantis teacher trainer. Participants were drawn from a community of teachers who were trained in implementing Quest Atlantis, and who were currently active in the classroom. An e-mail invitation was distributed to the list of selected teachers in which they were asked to provide their consent to participate in this study. Their choice to participate was indicated when they accessed the online survey link provided in the e-mail message. Teachers had the option to participate or not as stated in the e-mail message. A follow up e-mail message was sent to the original list of teachers as a reminder about participating in the study. The e-mail letter of informed consent to participants in this study is attached in Appendix C.

The Quest Atlantis trainer who assisted in this study has helped hundreds of elementary classroom teachers learn to use the immersive worlds environment in the classroom. Selection for this study was based on the teachers' known experience level in using Quest Atlantis. Creswell and Clark (2007) stated that it is typical of mixed-methods research to use a "homogeneous sampling of individuals who have membership in a subgroup with distinctive characteristics" (p. 112). The teachers surveyed were all elementary teachers experienced using the Quest Atlantis program. Creswell (1998) states that small sample sizes are typically used in qualitative mixed methods; this study

invited Likert-style survey data from a possible 30 elementary teachers. The list of survey questions are attached as Appendix B.

Human Subject Considerations

This study was conducted according to the ethical, federal, and professional standards set forth by United States regulations and by Pepperdine University to protect human subjects. Approval for this study was requested from the Institutional Review Board (IRB) responsible for reviewing research applications from the Pepperdine Graduate School of Education and Psychology. Under Pepperdine's IRB applicability policies, this research activity is exempted from federal regulation because it presents no more than minimal risk to human subjects since it meets Pepperdine University (2009) IRB exemption criteria. The researcher was responsible for assuring voluntary participation of teachers by obtaining informed consent electronically via the online survey tool. The researcher ensured that a copy of all data collections tools were included. The nature of the involvement of human subjects was described, as well as a justification for why this study should be considered exempt. To safeguard anonymity and privacy of the survey participants, the researcher will store all the survey data on a password-protected personal backup disk drive. No HIPPAA educational-related components are required for this study. The researcher adhered to the procedures described by the IRB.

Data Analysis and Interpretation

To arrive at generalizations about acquired 21st century competencies of students using Quest Atlantis, the analysis process for this research uses the following model.

Bazeley (as cited in Andrew & Halcomb, 2009) argues that when analyzing mixed-methods data, there are three analysis issues to consider:

1. The (relative) quality of each of the separate analyses.
2. How the results of the separate analyses are to be synthesized in order to draw conclusions that incorporate both sets of data.
3. Strategies to manage findings that are contradictory rather than complementary. (p. 89)

The reason for using triangulation is to determine if results from one set of data converge to indicate the results of another set of data, and often, the different data sets include quantitative data and qualitative data. Triangulation may be effective when the strengths of one approach can offset the weakness of the other approach (McMillan & Schumacher, 2010). In this study, existing quantitative test data, existing qualitative engagement survey data, and newly acquired qualitative survey data of teacher observations were used. The researcher used multiple perspectives and theories to interpret the data and enhance the understanding of the connections among engagement, 21st century competencies, virtual worlds learning, and social-learning theories. Janesick (1998) corroborated this style of interpretation.

The researcher employed statistical analysis software using a descriptive technique approach to analyze the results of the Likert surveys. In the teacher survey, numerical values were assigned to each of the responses as follows: strongly agree = 1, agree = 2, undecided = 3, disagree = 4, and strongly disagree = 5. The range of responses is displayed with bar charts showing how survey respondents indicated agreement, disagreement, and so forth. Likert-scale data were summarized with the mode in

numerical terms, which is the most frequent item response. One additional open-ended question concludes the survey. The question is phrased as follows: What did you observe or discover about students working in Quest Atlantis that you would like to share with this study? The final question seeks to uncover points of view or concepts that teachers found important to this study, but were not addressed directly in this study.

Validity and Reliability

Validity refers to whether the survey measures what is intended to be measured, in this case, 21st century competencies. Creswell (1998) stated that qualitative researchers should have a minimum of two procedures for internal validity and verification of the study. The researcher in this study used the following:

- Ongoing engagement with and knowledge of the field being studied,
- Removing possible researcher bias by identifying past classroom teacher experiences,
- Survey review by academic experts as indicated earlier.

Representative sample. Choice of a representative sample, as is done in this study, also helps ensure external validity because the results of the study can be generalized beyond the specific setting of the current research (Bryman & Bell, 2007). In this case, results can be generalized to other similar classrooms of student groups using Quest Atlantis. Also, the Likert survey for this study was designed according to survey question recommendations by Popham (2002) to avoid bias in questions and statements by making sure to have both negatively and positively phrased questions.

Validity of qualitative designs. Triangulation mixed methods is a qualitative research design. The validity of qualitative designs, according to McMillan and Schumacher (2010),

> …refers to the degree of congruence between the explanations of the phenomena and the realities of the world.…In other words, validity of qualitative designs is the degree to which the interpretations have mutual meanings between the participants and the researcher. (p. 330)

Seeking these mutual meanings is precisely the goal of the survey of Quest Atlantis teachers.

Parallel technique for survey statements. Using a parallel technique recommended by Popham (2002), the teacher survey used in this study has alternative forms of questions, highlighting content from a positive view as well as from a negative view so as not to influence responses one way or another. Examples of this technique used in the survey, which targets problem solving and collaboration, are as follows:

(Problem Solving) I observed improvement in perseverance, staying with a problem until solved.

(Problem Solving) I did no*t* observe my students openly discussing how to solve problems.

(Collaboration) I have observed collaboration skills among my students in one or more academic areas.

(Collaboration) My students do not show self-regulating behavior while working in Quest Atlantis.

Experts in educational technology, multiuser virtual environments, and game design were consulted on the validity of the survey tool before it was administered online to Quest Atlantis teachers. After the expert review, feedback on content was incorporated. It was the researcher's goal to have an instrument that clearly addressed the classroom experiences of teachers and their questing students.

Limitations of the Study

In self-reporting studies such as the Likert-style survey of Quest Atlantis teachers, the possibility exists for inaccurate results. Such a study is limited by the manner in which teachers respond to the survey based on their personal perceptions. Teachers may feel they are being evaluated for their technical skills, or could feel they might be expected to respond in a certain fashion. The researcher cannot control for teachers who may respond in a way they think they are expected to as opposed to responding without bias.

Summary

This chapter highlighted the need for learning approaches that can foster 21st century competencies, as suggested by education researchers and as recommended in the recent NETP from the U.S. Department of Education. Research questions and the reasoning for choosing a triangulation mixed-methods design for this study are provided, citing triangulation research experts. Included are existing data sources from tests of genetics content embedded in a virtual worlds mission, an existing engagement survey, and a survey of selected teachers (see Appendix B), all of whom are trained and knowledgeable in implementing Quest Atlantis in a classroom setting. IRB considerations also are provided covering the protection of participants, the data

gathered, and adherence to approved procedures in the study. A discussion of triangulation mixed methods and establishing the validity of the survey per expert evaluation were presented. The researcher stated limitations of the study related to the self-reporting nature of the survey, which could allow for teachers to make assumptions about their role in the study.

Chapter 4 presents two varieties of existing quantitative data from Indiana University, provides a statistical analysis of that data, and reports the findings of the Likert-style survey of experienced Quest Atlantis teachers. Chapter 5 examines ideas and information from the three data sources, summarizes and concludes how these qualitative and quantitative data support the research questions, then offers recommendations for future research on K-12 students learning with 21st century virtual world approaches such as Quest Atlantis.

Chapter 4: Results

As previously established, schools across the United States are under pressure to increase student achievement and to demonstrate improvements with standardized test results. Researchers point to low engagement as integral to low student achievement. Recently, organizations calling for school reform have modified their focus to include 21st century competencies. One promising approach to meeting both content learning and competency needs are virtual worlds learning environments. This mixed-methods study looked at a virtual worlds program called Quest Atlantis by surveying experienced Quest Atlantis teachers on their observations of 21st century competencies among students in their classrooms.

The purpose of this chapter is to provide results related to the study's three research questions: (a) To what degree do the teachers of students who use Quest Atlantis observe 21st century competencies acquisition?; (b) To what degree are students engaged while learning with Quest Atlantis?; and (c) What other benefits do teachers and practitioners see from students working in Quest Atlantis? This chapter is organized by research question, presenting findings first and analysis second. The chapter concludes with an observation of student socioeconomic status and a summary.

Quantitative and Qualitative Data

This study utilizes three data sources (see Table 2), which are triangulated in analysis to build a solid view of educational experiences encompassing teacher observations of specific competencies in their students, student engagement feedback, and content assessment.

Table 2

Research Questions Aligned With Data Sources

Research Questions and Data Sources	
Research Question 1	Survey of Quest Atlantis Teacher Observations of 21st Century Competencies
Research Question 2	Likert-style Engagement Survey Pre- and Posttests of Content
Research Question 3	Teacher Open-Ended Responses

Qualitative data on student actions and behavior with 21st century competencies were gathered in an online survey from 18 experienced Quest Atlantis elementary teachers. Teacher open-ended responses were gathered from the same survey. Quantitative achievement data from student pre- and posttests, as well as qualitative engagement data, were provided by the Quest Atlantis Project at Indiana University. The intent of using multiple sources is to provide a more complete picture of the learning process. Existing data used in this study are from experienced student users of Quest Atlantis, which included students ranging from ages 9 to 10 from lower socioeconomic backgrounds. Engagement data and test scores were generated in a 5-day classroom intervention using a Quest Atlantis mission called Drakos. Before the start of work in Drakos, students were given a pretest on the basics of genetics. See Appendix A for pre- and posttests.

The content of the Drakos mission was based on the study of dragonfly genetics—how different offspring traits and colors are produced from various genetic combinations of dragonfly parents. Students played the role of scientists in capturing, analyzing, and breeding the virtual dragonflies to meet specific genetic requirements built into the narrative of Drakos. The Drakos mission was conducted in the same virtual

worlds environment as used by the Quest Atlantis classroom teachers surveyed in this study. Observations by those teachers are similar to observations that would be seen by any teacher in a classroom using Quest Atlantis. This similarity between the classroom experiences that generated the existing Drakos data helps to generalize the findings of teacher survey observations to the broader population of elementary classrooms using Quest Atlantis.

Research Question 1: Observations of 21st Century Competencies

Researchers increasingly support the idea of competencies beyond content knowledge; that is, learning basic content in isolated fashion for testing purposes is not enough. Deeper learning occurs as a result of students using their competencies in conjunction with academic content (Dede, 2009; Jenkins et al., 2006; Partnership for 21st Century Skills, 2011; Voogt & Roblin, 2010). To explore and examine the idea of competencies, research question 1 asks: To what degree do the teachers of students who use Quest Atlantis observe 21st century competencies acquisition?

Data from teacher observation survey. Thirty experienced Quest Atlantis classroom teachers were invited to participate in this survey, of which 18 consented and took the survey (60%). The survey was constructed with statements that targeted the following 21st century competencies: technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness. Survey statements were made available to participants in an online Qualtrics survey for a 3-week period. General definition guidelines for 21st century competencies were provided in the online survey. Most survey statements were phrased positively, but some were phrased negatively. Responses were made according to the following choices: Strongly Agree, Agree,

Neither Agree or Disagree, Disagree, and Strongly Disagree. Because some statements were designed with a negative phrasing, those statements' numbers were reversed in the analysis. For example, the statement "My students do not understand how to sort information according to validity and truthfulness" expresses a critical-thinking observation in a negative phrasing, which requires a Strongly Disagree response to express a positive connotation. See Appendix B for the complete survey tally of survey and responses to the open-end question.

Figure 5 presents the teacher observation results of each 21st century competency, and shows that all were rated high and were all relatively close in percentages, which is an indication that goals of the Quest Atlantis program are being met by fostering 21st century competencies. Normally, when all measures across a range score strongly toward high, it could be a result of respondents' feelings that they are being judged by their feedback, respondents' haste to finish the survey, or other possible personal reasons. However, the data show otherwise in that there is variability among the responses. For example, technology skills were rated extremely high at 98%, creativity was rated substantially lower at 65%, while the remaining competencies occupied a range between 81% and 92%, revealing specific choices in teacher responses.

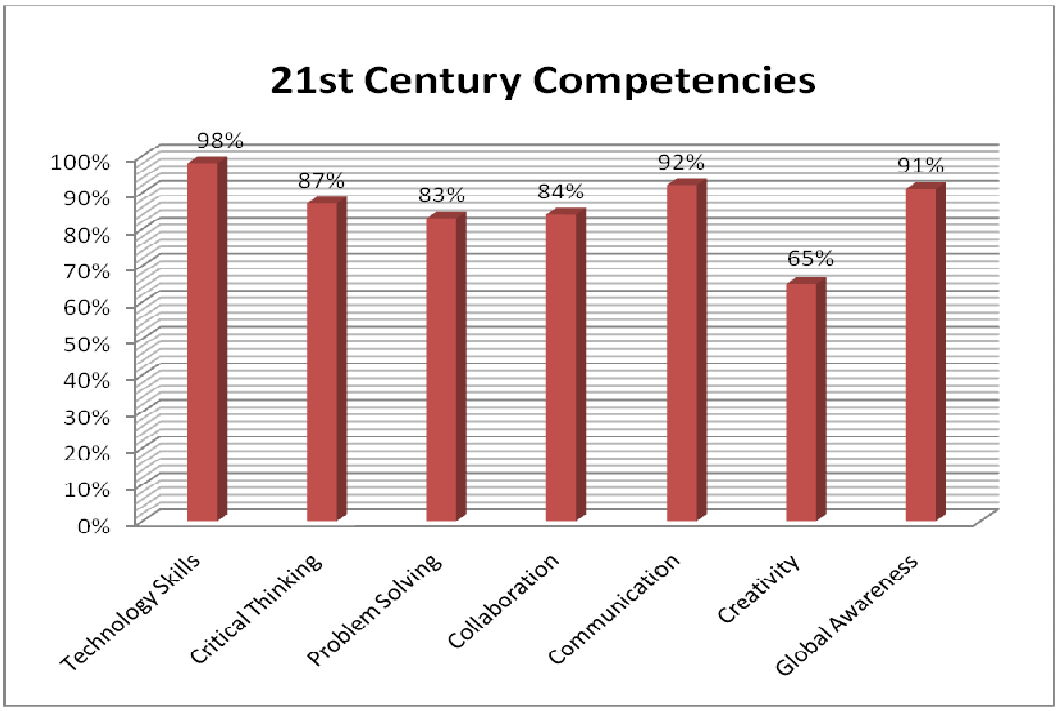


Figure 5. Comparison of 21st century competencies.

Breakdown of Teacher Observations by Competency

The following sections show the overall survey results as individual graphic views of respondents per each 21st century competency. These graphs provide a closer focus on the competencies that emerged in classrooms according to the observations of experienced Quest Atlantis teachers. See Appendix B for the survey statements.

Technology skills: Teacher observations. The strongest overall observation was in technology skills at 98%. Quest Atlantis is accessed on a computer and requires students to use a wide range of interfaces in order to configure an avatar, select missions, choose response pathways, send telegrams, type in a chat screen, respond to polls, pull down actions and view commands, add objects to a virtual backpack (Q-Pod), respond to missions with a text editor, and upload documents and graphics. After technology skills,

communication, at 92%, is second strongest. Teacher responses to technology survey statements 1 through 4 are shown in Figure 6.

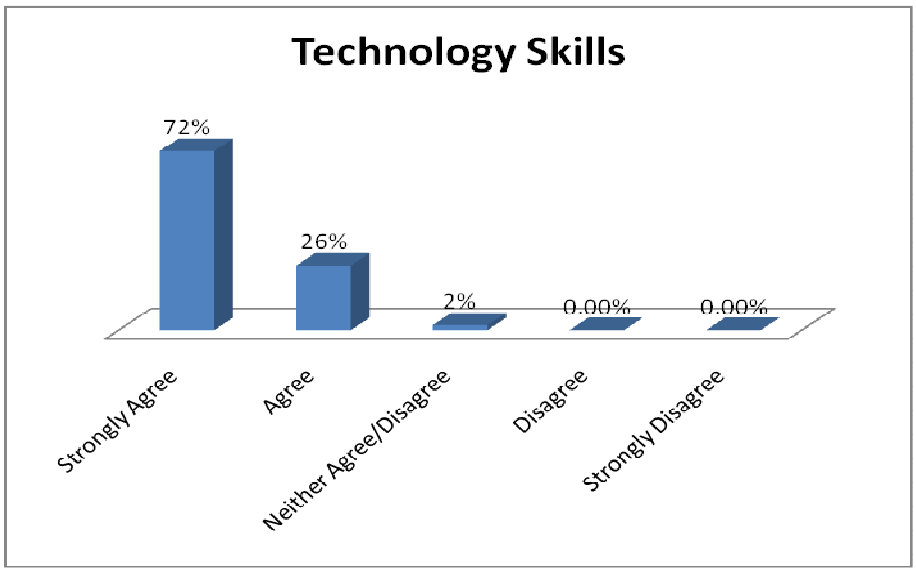


Figure 6. Technology skills results.

Communication: Teacher observations. Communication skills are facilitated by the technology interface, enabling students to communicate with their classroom teacher, in which assessment comments are entered by the teacher. A successful entry on the part of the student ensures completion of part of a mission and allows the student to continue, otherwise, a teacher may write a comment asking a student to revise a written response and resubmit. Communication skills are also exercised in telegrams and chatting. Students have the ability to communicate with anyone currently in the virtual world—sometimes other students, sometimes teachers from other classrooms. Teacher responses to communication statements 21 through 25 are shown in Figure 7.

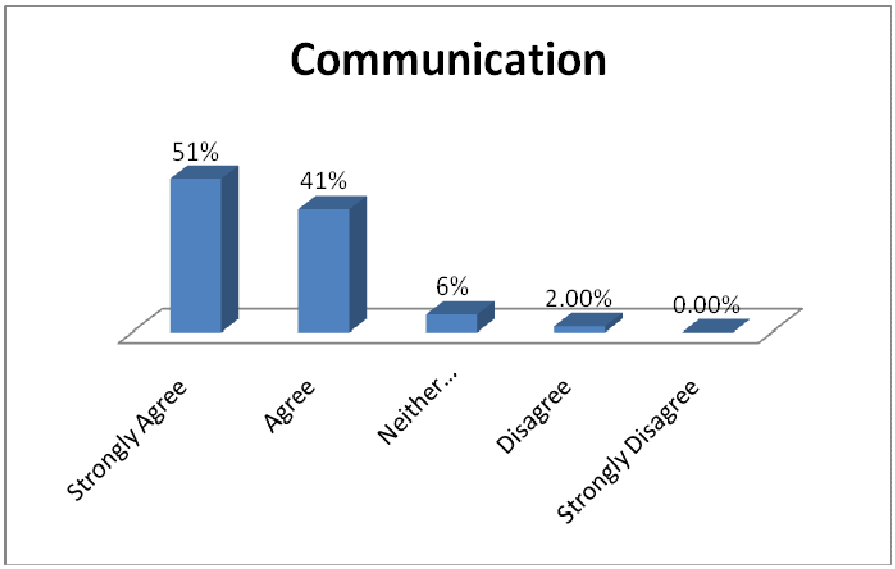


Figure 7. Communication results.

Global awareness: Teacher observations. Global awareness was the third rated 21st century competency observed by Quest Atlantis teachers at 91%. Global awareness is fostered throughout the set of quests and missions, is part of the Quest Atlantis backstory, and is experienced in the everyday interactions in-world by students and teachers. The virtual environment is shared by students and teachers from six continents. Students are likely to encounter students from Australia, England, the United States, South Africa, Japan, Turkey and other countries. While the main language used in Quest Atlantis is English, opportunities for language sharing happens frequently as students and teachers interact.

Global concerns recently took the form of sharing compassion for the victims of the earthquake-induced tsunami that devastated Japan. Quest Atlantis designers responded by adding a new character, Harumu, in the virtual world entry point so that all players would encounter him upon logging in to Quest Atlantis. When students clicked Harumu, he provided information to help student understand the catastrophic situation.

Additionally, Harumu tells the legend of the 1,000 cranes and says he wants to fold 1,000 cranes in the hopes that his wishes for his friends back in Japan will be realized. Students are drawn into this effort when Harumu explains that he needs much more help to make the cranes. He shows instructions for making origami paper cranes. Students are invited to add one of four wishes to their crane: Health, Hope, Comfort, or Peace. Once students complete a virtual crane, a confirmation appears that contains the kanji symbol for those words. This is an example of embedding a 21st century competency into a real context, and providing the opportunity to participate in deliberate contextual learning that goes beyond the walls of the classroom. Teacher responses to global awareness statements 31 through 35 are shown in Figure 8.

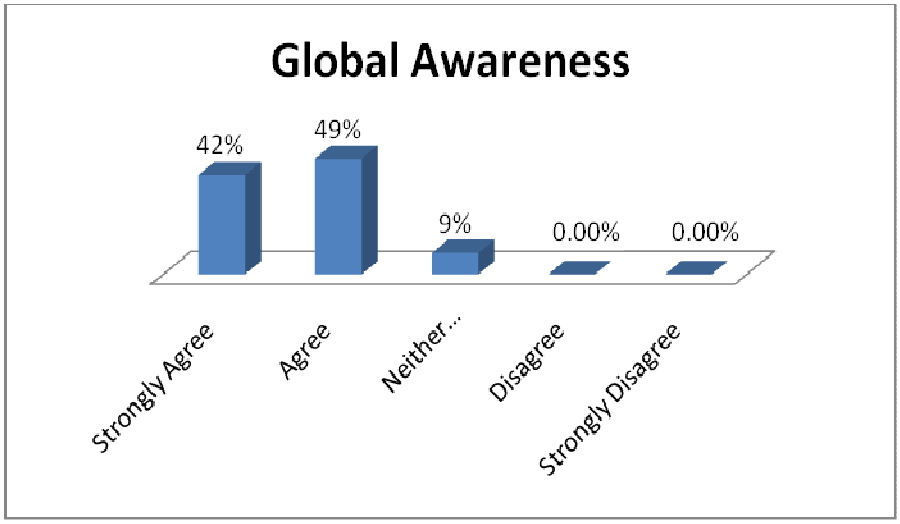


Figure 8. Global awareness results.

Critical thinking, collaboration, and problem solving: Teacher observations. The next range of 21st century competencies were observed as follows: critical thinking at 87%, collaboration at 84%, and problem solving at 83%. Because these three competencies were close in ratings, and because they are often weaved together in practice, they are presented as a group in this section (see Figures 9, 10, and 11). Critical

thinking, collaboration, and problem solving are typical student practices applied in understanding tasks when first presented with each new mission, when talking to the main characters, making pathway decisions, conferring with real-world classroom peers, coquesting with peers as avatars, and using the real-time navigational system that is married to avatars' movement similar to global positioning programs. As has been referenced in this study, students solve problems individually and with peers in a variety of ways, including using code machines and graphical organizers, deciphering hieroglyphics, and conducting conversational interactions with key virtual characters. By design, Quest Atlantis missions take students through the practice of 21st century competencies as students play the game. Teacher responses to survey statements 5 though 10 produced the following results.

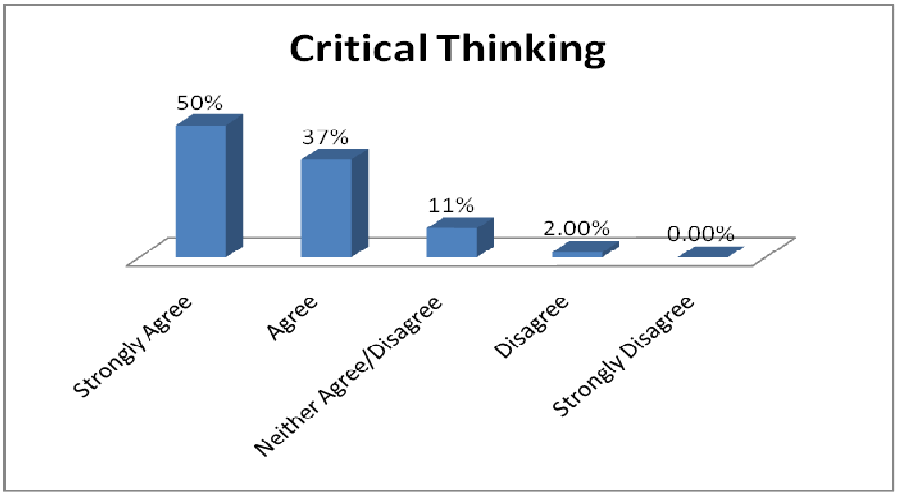


Figure 9. Critical thinking results.

Teacher responses to problem solving survey statements 11 though 14 produced the following results.

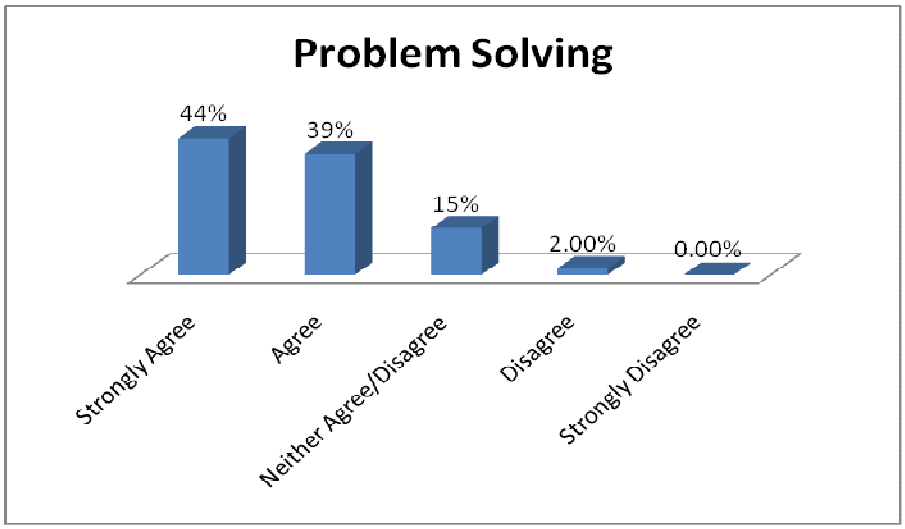


Figure 10. *Problem solving results.*

Teacher responses to collaboration survey statements 15 though 20 produced the following results.

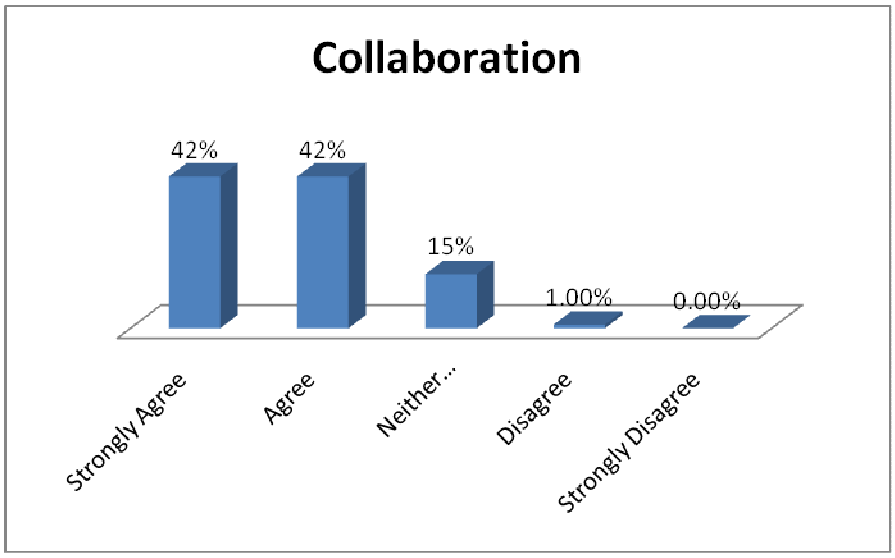


Figure 11. Collaboration results.

Creativity: Teacher observations. Creativity was observed at a much lower percentage than the other 21st century competencies—Strongly Agree 15% and Agree 50%. Creativity practice happens as students negotiate various dilemmas and situations, provide written responses, configure avatars, and construct virtual 3-D objects alone and

in teams. The question arises as to why teachers observed creativity as the lowest of the 21st century competencies and bears further examination.

Quest Atlantis offers choices to both teachers and students. For teachers, choices are similar to regular classroom curricular choices; that is, the teacher assembles and schedules lessons to be taught in the classroom. Similarly, to facilitate learning in the virtual world, the teacher uses his or her knowledge of the wide range of available missions and chooses which of these to assign to students using the Teacher Toolkit (described in Chapter 2). Only the missions selected by the teacher appear on students' home pages, allowing specific academic topics for focus and concentration. This is one possibility of the discrepancy in creativity ratings; that is, teachers, feel pressure to provide content that teaches to standardized tests, could be leaning toward missions that favor math, literacy, and science more than those that target artistic or creative expression. A prime example of this is the 3-D building opportunities in one location of Quest Atlantis. Building with virtual objects is time consuming and requires adequate experimentation time—tinkering time that could be perceived by teachers as nonproductive playing time. If teachers do not feel comfortable with 3-D building, they could be less likely to assign student time in these areas.

From the student perspective, choice is a major part of working in Quest Atlantis. When students interact with virtual characters, they are typically asked questions that have divergent results; that is, one answer will lead down one path, a different answer down another. This branching, by student choice, can result in activities, some of which require more creativity than others. Students could be influenced by teachers if a general classroom focus exists toward math and literacy, for example. Ideally, as the teacher

facilitates a mission with students, the choices would remain in the control of the student, which helps to increase the ownership, personalization, and, therefore, the engagement for the student.

Students participating in the narrative of a mission are given the opportunity to create their own destiny, much the same as people in the real world have everyday choices that affect their lives. A central tenet of Quest Atlantis is that students are change agents and have the ability to make choices that redirect and redefine their activities as they proceed through missions—in short, participants' actions are meaningful and consequential in the environment, determining, among other things, which competencies will be practiced. Teacher responses to creativity statements 26 through 30 are shown in Figure 12.

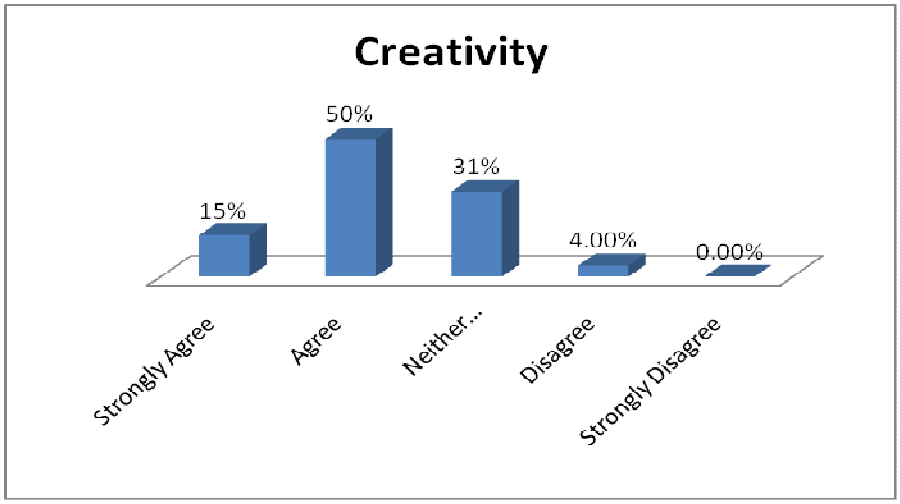


Figure 12. Creativity results.

Cultivating 21st Century Competencies

As students practice these competencies, they are, in effect, cultivating the competencies that enable them to understand and use the content of the missions, whether it be genetics, statistics, persuasive writing, metaphors, Internet safety, insects, ancient

cultures, or wildlife preservation. Colvin (2008) refers to this kind of learning or cultivation of competencies as deliberate practice—the idea of what a person specifically practices, and in what environment, constitutes a large part of what a person embodies and learns. Earlier research corroborates this idea, including Barab and Duffy's (2000) contention that practice fields cultivate learning and understanding through complex interactions with the environment. Brown et al. (1989) argued similarly for a doing and knowing perspective; that is, knowledge is situated in the culture and learning is achieved through actions and activity with that environment or culture. A student engaged in a mission such as Drakos is situated squarely in the practice field described by Barab and Duffy (2000) as, "From an instructional perspective, the goal shifts from the teaching of concepts to engaging the learner in authentic tasks that are likely to require the use of those concepts or skills" (p. 30). Teacher observations of their students exhibiting 21st century competencies supports the efficacy of situated learning (Barab & Duffy, 2000; Brown et al., 1989; Lave & Wenger, 1991) in which content is learned in a relevant context of activity and usefulness to the learner. Student competencies enable learners to connect with content-rich environments.

Research Question 2: Student Engagement

To explore and examine student engagement, research question 2 asks: To what degree are students engaged while learning with Quest Atlantis? This section presents a view of engagement through student responses; that is, their expression of engaged learning during work in a virtual world during a 5-day period. Research question 2 is also informed by the pre- and posttest data presented in this section, which connects the level of student engagement to a significant learning gain as measured by traditional testing.

Qualitative data on student engagement and quantitative pre- and posttest data were supplied by Indiana University.

Fifteen fourth grade students from a small Midwestern city were studied throughout a 5-day period. The classroom teacher and students were experienced with Quest Atlantis. Students were accustomed to working in Quest Atlantis as a blended part of their general classroom activities. After a pretest of genetics content (see Appendix A), the classroom teacher facilitated the introduction to the Drakos mission. For the study, students spent approximately 2 continuous hours online each day during a 5-day period working on the Drakos mission in the presence of the facilitating teacher. At the conclusion of five sessions, working in the Quest Atlantis virtual world, sharing, collaborating, writing, communicating, and problem solving, the students were administered an engagement survey designed by Indiana University (see Appendix D). Points that indicated engagement in the survey coincide with flow (Csikszentmihalyi, 1990), which is deep immersion in an experience, focused on authentic, meaningful tasks (Corno & Mandinach, 1983), and challenging work, immediate feedback, learning choices, and social interactions (Jones et al., 1994). Arici (2008) and Suter (2009) argued that the sense of presence in an immersive virtual experience serves to situate the participant in the activity, and enhances the realness of the setting and its characters. Table 3 shows the results of that engagement survey. All students were in low SES groups.

Table 3

Engagement Survey Results

Statement *N* = 15	Agree a lot 47%	Agree 32%	Agree a little 11%	Disagree a little 6%	Disagree 3%	Disagree a lot 1%
1. I was engaged in this activity	10	4		1		
2. I was concentrating during this activity	8	4	1	2		
3. I felt in control of the situation.	9	2	1	2	1	
4. This activity was challenging.	6	4	3		1	1
5. I was skillful at this activity.	7	3	3	1	1	
6. This activity was important to me.	10	1	1	2		1
7. I was succeeding at what I was doing.	6	6	3			
8. I was satisfied with how I was doing.	4	8	3			
9. I felt as if I were inside the environment.	9	5	1			
10. I felt as if the environment were real.	8	4	1	2		
11. I felt as if the characters were real.	3	6	5	1		
12. I felt as if I and the characters were together in the same place.	4	10		1		
13. I felt as if the events were happening at the same time I was there.	6	5	2	1	1	
14. I felt as if I were participating in the events.	8	6		1		
15. I felt as if the events were really happening.	7	5	1		2	
Response Frequency (225)	105 (6)	73 (5)	25 (4)	14 (3)	6 (2)	2 (1)
Statistics	Mean 5.1	Median 5.0	Mode 6.0	Standard Deviation 1.10		

Positive results of the engagement survey support the gains shown from the pre- and posttest results shown later in this chapter. The effect of engagement can be seen in

the results of a traditional test format. Learning content knowledge as a result of engagement and experience in a virtual environment is confirmed in the literature (Barab et al., 2006; Barab, Dodge, Thomas, et al., 2007; Barab, Zuiker, et al., 2007; Gee, 2003).

The responses were numerically valued as follows: Agree a Lot (6), Agree (5), Agree a Little (4), Disagree a Little (3), Disagree (2), and Disagree a Lot (1). Statistics were calculated in an Excel spreadsheet. Frequency of response values showed that the Agree a Lot occurred 105 times, Agree occurred 73 times, Agree a Little occurred 25 times, Disagree a Little occurred 14 times, Disagree occurred six times, and Disagree a Lot occurred two times. Table 3 shows a mean value of 5.1 with a small standard deviation of 1.10, indicating tightly grouped values around the mean**.** The most frequently occurring value, the mode, was 6. The median value for this survey was 5. When values were grouped by agreement and disagreement, the two resulting sets clearly show that 90% of students indicated they were engaged versus 10% indicating they were not engaged, as shown in Figure 13.

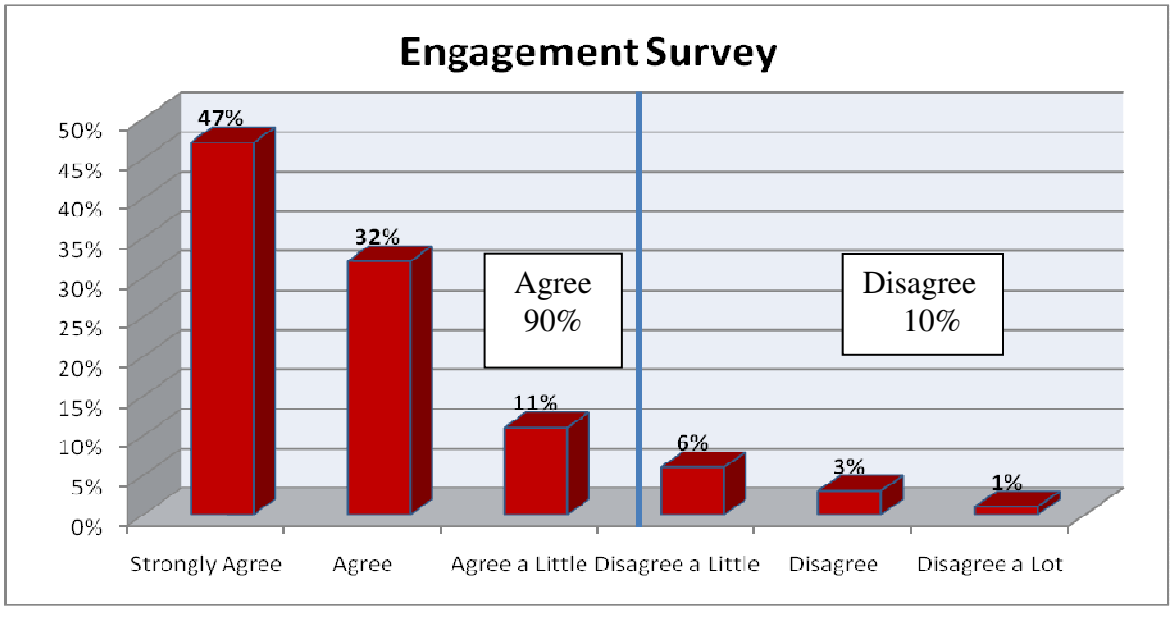


Figure 13. Engagement survey percentages.

Engagement is critical to learning. It is a part of the process that keeps a student connected and involved in an experience such that he or she will persevere with challenging situations (Bridgeland et al., 2006; Finn & Voelkl, 1993; Fredricks et al., 2004; Ingels et al., 2005; Willms, 2003). With today's focus on accountability, making sure that students learn and measuring that learning have become paramount throughout our public schools (Klopfer et al., 2009).

Analysis of Open-Ended Engagement Questions

In addition to responding to Likert-style engagement statements, students provided answers to the following three open-ended questions about their experiences while participating in the Drakos mission. See Appendix E for complete responses.

1. What was interesting and enjoyable about what you did today?
2. What was frustrating or not enjoyable about what you did today?
3. Because of this activity, do you find yourself more interested in genetics? Why?

Responses were brief. Total words for all three response sets consisted of 531 words, with an average of 14 words per response. To begin reviewing student responses for themes or categories related to the research questions, a model by Creswell (1998) was used for analyzing the data: reading through responses, making summaries, and sorting data into categories or codes. Reading through all responses, the researcher underlined key words related to this study's research questions. The researcher used a word frequency program for individual words and for recurring phrases to help create a summary. Analyzing at this point involved comparing the resultant summary with themes relevant to the research questions, creating categories, and then grouping per category, a

method proposed by Bryman and Bell (2007). The following categories emerged from grouping words and phrases from student responses. The categories result from combining word frequencies of all three questions, the goal of which was to uncover the major elements of engagement as expressed by the students. Categories are listed below in order of highest frequency of occurrence in student responses.

- Activity
- Learning
- Roles
- Feelings
- Sense of Place

Activity category. Activity was determined by students' use of action words. Words observed as relating to activity were design, splice, breed, catch, caught, doing, talk, find, put, deliver, and make. Active participation was described by the students as they were catching virtual butterflies and storing them in containers, and using various scientific machines such as the splice-o-matic and the breeding tanks to complete tasks. As avatars in a the 3-D world, students referenced talking to a giant dragonfly, designing new breeds of dragonflies, and using a genetics graphics organizer to match sizes and colors of insects for breeding. Activity was an integral part of their feeling of engagement. Engagement is enhanced by activity, doing things, and acquiring a hands-on feeling even though these activities are occurring virtually. The activity is both a foundation and integral part of learning and helps provide the connection for the learner to the content that exists in the contextual environment (Brown et al., 1989; Kaptelinin & Nardi, 2006; Lave & Wenger, 1991).

Example responses. The following example responses are listed below:

1. What I like about Drakos is when you have to *catch* dragonflies.
2. I got to *talk* to Delon the dragonfly.
3. I *caught* 1 big red and 1 little blue to *breed* drakos.
4. It also was enjoyable because you got to *catch* dragonflies.

Additional activities described included delivering packages, reporting to characters when jobs were finished, interpreting clues, finding their way in the world, and talking to scientists. With multiple opportunities for choices and instances of activities in this virtual world, students are more likely to stay engaged.

Learning category. Learning as a category was determined by students' use of words referencing their learning. Words observed as relating to learning were learn, learned, smart, smarter, know, and interested. Students expressed how being in the virtual world helped their learning. References were made to learning being fun, to becoming smarter, to being more interested in genetics after doing this mission, and to being more interested in science after working in the lab. Additionally, students used learned vocabulary such as cloning, breeding, and designing in describing their experiences. By using these new words, they illustrated with their own language how their learning had grown (Vygotsky, 1978) while also demonstrating a personal connection (enjoyment, engagement) to the learning.

In Quest Atlantis missions, students are presented with role-playing situations and opportunities to discuss their own thinking, which allows practice in metacognition. When students begin to regulate their approach to learning, they are, in fact, demonstrating how they can control their own thinking and learning (Schraw &

Moshman, 1995). Missions in Quest Atlantis provide this practice activity while students enjoy the engagement and attraction of being in the game.

Example responses. The following example responses are listed below:

1. Yes because I *learned* a lot about genetics and I *learned* it was fun.
2. Yes because *I want to know* how to breed so I can be a scientist.
3. Getting to *learn* all about dragonflies and their habitat.
4. I felt like I am *smarter*. The first time I did QA I wasn't that *smart*.
5. I found myself *more interested* in genetics because I did not *know* how to clone dragonflies and did not *know* what genetics were either.

Roles category. Roles as a category was determined by references to students taking on new roles or identities as a result of working in the Drakos mission. Words observed as relating to roles were teacher, scientist, quester, and avatar. Students communicated and worked with various male and female character role models in the Drakos mission. Uther, Xinga, and Ekon were scientists positioned at different locations and each had different purposes and tasks for students. Students observed these role model characters in laboratories and other locations using specialized machines, acting as teachers, posing challenging questions, and reminding students to check on mission progress. Positive role models inspire younger students, providing reasoning for future choices in social activity and career choices (Dede et al., 2004). Students expressed the excitement and attraction of being scientists and using scientific machines. Practicing these specialized roles provided the opportunity to try on new identities, a learning activity noted in childhood development through play (Arici, 2008; Barab & Duffy, 2000; Vygotsky, 1978) and argued by Lave and Wenger (1991) as being an essential descriptor

of legitimate peripheral participation by members of a community or affinity group (scientists in Quest Atlantis).

Example responses. The following example responses are listed below:

1. Yes because I want to know how to breed so I can *be a scientist*.
2. Maybe when I grow up I will know about genetics because maybe I want to *be a teacher*.
3. It was great because you get to *be a scientist* and work with people and breed drakos in the design-a drakos-pod.
4. I want to *be a scientist* now because I know more about genetics.

Feelings category. The feelings category was determined from student responses that indicated a feeling either positive or negative. Words observed as relating to feelings were fun, enjoy, challenging, frustrating, cool, easy, exciting, and awesome. While the Likert survey of engagement shows that students were mostly engaged and enjoying the Drakos mission, comments to the open-ended questions showed that some were challenged and the learning was not entirely fun, even at times, frustrating for some students. Some of the virtual actions that students did not like were those that were repetitive, when selecting an object with a mouse failed to elicit the expected response, difficulty in finding certain locations, and using some of the scientific machines to breed dragonflies. Characters in Quest Atlantis are not always polite, but intentionally rude sometimes in order to provide a practice situation of poor social interactions. This is a recurring theme in Quest Atlantis missions, which requires students to choose how to respond in a socially responsible manner, a construct referred to as a practice field for learning (Barab & Duffy, 2000; Scardamalia & Bereiter, 1993). In working through a

sometimes unpleasant encounter with an unfriendly or biased character, students must deal with their own feelings and reactions, thereby developing a personal history of practicing how to resolve such situations.

Example responses. The following example responses are listed below:

1. I thought it was really *fun* and *exciting* catching the Drakos.
2. Yes because it's *fun, challenging*, and *interesting*.
3. We got lost and the mouse didn't work. *It was hard*.
4. The most *frustrating* about the Drakos mission is when you have to get items for Uther.
5. The only thing that was *frustrating* was when you had to find Ekons cave.

Sense of place category. The place category represents students' expressions about sense of place. An important part of the engagement and attraction to working in a virtual world is the sense of place; that is, the way that participants experience space, objects, terrain, and other characters when they are navigating inside Quest Atlantis via personal avatars (Ketterer & Marsh, 2006; Steinkuehler & Williams, 2006; Suter, 2009). Words and references observed as relating to a sense of place were places, cave, habitat, being in a 3-D world, thought I was, be, and being.

Ideally, participants would begin to feel as though they were living inside the space and interacting directly with the characters. The engagement survey results for statements regarding if students felt they were inside the environment or if the environment was real yielded 93% and 87% respectively in agreement. Working and solving problems in the Drakos mission involved students finding the atrium location where the scientist Uther starts the mission and where the dragonflies lived, working in

the lab, discovering Ekon's disguised cave by clicking on a rock, finding the location of Xinga in her laboratory, and encountering the giant dragonfly named Delon.

Example responses. The following example responses are listed below:

1. I liked *being* in a *3-D world* like Quest Atlantis.
2. It was hard to find Ekon but it was cool that he was *in a cave*.
3. When you *clicked on a rock* you *entered the cave*.
4. I just like *cloning in the lab* because you can make more than you have
5. I *thought I was* the avatar.

The idea of immersion has been argued as a critical component of successful learning in virtual-world environments (Arici, 2008; Dede et al., 2004; Suter, 2009). Qualitative data from students demonstrate that they were not only engaged, but also immersed in the virtual environment.

Discussion of categories. Student references that suggested engagement included immersion in the virtual world, catching dragonflies, breeding dragonflies, learning about habitats, exploring a cave, using machines, having fun, being a scientist, and talking to virtual characters. While some students expressed situations that they found challenging or frustrating, some students expressed they were not frustrated. Situations or events presented by the students that were frustrating or challenging included following instructions from characters in the narrative, traveling back and forth between different characters, difficulty finding some characters, becoming lost in the virtual world, difficulty catching dragonflies, and breeding dragonflies.

Students expressed their overall reaction to the events and activities of the Drakos mission in terms of having or not having an increased affinity for genetics. Content

references included phenotypes, genotypes, genetics, cloning, breeding, calculating with a Punnet square, and working as a scientist. Of the 15 respondents, only one student replied negatively; the remaining 14 replied positively in regard to an increased interest for the concepts learned while working as a genetics scientist in the Drakos mission. Figure 13 provides a clear picture of student engagement with the Drakos mission: 90% in agreement.

Traditional Testing: Pre- and Posttest Results

A common and widely used method for evaluating differences in means between two groups is the paired samples *t*-test (McCall, 2002). For the existing test data in this study, the *t*-test was used to check for a difference in students' pre- and posttest scores. Before and after working in the Drakos mission, the fourth grade students were tested on their knowledge of genetics. Tables 4, 5, and 6 show the available data from the pre- and post- *t*-test scores. Provided are results from paired samples correlations, paired sample statistics, and paired samples test comparisons. Shown are improvements with the pretest to posttest mean increasing from 6.633 to 10.133. Pretest to posttest standard deviation changed from 2.0219 to 4.3072. The paired-samples *t*-test indicated that scores were significantly higher for the posttest subscale ($M = 10.1$, $SD = 4.30$) than for the pretest subscale ($M = 6.63$, $SD = 2.02$), $t(14) = -3.42$, with $r = 0.46$ and $d = 1.04$. The gain is small, but statistically it is significant. Students showed improved results on the posttest following the 5 days of using Quest Atlantis to learn the content of the tests. See Appendix A for the pre- and posttests used.

Table 4

Paired Samples Correlations

Paired Samples Correlations			
	N	Correlation	Sig.
Pretotal & Posttotal	15	.400	.140

Table 5

Paired Samples Statistics

Paired Samples Statistics				
	Mean	N	Std. Deviation	Std. Error Mean
Pretotal	6.633	15	2.0219	.5221
Posttotal	10.133	15	4.3072	1.1121

Table 6

Paired Samples Tests

Paired Samples Test								
Pretotal and Posttotal	Paired Differences					t	df	Sig. 2-tailed
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
	-3.5000	3.9596	1.0224	-5.6928	-1.3072	-3.423	14	.004
Effect Size Calculation: Cohen's d = 1.0402658399709133 Effect-size r = 0.461445								

Discussion of pre- and posttests. A set of traditional test scores was needed for this study in light of the current pressures on educators to prove that learning has occurred by using tests of learned content. These pre- and posttest scores illustrate that student learning in a virtual worlds environment can be accountable, as in traditional educational measuring methods. The engagement survey showed the students' reaction to a challenging, nontraditional learning situation, the virtual Drakos mission. The pre- and posttests show the connection between a traditional format for obtaining knowledge

(testing) with a nontraditional method of exposing students to intended content (genetics). The outcome is clear by the data—students not only reported being engaged in the virtual worlds environment while learning about genetics (as shown by Figure 13), but the knowledge they learned in the virtual environment transferred to a traditional written test, and significant gains were shown

Research Question 3: Other Benefits Teachers Reported

To examine additional input and thoughts from research participants, research question 3 asks: What other benefits do teachers and practitioners see from students working in Quest Atlantis? In addition to responding to online Likert-style engagement statements, Quest Atlantis teachers also provided answers to the following:

1. What did you observe or discover about students working in Quest Atlantis that you would like to share with this study?
2. The socioeconomic status of my class would best be described as:

Low Middle High

Total words for the response to question 2 above consisted of 753 words, with an average of 42 words per response. The researcher used a model by Creswell (1998) for analyzing the data: reading through responses, making summaries, and sorting data into categories or codes. Reading through all responses, the researcher underlined key words related to the seven 21st century competencies addressed in the Quest Atlantis teacher survey. The researcher used a word frequency program for individual words and for recurring phrases to help create a summary. Analyzing involved comparing the resultant summary with themes relevant to the survey questions, creating categories, and then grouping per

category, a method proposed by Bryman and Bell (2007). See Appendix B for the teacher response texts.

Themes From Open-Ended Teacher Responses

Question 2 above is directly aligned with this study's research question 3: What other benefits do teachers and practitioners see from students working in Quest Atlantis? Responses to the open-ended question on the teacher survey addressed this research question. The major themes that emerged from the analysis of text responses were student engagement (seven out of 18 teachers), collaboration (six out of 18 teachers), critical thinking (five out of 18 teachers), global awareness (four out of 18 teachers), and communication (three out of 18 teachers). Table 7 shows the major themes and minor themes that emerged from the open-ended response by percentage of reported frequency.

Table 7

Major and Minor Themes From the Open-Ended Teacher Question

Major Themes
Student Engagement (39%) Collaboration (28%) Critical Thinking (28%) Global Awareness (22%) Communication (17%)
Other Themes (less than 3%)
Motivation Presence in Virtual Space Transfer of Knowledge Improved Behavior Improved work habits Social activism Teacher Professional Development

Teachers were responding to a question regarding other benefits they might want to share with this study. The major themes in Table 6 clearly reinforce the findings in

research questions 1 and 2. Research question 1 addresses 21st century competencies, and teachers reiterated these in their comments with collaboration and critical thinking (28%), global awareness (22%), and communication (17%). The data also connect to research question 2, which addresses student engagement (39%). By triangulation, the data from the teacher open-ended responses support the two research questions.

Benefits volunteered by teachers with less than 3% frequency were listed as minor themes in Table 7. Motivation, for example, ties directly into engagement; if students are motivated to continue, they will persevere in the virtual world or in the real world as well. A sense of presence in the virtual space was mentioned as a benefit, which also emerged as a theme in the student open-ended responses. If the virtual space is perceived as real space, then teachers could expect a higher level of engagement (Steinkuehler & Williams, 2006; Suter, 2009). Transfer of knowledge is important for any learning situation; the idea of what is learned in one context may be extended and utilized in other contexts. Improved behavior and work habits were seen as benefits. Deliberate practice of these skills through the I-BURST rules of conduct (rules learned by new users of Quest Atlantis) and the discipline embedded in activities are common in Quest Atlantis missions. Social activism can be viewed as an outcome of the practice of Personal Agency in Quest Atlantis. Students are guided through missions and activities in which they come to understand that their voices have meaning and that they will be heard. Another theme, teacher professional development, is a requirement for educators to enter into Quest Atlantis. Teachers undergo four class sessions with a Quest Atlantis trainer, and these sessions are conducted online, in-world using the Quest Atlantis program and Skype video conferencing simultaneously. Technology professional development,

therefore, happens up front as teachers use Internet-based tools to begin training, followed by professional development in understanding the Quest Atlantis curriculum, making academic mission choices, using the online teacher toolkit, setting up classes of students, assigning and monitoring student work, and training students in the use of this virtual environment in the classroom.

SES. Teachers were asked to respond to: The socioeconomic status of my class would best be described as: Low, Middle, High. Responses were Low 6, Middle 10, and High 2, for a total of 18 classes (see Appendix B). While this study did not devote a research question to SES, the numbers recorded by teachers could bring useful information to light for the purposes of this study.

The researcher analyzed teacher observation survey data per SES to investigate if patterns or differences might emerge in the teacher ratings of 21st century skills. Table 8 shows the complete breakdown of 21st century competencies per socioeconomic status.

Table 8

Teacher Observations by SES

Teacher Observations by SES							
	Socioeconomic Level				Socioeconomic Level		
	Low	Middle	Upper		Low	Middle	Upper
Technology Skills				Communication			
Strongly Agree	75%	70%	88%	Strongly Agree	60%	42%	50%
Agree	25%	28%	12%	Agree	37%	46%	50%
Neither	0%	2%	0%	Neither	3%	10%	0%
Disagree	0%	0%	0%	Disagree	0%	2%	0%
Strongly Disagree	0%	0%	0%	Strongly Disagree	0%	0%	0%
Critical Thinking				Creativity			
Strongly Agree	56%	43%	67%	Strongly Agree	10%	12%	50%
Agree	38%	32%	33%	Agree	63%	46%	20%
Neither	3%	11%	0%	Neither	23%	40%	10%

(*table continues*)

Teacher Observations by SES								
	Socioeconomic Level					Socioeconomic Level		
	Low	Middle	Upper			Low	Middle	Upper
Disagree	3%	1%	0%		Disagree	4%	2%	20%
Strongly Disagree	0%	0%	0%		Strongly Disagree	0%	0%	0%
Problem Solving					Global Awareness			
Strongly Agree	54%	35%	50%		Strongly Agree	53%	34%	50%
Agree	42%	43%	25%		Agree	47%	50%	50%
Neither	0%	22%	25%		Neither	0%	16%	0%
Disagree	4%	0%	0%		Disagree	0%	0%	0%
Strongly Disagree	0%	0%	0%		Strongly Disagree	0%	0%	0%
Collaboration								
Strongly Agree	56%	33%	50%					
Agree	36%	42%	42%					
Neither	4%	22%	8%					
Disagree	0%	3%	0%					
Strongly Disagree	0%	0%	0%					

Table 8 takes a more detailed view of the overall results shown previously in Table 7: technology skills were highest across all classes observed, while creativity was lowest across all classes. By socioeconomic level, creativity stands out with the least observed results in the Lower SES (10%), second lowest in the Middle SES (12%), and (50%) for the Upper SES. These are lower values than in any other category recorded in the teacher observations. To achieve an overview, Figure 14 shows Strongly Agree and Agree results per SES. The following high and low picture emerges for the categories:

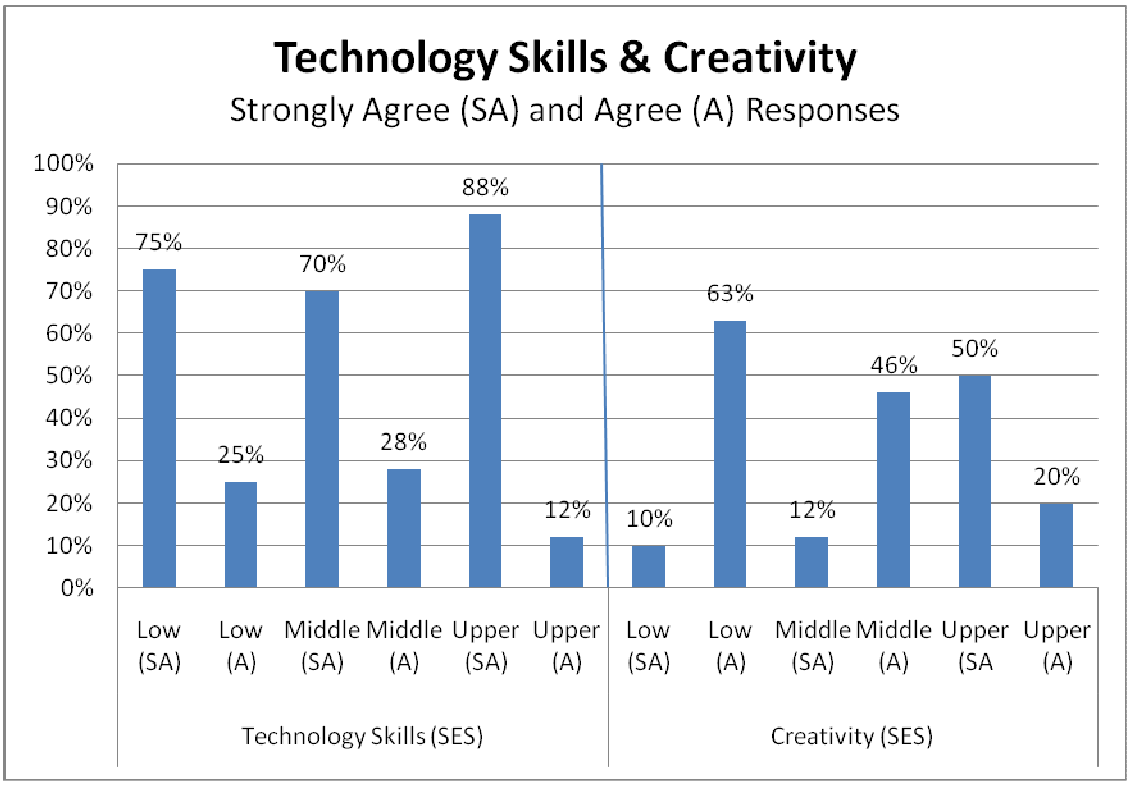


Figure 14. Technology skills and creativity per SES.

Technology skills are high and close in value across SES levels, while creativity was overall observed at a higher rate in the lower SES levels, followed by the Upper, and then the Middle SES level. The reason for higher creativity values among the lower SES groups is not immediately apparent from this study's data and bears further attention. The researcher acknowledges that only two classes of Upper socioeconomic background were included in the teacher observations of 21st century skills, and this group should be enlarged for future examinations to enhance validity of the study.

Noting that total percentages in agreement across all SES groups were high, and that 89% of those observed were middle and lower SES indicates a promising connection to virtual learning in terms of the challenges to public schools where the majority of achievement issues occur in lower and middle socioeconomic populations. Public schools

have increasingly high levels of socioeconomic diversity. Results of the socioeconomic breakdown of data in this section speak to the fact that Quest Atlantis seems to be an effective method for fostering 21st century competencies across the kind of broad population base as is found in public schools.

Summary

Three sources of data are provided in this chapter: existing quantitative data from student pre- and posttests, existing data on student engagement, and qualitative survey results of experienced Quest Atlantis teachers' observations of students using Quest Atlantis in classroom settings. Teacher observations were acquired in an online survey targeting 21st century competencies: technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness. Additional data were gathered on SES, and teachers responded to an open-ended question regarding other benefits of Quest Atlantis that could be shared with this study. A discussion of themes from teacher responses is provided. The major content themes that emerged from teacher comments on benefits they wanted to share with this study were engagement, collaboration, critical thinking, global awareness, and communication.

Pre- and posttest data show gains in learning genetics content from student sessions in a Quest Atlantis mission called Drakos. Results of an engagement survey of student reactions while working in the virtual worlds mission is shown in Figure 13. Students engagement results were 90% in agreement with statements, indicating engagement in terms of perceived challenges, control, skill, importance, success, satisfaction, participation, and a sense of presence in the virtual world.

Three additional open-ended student responses from the engagement survey were analyzed for categories. From that analysis, five categories emerged from student comments: activity, learning, roles, feelings, and place. Students wrote of their experiences and reactions in the comments, expressing the challenges, sometimes the frustrations, and all the while using the vocabulary of the virtual-world mission, indicating they were learning genetics principles.

A discussion on SES was presented, pointing out that 16 out of 18 classes were composed of lower and middle SES. A breakdown of 21st century skills was shown as possibly relevant to future considerations for methods intended to meet the broad socioeconomic range of students in public schools.

This study provides educators and educational game designers with information, culled from the literature and this study's findings, to support virtual-worlds learning in classrooms as a means of cultivating 21st century competencies and increasing student engagement. The data in this chapter suggest implications not only for classroom practice, but also for future research in virtual worlds learning approaches, which will be discussed in Chapter 5.

Chapter 5: Conclusions

Organizations and researchers calling for school reform have begun looking beyond academic skills in terms of testing factual content, and are considering education in terms of the competencies that students need to succeed—21st century competencies, which include technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness (Dede, 2009; Jenkins et al., 2006; Partnership for 21st Century Skills, 2011; Voogt & Roblin, 2010).

Student engagement with learning, particularly in the current test-heavy environment, has been noted as a serious issue in schools across the United States (Barab et al., 2010; Bracey, 2009; Finn & Voelkl, 1993; Fredricks et al., 2004; Willms, 2003; Yeh, 2008). One promising direction for learning is educational gaming (Barab, Dodge, Tuzun, et al., 2007; Gee, 2003).

This mixed-methods study looked at engagement and acquisition of 21st century competencies using a virtual worlds program called Quest Atlantis by surveying experienced Quest Atlantis teachers and using existing data. Acquisition of 21st century competencies was reported along with high engagement, as well as other related results shown in Chapter 4. This chapter is organized as follows: Findings of each research question are reviewed, conclusions of the study are provided, future research in creativity and socioeconomic implications for virtual worlds learning are given, and the chapter concludes with closing thoughts on the promise of virtual learning approaches.

Review of Findings

The following sections summarize previous findings as related to each of the study's research questions.

RQ1: To what degree do the teachers of students who use Quest Atlantis observe 21st century competencies acquisition?

RQ2: To what degree are students engaged while learning with Quest Atlantis?

RQ3: What other benefits do teachers and practitioners see from students working in Quest Atlantis?

21st century competencies acquisition (RQ1). Results from the Quest Atlantis teacher survey showed that their students were practicing and exhibiting 21st century competencies in the classroom. Reports on specific competencies showed technology skills (98%), communication (92%), global awareness (91%), critical thinking (87%), collaboration (84%), problem solving (83%), and creativity (65%). That technology skills received the largest percentage could be a result of the situated setting of using Quest Atlantis; that is, students interface regularly with laptops and desktop computers, mouse, and keyboard. Accessing the virtual world meaningfully also means that students understood how and when to use various screens and menus, and knew which icons and objects could be clicked to begin a particular action or activity.

Communication is built-in, so to speak, in that students communicate on many different levels. They discuss missions and ask questions of classroom peers, sharing information and directions. They send telegrams (a short e-mail) to anyone in the virtual world, and can also talk to any other student or teacher in real time with the text screen. Communication is modeled as narratives unfold, told by Quest Atlantis characters, and as students have the opportunity to respond in conversational situations.

Teachers responded that their students had a strong sense of global awareness, a competency fostered by immersion in a virtual world populated by students and teachers

from five continents. Knowing and understanding the significance of one's place in the world and in the local community is supported by missions in which students are asked to help with dilemmas or situations that affect everyone.

Critical thinking, collaboration, and problem solving were, according to the teachers, a major part of student behaviors while working in Quest Atlantis. In terms of social learning, these three competencies play a major role. Missions such as Drakos encourage students to collaborate, to examine problems together, to think through the issues of the problem, and to sort possible approaches. The deliberate practice of these competencies in meaningful contexts and situations helps students learn how to self-regulate their approaches and how to apply the competencies to other situations. Educators often refer to transfer of knowledge, as in using a fact learned in school for a real-world application, whereas learned competencies are applicable beyond the restrictions of facts and are a way of being, a way of learning in many contexts.

Creativity was observed by Quest Atlantis teachers less frequently than any of the 21st competencies. The Strongly Agree category received 15%. Survey questions limited the responses for creativity to artistic expression, manipulating 3-D structures, creative language use, and art forms and color. Possible reasons for a smaller frequency of observations could be that teachers had not yet assigned missions involving artistic expression or learning to build with 3-D structures.

Student engagement (RQ2). Results came directly from students immersed in Quest Atlantis. The student engagement survey (see Appendix D) showed a high level of engagement. Students responded in terms of their concentration while working and their control of the situation. They indicated they were challenged, they were skillful, and the

work was important to them. They said they were succeeding and they were satisfied with their progress. The environment, although virtual, seemed real to them such that they felt like they were participating in the events of the Quest Atlantis missions. Student responses to open-ended questions support the engagement shown by the survey. Students used the newly learned vocabulary of the Drakos mission in their responses and expressed reinforcement of their engagement in areas of active learning, role models, feelings, and described a sense of presence—that locations in the virtual world seemed real.

Because the outcome of enhanced student engagement in schools has been seen as directly related to higher student achievement, this study incorporated a pre- and posttest to examine the effect of the virtual world on learning. Students showed by their test scores that they had made a significant gain in learning the genetics content of the Drakos mission.

The connections to engagement and increased achievement are evident, and in that the learning happened in a nontraditional setting; using virtual worlds–based curriculum speaks to the efficacy of the approach. Transfer of knowledge can be shown by these results as well because the experience-embedded content in Drakos was different than the format and style of the tests. The test data illustrate that student learning in a virtual worlds environment is as accountable as traditional educational methods.

Other benefits (RQ3). In order to uncover any other topics or concerns not specifically addressed by this study, Quest Atlantis teachers were asked the following question: What did you observe or discover about students working in Quest Atlantis that you would like to share with this study? The number one theme expressed by teachers,

which is highly significant to this study, was that students were engaged learners while using Quest Atlantis. This is important in that it supports the student engagement data described by RQ2. Not only were students exhibiting 21st century competencies, but they were highly engaged, an argument supported in the literature (Barab, Dodge, & Ingram-Goble, A, 2006; Dede et al., 2004; Finn & Voelkl, 1993; Fredricks et al., 2004; Gee, 2003; Willms, 2003; Yeh, 2008).

Minor themes that emerged include improved behavior and work habits, transfer of knowledge, social activism, motivation, a sense of presence in the virtual space, and teacher professional development. Classroom management experts have written on many occasions that one of the keys to a well-run classroom where behavior problems are minimized and students are working is keeping students engaged in their learning (Hoy & Weinstein, 2006). Teacher professional development is an important minor theme, as it is one of the significant aspects of improving student achievement being addressed in recent years (NETP, 2010; Partnership for 21st Century Skills, 2011).

Conclusions

The purpose of this study was to cast light on effective virtual-world approaches that cultivate 21st century competencies and student engagement in schools. Based on the information from the literature on engagement, educational gaming, virtual environments, student achievement, learning theory, 21st century competencies, and on the analysis of quantitative and qualitative data, the following conclusions can be made from this study:

1. Using Quest Atlantis fosters the acquisition of 21st century competencies in students as reported by their teachers;

2. The Quest Atlantis virtual environment is highly engaging for students according to reports from both students and teachers; and
3. Academic content learned in the Quest Atlantis virtual world can be used as a measure of understanding in that it transfers to traditional testing formats.

Quest Atlantis cultivates 21st century competencies. Data analyzed in this study show that Quest Atlantis teachers are observing 21st century competencies in the behaviors and actions of their students. The data show this in the teacher survey and in the teacher open-ended comments (see Appendix B).

The importance of these competencies is supported in the literature from the perspective of practice fields (Barab & Duffy, 2000) learning by doing (Dewey, 1963; Gee, 2003), situated cognition (Brown et al., 1989), collaborative learning in communities (Jenkins et al., 2006; Lave & Wenger, 1991; Squire et al., 2008), and deliberate practice (Colvin, 2008). In the act of using these competencies, students cultivate new levels of competency and deeper understanding of associated content. Immersion in a pursuit, whether in the real or virtual world, places the learner ready to proceed on a complex journey in which he or she will use a combination of knowledge and competencies to succeed (Gee, 2003). In Quest Atlantis, learners of differing abilities and interests find themselves challenged to complete missions, which directly and subtly take the learners on a practice path to embark on systematic use of technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness.

New research on 21st century competencies by Peppler and Solomou (2011) has been published since this researcher began the current study; their research supports

previous literature on learning in virtual worlds, as well as supporting data from the current study. Peppler and Solomou focused on digital creativity as it occurs in a virtual architecture unit in Quest Atlantis. Collaboration, problem solving, communication, and the use of social media emerge as significant means of fostering creativity in their work. Their view offers a blending of 21st century competencies and demonstrates the interrelatedness of the competencies that are integral to learning. They argue that creativity in virtual worlds can be seen as more collaborative than individual behavior. The Likert-style questions to Quest Atlantis teachers on creativity from the current study (see Appendix B) also examine building with 3-D structures as a descriptor of creative behavior. Peppler and Solomou describe creativity in terms of collaborating in 3-D space while socializing and collaborating with communication technology: "Creative ideas were those that were adopted in the 3D space and were appropriated within Questers' online chat and building practices" (p. 18). Clearly, this new research also uncovers evidence of students deliberately practicing, effectively cultivating 21st century competencies.

Virtual environments enhance student engagement. Likert-style data as well as open-ended response data in this study show that students experienced high levels of engagement in Quest Atlantis. Engagement in Quest Atlantis is fostered as students have opportunities for choice, socialization, exploration, and individual curriculum pathways (differentiation). Actions by students in Quest Atlantis have consequences and meaning that enhance engagement with learning activities and associated content (Barab & Duffy, 2000; Lave & Wenger, 1991). Peer teaching and collaboration happen naturally as students solve problems and navigate the terrain of the virtual environment, teleporting to

different worlds, encountering role models, negotiating meaning, creating with 3-D structures, renting virtual land, and all while learning academic content embedded in missions and quests.

Knowledge is transferred from virtual to real-world applications. This study showed that students learned genetics content through their experiences in the Quest Atlantis Drakos mission, and the evidence of that learning was shown in traditional testing format. Students gained knowledge of dragonfly phenotypes through immersive virtual world experiences, then transferred their understanding to a posttest requiring a basic understanding of genetics.

With the focus of today's schools overwhelmingly on standardized testing, educational gaming may be perceived as inappropriate for meeting accountability requirements. This study has shown otherwise. Evidence from the literature on virtual world learning benefits (Annetta et al., 2009; Arici, 2008; Barab, Dodge, Tuzun, et al., 2007; Gee, 2003; Gee & Shaffer, 2010) confirms that participants consistently gain knowledge at high levels, and further, use their acquired knowledge and experiences to continue their personal learning paths (i.e., they only move forward in the game if they learn and succeed with each mission task). Gee (2003, 2005) wrote extensively on the intrinsic engagement of virtual learning coupled with the acquisition of in-world knowledge and competencies that are not only readily useful in the real world, but are quickly becoming requirements by companies seeking competent innovative, collaborative workers.

Suggestions for Future Research

This mixed-methods study showed literature research and data supporting promising virtual world approaches for fostering 21st century competencies and increasing student engagement in schools. The results of this study can be useful to educators as they struggle with pressures from politicians and the U.S. Department of Education to show improvement in student achievement. As educators make decisions for software in schools to help student achievement, they are encouraged to seek solutions such as Quest Atlantis, one which has been shown to foster 21st century competencies, increase student engagement, and promote the learning of testable academic content. From the data returned in this study, two topics for further research in virtual worlds learning have emerged: creativity and the effect of SES.

Creativity. Creativity was scored the lowest among the observable 21st century competencies. Possible reasons could include teacher choices in missions such that creativity-based lessons might be overlooked if teachers feel pressure to assign missions in math or literacy. Building 3-D structures in Quest Atlantis is a creative endeavor that is perhaps among the most free form of available activities. Building takes considerable time to practice and learn and could be seen by teachers as a poor use of time in a school day under pressure to cover curriculum. Current studies by Peppler and Solomou (2011) are progressing in this area, combining literature themes with architecture and social media to bring creativity to light in virtual worlds. To expand on their work, an in-depth study of creativity as it applies to concrete actions that teachers can see as increasing student achievement is recommend. A qualitative study involving a version of the pre-

and posttesting done in this study could be applied to creative writing, design, and fine arts content.

In fostering 21st century competencies, creativity underpins a particular area of importance. Innovation is highly regarded and is often touted as the key to economic success and the future of the United States. To be innovative involves an understanding of how to create, and most often, innovators have been seen to emerge after significant experiences and education rather than being born on the cutting edge of a discipline (Jones, 2008). Participating with others, collaboratively solving problems, can lead to innovative approaches. Creating can mean observing what exists, and assembling those components or concepts in atypical ways sometimes contrary to the status quo.

SES. This study did not target SES as one of the research questions, but SES emerged as an area with possible implications. A quantitative study of student SES as it relates to learning in virtual worlds is recommended. SES came to light in this study because of the broadening, diverse population of students attending public schools. SES in education has been analyzed for many purposes, but most often for allocation of services or revenues. Educators have pointed to inequities in schools in that many low income groups in predominantly low income populated schools spend more time drilling for tests than students in more affluent schools. Opportunities for developing 21st century competencies are rarely observed under test-heavy conditions where teachers and administrators are under pressure to meet standardized test goals. It is feasible that specific variables related to SES could emerge to guide further the design of effective and engaging virtual worlds learning environments, especially for students in high-needs schools. Applying a virtual worlds quantitative study targeting specific content such as is

currently under development in the Common Core Standards could be an approach advantageous to both disengaged students and educators seeking to meet the new standards.

Summary

This study has explored new learning approaches using virtual worlds as a means for addressing low student engagement in schools and fostering 21st century competencies. While standardized testing has been the major approach in attempts to improve student achievement, it has not been shown to be an effective solution, as educators and researchers agree that excessive preparation and practicing for tests does not address the competencies students need for learning to take place. Education recommendations at the national level present a broader view of learning beyond traditional schooling. The U.S. Department of Education has published in its NETP (2010) that academic content can be taught and learned in a variety of situations using educational technology, and student achievement can be seen and measured in ways other than high-stakes standardized testing. New ideas include promoting 21st century competencies and creating noninvasive assessments with technology to measure those competencies. The need to engage students in small and large groups, in which they participate in learning suited to individual interests, is cited as what learning should look like. Included in the recommendations of methods for engaging students are virtual worlds, games, and other interactive, exploratory technologies with embedded academic content. The NETP (2010) states, "Twenty-first-century competencies and such expertise as critical thinking, complex problem solving, collaboration, and multimedia communication should be woven into all content areas" (p. 13).

This mixed-methods study used quantitative and qualitative data from students and trained teachers experienced with a virtual worlds learning environment called Quest Atlantis. Research questions addressed teacher observations of 21st century competencies in students, the degree that students are engaged with Quest Atlantis, and looked for other benefits seen by teachers. Findings indicated that 21st century competencies were demonstrated in high frequency among students, as reported by teachers; students were highly engaged; content learned in virtual worlds was evidenced in traditional testing; and low SES students demonstrated 21st century competencies as much as other students. Future research is recommended to examine why relatively lower levels of student creativity were reported by teachers in this study. Additionally, because students of low SES showed equal or better results in 21st century competencies, further study of socioeconomic variables relating to learning in virtual worlds is recommended.

Quest Atlantis is one example of virtual worlds learning that brings many critical aspects of learning together. As educators make decisions about future effective learning approaches, and as educational game designers move toward innovative products, both groups may see mutual benefit as their interests intersect in virtual worlds.

REFERENCES

Alexander, K. L., Entwisle, D. R., & Dauber, S. L. (1993). First-grade classroom behavior: Its short-and long-term consequences for school performance. *Child Development, 64,* 801–814. doi:10.1111/j.1467-8624.1993.tb02944.x

Alexander, K. L., Entwisle, D. R., & Horsey, C. S. (1997). From first grade forward: Early foundations of high school dropout. *Sociology of Education, 70,* 87–107. Retrieved from http://www.jstor.org/stable/2673158

Amrein, A. L., & Berliner, D. C. (2002). High-stakes testing, uncertainty, and student learning. *Education Policy Analysis Archives*, *10*(18). Retrieved from http://epaa.asu.edu/epaa/v10n18/.

Andrew, S., & Halcomb, E. J., (Eds.). (2009). *Mixed methods research for nursing and the health sciences*. Chichester, United Kingdom: Wiley-Blackwell.

Annetta, L., Mangrum, J., Holmes, S. Collazo, K., & Cheng, M. (2009). Bridging realty to virtual reality: Investigating gender effect and student engagement on learning through video game play in an elementary school classroom. *International Journal of Science Education*, *31,*(8), 1091–1113. doi:10.1080/09500690801968656

Arici, A. (2008). *Meeting kids at their own game: A comparison of learning and engagement in traditional and 3D muve educational-gaming context* (Unpublished doctoral dissertation). Indiana University, Bloomington, IN.

Barab, S., Arici, A., & Jackson, C. (2005). Eat your vegetables and do your homework: A design-based investigation of enjoyment and meaning in learning. *Educational Technology, 65*(1), 15–21. Retrieved from http://inkido.indiana.edu/research/onlinemanu/papers/eat your veggies23.pdf

Barab, S., Dodge, T., & Ingram-Goble, A. (2006). *Reflexive play spaces: A 21st century pedagogy.* Paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.

Barab, S., Dodge, T., Thomas, M., Jackson, C., & Tuzun, H. (2007). Our designs and the social agendas they carry. *Journal of the Learning Sciences, 16*(2), 263–305. doi:10.1080/10508400701193713

Barab, S., Dodge, T., Tuzun, H., Job-Sluder, K., Jackson, C., Arici, A., …Heiselt, C. (2007). The Quest Atlantis Project: a socially-responsive play space for learning. In B. E. Shelton & D. Wiley (Eds.), *The educational design and use of simulation computer games* (pp. 159–186). Rotterdam, The Netherlands: Sense Publishers. doi:10.1.1.88.2456

Barab, S., & Duffy, T. M. (2000). From practice fields to communities of practice. In D. Jonassen & S. Land (Eds.), *Theoretical foundation of learning environments* (pp. 25–56). Mahwah, NJ: Erlbaum.

Barab, S., Gresalfi, M., Dodge, T., & Ingram-Goble, A. (2010). Narratizing disciplines and disciplinizing narratives: Games as 21st-century curriculum. *International Journal for Gaming and Computer Mediated Simulations*, *2*(1), 17–30. doi:10.4018/jgcms.2010010102

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research & Development, 53*(1), 86–107. doi:10.1007/BF02504859

Barab, S., Thomas, M. K., Dodge, T., Newell, M., & Squire, K. (2004). Critical design ethnography: Designing for change. *Anthropology & Education Quarterly, 35*(2), 254–268. doi:10.1525/aeq.2004.35.2.254

Barab, S., Zuiker, S., Warren, S., Hickey, D., Ingram-Goble, A., Kwon, E-J., …Herring, S. C. (2007). Situationally embodied curriculum: Relating formalisms and contexts. *Science Education*, *91*(5), 750–782. doi:10.1.1.137.7291

Blumenfeld, P., Soloway, E., Marx, R., Krajcik, J., Guzdial, M., & Palincsar, A. (1991). Motivating project-based learning: Sustaining the doing, supporting the learning. *Educational Psychologist*, *26*(4), 369–398.

Bowen, B. (2002). *Student engagement and its relation to quality work design: A review of the literature*. Retrieved from http://chiron.valdosta.edu/are/ebowenLitReview.pdf

Bracey, G. (2009). *The Bracey Report on the condition of public education.* Boulder, CO and Tempe, AZ: Education and the Public Interest Center & Education Policy Research Unit. Retrieved from http://epicpolicy.org/publication/Bracey-Report

Bridgeland, J., Dilulio, J., & Morrison, K. (2006). *The silent epidemic: Perspectives of high school dropouts.* A report by Civic Enterprises in association with Peter D. Hart Research 35 Associates for the Bill & Melinda Gates Foundation. Retrieved from http://www.civicenterprises.net/pdfs/thesilentepidemic3-06.pdf

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42. doi:10.3102/0013189X018001032

Bryman, A., & Bell, E. (2007). *Business research methods* (2nd ed.). New York, NY: Oxford University Press.

Colvin, G. (2008). *Talent is Overrated: What Really Separates World-Class Performers from Everybody Else.* New York, NY: The Penguin Group.

Connell, J. P. (1990). Context, self, and action: A motivational analysis of self-system processes across the life-span. In D. Cicchetti (Ed.), *The self in transition: Infancy to childhood* (pp. 61–97). Chicago, IL: University of Chicago Press.

Corno, L., & Mandinach, E. (1983). The role of cognitive engagement in classroom learning and motivation. *Educational Psychologist, 18*, 88–108. doi:10.1080/00461528309529266

Creswell, J. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: Sage.

Creswell, J. W., & Clark, V. L. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Csíkszentmihályi, M. (1990). *Flow: The psychology of optimal experience.* New York, NY: Harper & Row.

De Freitas, S. (2006). *Learning in immersive worlds. A review of game-based learning*. Retrieved from http://www.jisc.ac.uk/media/documents/programmes/elearning _innovation/gaming report_v3.3.pdf

De Freitas. S. (2008). *Serious virtual worlds: A scoping study joint information systems committee*. Prepared for the JISC e-Learning Programme. Retrieved from http://www.jisc.ac.uk/media/documents/publications/seriousvirtualworldsv1.pdf

Dede, C. (2009). Immersive interfaces for engagement and learning. *Science, 323*(5910), 66–69. doi:10.1126/science.1167311

Dede, C. (2010). Comparing frameworks for 21st century skills. In J. Bellanca & R. Brandt (Eds.), *21st century skills* (pp. 51–76). Bloomington, IN: Solution Tree Press.

Dede, C., Ketelhut, D., & Ruess, K. (2003). *Designing for motivation and usability in a museum based multi-user virtual environment*. Retrieved from http://muve.gse.harvard.edu/muvees2003/documents/AELppr.pdf

Dede, C., Nelson, B., Ketelhut, D., Clarke, J., & Bowman, C. (2004). *Design-based research strategies for studying situated learning in a multi-user virtual environment.* Paper presented at the 2004 International Conference on Learning Sciences. Mahweh, NJ.

Dewey, J. (1963). *Experience & education.* New York, NY: Macmillan.

Dickey, M. D. (2005). Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. *Educational Technology Research and Development, 53*(2), 67–83. Retrieved from http://it.coe.uga.edu/studio/new_site_content/onlinearticles2/dickey2005.pdf

Doherty, K., & Abernathy, S. (1998).Turning around low-performing schools: A guide for state and local leaders. Washington, DC: U.S. Department of Education. Retrieved from http://www.ed.gov/pubs/turning

Duncan, A. (2010). *Secretary Arne Duncan's Remarks at OECD's Release of the Program for International Student Assessment (PISA) 2009 Results.* Retrieved from U. S. Department of Education website: http://www.ed.gov/news/speeches/secretary-arne-duncans-remarks-oecds-release-program-international-student-assessment

Eccles, J. S., & Midgley, C. (1989). Stage/environment fit: Developmentally appropriate classrooms for early adolescents. In R. Ames & C. Ames (Eds.), *Research on motivation in education* (Vol. 3, pp. 139–181). New York, NY: Academic Press.

Finn, J. D. (1993). *School engagement and students at risk* (Publication No. NCED 93470). Washington, DC: US Department of Education, National Center of Educational Statistics. (ERIC Document Reproduction Service No. ED 362 322).

Finn, J. D., & Voelkl, K. E. (1993). School characteristics related to student engagement. *Journal of Negro Education*, *62*, 249–268. Retrieved from www.uccs.edu/Documents/coe/people/faculty/carpenterd/GapOrGaps.pdf

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. doi:10.3102/00346543074001059.

Friedman, T. (2005). *The world is flat.* New York, NY: Farrar, Straus & Giroux.

Gardner, H. (1991). *The unschooled mind: How children think and how schools should teach*. New York, NY: Basic Books.

Gardner, H. (1999). *The disciplined mind: What all students should understand*. New York, NY: Simon & Schuster.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York, NY: Palgrave Macmillan.

Gee, J. P. (2005). *Why video games are good for your soul*. Sydney, Australia: Common Ground.

Gee, J. P., & Shaffer, D. W. (2010). *Looking where the light is bad: Video games and the future of assessment* (Epistemic Games Group Working Paper No. 2010-02). Madison, WI: University of Wisconsin-Madison.

Gerstein, J. (2009). Beyond the game: Quest Atlantis as an online learning experience for gifted elementary students. *Journal of Virtual WorldsResearch, 2*(1), 4–18. Retrieved from http://journals.tdl.org/jvwr/article/viewArticle/403313795

Greeno, J. G., Collins, A. M., & Resnick, L. B. (1996). Cognition and learning. In D. B. R. Calfee (Ed.), *Handbook of educational psychology* (pp. 15–46). New York, NY: Simon & Schuster Macmillan.

Hanushek, E. A. (2002) *The long run importance of school quality* (National Bureau of Economic Research Working Paper No. W9071). Available at SSRN: http://ssrn .com/abstract=319747

Henry, P. (2007). The case against standardized testing. *The Minnesota English Journal*, (43), 39–71. Retrieved from http://www.mcte.org/journal/mej07/3Henry.pdf

Herz, J. C. (1997). *Joystick nation: How videogames ate our quarters, won our hearts, and rewired our minds.* Boston, MA: Little, Brown and Company.

Hoy, A. W., & Weinstein, C. S. (2006). Students' and teachers' knowledge and beliefs about classroom management." In C. Evertson & C. Weinstein (Eds.), *Handbook of classroom management: Research, practice, and contemporary issues,* (pp. 181–220). Mahwah, NJ: Erlbaum.

Ingels, S. J., Burns, L. J., Charleston, S., Chen, X., Cataldi, E. F., & Owings, J. A. (2005). *A profile of the American high school sophomore in 2002: Initial results from the base year of the Education Longitudinal Study of 2002* (NCES 2005-338). Retrieved from http://nces.ed.gov/pubs2005/2005338.pdf

Janesick, V. J. (1998). *Journal writing as a qualitative research technique: History, issues and reflections.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Jenkins, H., Clinton, K., Purushotma, R., Robison, A. J., & Weigel, M. (2006). *Confronting the challenges of participatory culture: Media education for the 21st century*. Chicago, IL: The MacArthur Foundation.

Jonassen, D. H. (1988). Integrating learning strategies into courseware to facilitate deeper processing. In D. H. Jonassen (Ed.), *Instructional designs for microcomputer courseware* (pp. 151–181). Hillsdale, NJ: Lawrence Erlbaum.

Jones, B. F. (2008). The burden of knowledge and the death of the renaissance man: Is innovation getting harder? *Review of Economic Studies*. Retrieved from http://www.nber.org/papers/w11360

Jones, B., Valdez, G., Norakowski, J., & Rasmussen, C. (1994). Designing learning and technology for educational reform. *North Central Regional Educational Laboratory.* Retrieved from http://www.ncrtec.org/capacity/profile/profwww.htm

Kaptelinin, V., & Nardi, B. (2006). *Acting with technology: Activity theory and interaction design*. Cambridge, MA: MIT Press.

Karoly, L. A. (2004). *The 21st century at work: Forces shaping the future workforce and workplace in the United States*. Santa Monica, CA: RAND Corporation.

Ketelhut, D. J., Dede, C., Clarke, J., Nelson, B., & Bowman, C. (2007). Studying situated learning in a multi-user virtual environment. In E. Baker, J. Dickieson, W. Wulfeck, & H. O'Neil (Eds.), *Assessment of problem solving using simulations*. Mahwah, NJ: Lawrence Erlbaum Associates.

Ketterer, J., & Marsh, G. (2006). Re-conceptualizing intimacy and distance in instructional models. *Online Journal of Distance Learning Administration, 9*. Retrieved from University of West Georgia website: http://www.westga.edu/~distance/ ojdla/spring91/ketterer91.pdf

Klopfer, E., Osterweil, S., & Salen, K. (2009). *Moving learning games forward*. Boston, MA: Creative Commons. Retrieved from http://education.mit.edu/papers/ MovingLearningGamesForward_EdArcade.pdf

Kohn, A. (1992). *No contest: The case against competition*. Boston, MA: Houghton Mifflin.

Kohn, A. (2000). *The case against standardized testing: Raising the scores, ruining the schools*. Portsmouth, NH: Heinemann.

Kozol, J. (2007). Letters to a young teacher. *Education Week.* Retrieved from http://www.edweek.org/ew/articles/2007/08/29/01kozol.h27.html

Ladwig, J. G. (2010). Beyond academic outcomes. *Review of Research in Education, 34*, 113–141. doi:10.3102/0091732X09353062

Land, S. M. (2000). Student-centered learning environments. In D. Johanassen & S. M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 1–23). Hillsdale, NJ: Lawrence Erlbaum.

Lasserre-Cortez, S. (2006). *A mixed methods examination of professional development through whole faculty study groups* (Unpublished doctoral dissertation).

Louisiana State University, Baton Rouge, LA.

Laurel, B. (1998). An interview with Brenda Laurel. In J. Cassell & H. Jenkins (Eds.), *From Barbie to Mortal Kombat: Gender and computer games* (pp. 118–135). Cambridge, MA: MIT Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* New York, NY: Cambridge University Press.

Lucas, K., & Sherry, J. L. (2004). Sex differences in video game play: A communication-based explanation. *Communication Research, 31*(5), 499–523. doi:10.1177/0093650204267930

Ludgate, H. (2008). *Inside curriculum-embedded virtual worlds: Collaborative dialogue in Quest Atlantis* (Doctoral dissertation). Retrieved from Dissertations & Theses at Pepperdine University - SCELC. (Publication No. AAT 3324602).

Malaby, T. (2009). *Making virtual worlds: Linden lab and second life*. Ithaca, NY and London, United Kingdom: Cornell University Press.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science, 4*, 333–369. Retrieved from http://www.wiley.com

McCall, C. H. (2002). *Understanding statistical methods* (1st ed.). New York, NY: Writers Club Press.

McMillan, J. H., & Schumacher, S. (2010). *Research in education: Evidenced based inquiry*. Boston, MA: Pearson.

National Education Technology Plan. (2010). *Transforming American education: Learning powered by technology. National education technology plan, 2010.* [Technical report]. Retrieved from U.S. Department of Education website: http://www.ed.gov/technology/netp-2010

Newmann, F. (1992). Higher-order thinking and prospects for classroom thoughtfulness. In F. Newmann (Ed.), *Student engagement and achievement in American secondary schools* (pp. 62–91). New York, NY: Teachers College Press.

Newmann, F., Wehlage, G. G., & Lamborn, S. D. (1992). The significance and sources of student engagement. In F. Newmann (Ed.), *Student engagement and achievement in American secondary schools* (pp. 11–39). New York, NY: Teachers College Press.

Ohanian, S. (1999). *One size fits few: The folly of educational standards*. Portsmouth, NH: Heinemann.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York, NY: Basic Books.

Partnership for 21st Century Skills. (2011). *Framework for 21st century learning*. Retrieved from http://www.21stcenturyskills.org/index.php?option=com_content&task=view&id=254&Itemid=120

Peppler, K., & Solomou, M. (2011). Building creativity: Collaborative learning and creativity in social media ennvironments. *On the Horizon, 19*(1), 13–23. Retrieved http://kpeppler.com/wp-content/uploads/2011/03/2011_Peppler_Building_Creativity.pdf

Pepperdine University. (2009). *Protection of human participants in research: Policies and procedures manual* (Rev. ed.). Retrieved from http://services.pepperdine.edu/irb/policies/appb_exempted.htm

Perkins, D. (1993). Person-plus: A distributed view of thinking and learning. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations* (pp. 88–110). Cambridge, United Kingdom: Cambridge University Press.

Popham, W. J. (2002). *Classroom assessment: What teachers need to know:* Boston, MA: Allyn and Bacon.

Prensky, M. (2001). *Digital game-based learning*. New York, NY: McGraw-Hill.

Quest Atlantis: Home Page. (n.d.). Retrieved from http://atlantis.crlt.indiana.edu/

Quest Atlantis: QA Grant Support. (n.d.). Retrieved from http://atlantis.crlt.indiana.edu/site/view/Sponsors#23

Scardamalia, M., & Bereiter, C. (1993). Technologies for knowledge-building discourse. *Communications of the ACM, 36*, 37–41. doi:10.1145/155049.155056

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational Psychology Review, 7*(4), 351–371. Retrieved from http://digitalcommons.unl.edu/edpsychpapers/40

Shaffer, D. W. (2006). *How computer games help children learn*. New York, NY: Palgrave Macmillan.

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research, 78*(1), 153–189. doi:10.3102/0034654307313795

Shute, V. J., & Torres, R. (in press). Where streams converge: Using evidence-centered design to assess Quest to Learn. In D. Robinson, J. Clarke-Midura, & M. Mayrath (Eds.), *Technology-based assessments for 21st century skills: Theoretical and practical implications from modern research.* New York, NY: Springer-Verlag.

Soderberg, P., & Price, F. (2003). An examination of problem-based teaching and learning in population genetics and evolution using EVOLVE: A computer simulation. *International Journal of Science Education, 25*(1), 35–55. doi:10.1080/09500690110095285

Squire, K. D., DeVane, B., & Durga, S. (2008). Designing centers of expertise for academic learning through video games. *Theory into Practice, 47*(3), 240–251. Retrieved from http://website.education.wisc.edu/kdsquire/tenure-files/07-squire-TIP-CIV3-devane-durga.pdf

Steinkuehler, C., & Williams, D. (2006). Where everybody knows your (screen) name: Online games as "third places."*Journal of Computer-Mediated Communication, 11*(4). doi:10.1111/j.1083-6101.2006.00300.x

Strangman, N., Hall, T., & Meyer, A. (2003). *Virtual reality/simulations with UDL.* Wakefield, MA: National Center on Accessing the General Curriculum. Retrieved from http://aim.cast.org/learn/historyarchive/backgroundpapers/virtual_simulations_udl

Suter, V. (2009). *I am here—are you there? Sense of presence and implications for virtual world design* (Doctoral dissertation). Retrieved from Dissertations & Theses at Pepperdine University - SCELC. (Publication No. AAT 3449167).

Sykes, W., & Reid, R. D. (1999). Virtual reality in schools: The ultimate educational technology. *THE Journal*, *26*(7), 61-64. Retrieved from http://www.questia.com/googleScholar.qst?docId=5001235196

Van Eck, R. (2007). Building artificially intelligent learning games. In D. Gibson, C. Aldrich, & M. Prensky (Eds.), *Games and simulations in online learning: Research and development frameworks* (pp. 271–307). Hershey, PA: Information Science.

Vandeventer, S. S., & White, J. A. (2002). Expert behavior in children's video game play. *Simulation & Gaming, 33*(1), 28–48. doi:10.1177/1046878102033001002

Vendlinski, T., & Stevens, R. (2002). Assessing student problem-solving skills with complex computer-based tasks. *Journal of Technology, Learning, and Assessment, 1*(3). Retrieved from http://www.jtla.org

Voogt, J., & Roblin, N. P. (2010). *21st century skills discussienota*. Universiteit Twente. Retrieved from http://onderzoek.kennisnet.nl/onderzoeken/overig /21stcenturyskillsdiscussienota

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wehlage, G. G., Rutter, R. A., Smith, G. A., Lesko, N. L., & Fernandez, R. R. (1989). *Reducing the risk: Schools as communities of support*. Philadelphia, PA: Farmer Press.

Weiss, H. B, Mayer, E., Kreider, H., Vaughn, M., Dearing, E., Hencke, R., & Pinto, K. (2003). Making it work: Low-income working mothers' involvement in their childrens' education. *American Educational Research Journal, 40*(4), 879–901. Retrieved from http://www.jstor.org/pss/3699411

Willms, J. D. (2002). *Vulnerable children: Findings from Canada's national longitudinal survey of children and youth.* Edmonton, AB: University of Alberta Press.

Willms, J. D. (2003). *Student engagement at school: A sense of belonging and participation. Results from PISA 2000.* Paris, France: OECD.

Woodard, E. H., IV, & Gridina, N. (2000). *Media in the home 2000: The fifth annual survey of parents and children* (Survey Series No. 7). Philadelphia, PA: Annenberg Public Policy Center of the University of Pennsylvania.

Yeh, S. (2008). The cost-effectiveness of comprehensive school reform and rapid assessment. *Education Policy Analysis Archives*, (16), 13. Retrieved from http://epaa.asu.edu/ojs/article/viewFile/38/164

APPENDIX A

Pre- & Posttests

Name: _____ Date: _____

SECTION A

1. Your class just received six new hamsters. Their names are Billy, Suzy, Meimei, Ogun, Hiro and Kaya. The chart below shows what we know about hamster genes. Use your knowledge of genetics to find out more about your new pet hamsters.

Hamster Genes		
Fur length	**Long: BB or Bb**	**Short: bb**
Tail	**Tail: RR or Rr**	**No tail: rr**
Color	**Brown: DD or Dd**	**White: dd**

Billy the hamster genotypes
Bb **Rr** **Dd**

Study the chart on hamster genes. Look at Billy the hamster's genotypes and answer the following questions.

A. What type of fur does Billy have? _____

B. Does Billy have a tail? _____

C. What color is Billy? _____

Suzy the hamster phenotypes
Short fur **Has tail**

Study the chart on hamster genes. Circle ALL the genotypes that might match Suzy the

hamster's phenotypes:

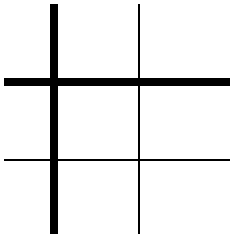
D. Suzy has short fur. What might her *fur* genotype be?

BB Bb bb

E. Suzy has a tail. What might her *tail* genotype be?

RR Rr rr

2. Put dots in the spaces that represent ADULTS on a Punnett Square.



3. Meimei and Ogun are going to have babies. Use the chart below to answer the questions about their offspring.

Hamster Genetics		
Fur length	**Long: BB or Bb**	**Short: bb**
Tail	**Tail: RR or Rr**	**No tail: rr**

Meimei the hamster's genotype
Bb

Ogun the hamster's genotype
bb

A. Use the *Punnett Square* on the right to answer the question. You can also use the information in the chart above.

Could one of Meimei's and Ogun's offspring have short fur?
Yes ____ No ____

	B	**b**
b		
b		

B. Meimei has the Rr genotype for tail while Ogun has no tail. Use the space below to show your work and answer questions C and D.

C. Could one of Meimei's and Ogun's offspring have a tail? Yes ____ No ____
D. If Meimei and Ogun have 4 offspring, how many will have no tail?

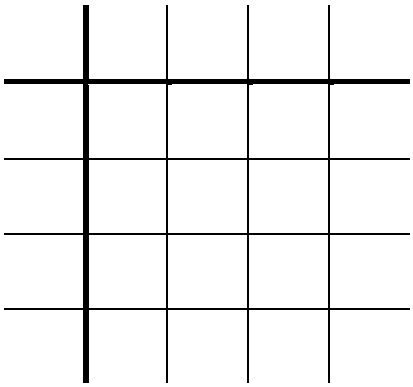
0 ____ 1/4 ____ 2/4 ____ 3/4 ____ 4/4 ____

4. Hiro and Kaya are going to have babies. Use the chart below to answer the questions about their offspring. You may use the Punnett Square below to help you.

Hamster Genetics		
Fur length	**Long: BB or Bb**	**Short: bb**
Tail	**Tail: RR or Rr**	**No tail: rr**

Kaya the hamster's genotypes
Bb
Rr

Hiro the hamster's genotypes
bb
rr



A. Using the Punnett Square above, could one of Hiro and Kaya's babies have **long fur** and AND a **tail**?

Yes ____ No ____

B. If Hiro and Kaya have 16 babies, how many will have **long fur** AND **no tail**? Circle the correct answer.

1/16	**2/16**	**3/16**	**4/16**	**5/16**	**6/16**	**7/16**	**8/16**
9/16	**10/16**	**11/16**	**12/16**	**13/16**	**14/16**	**15/16**	**16/16**

OR, impossible to tell from what's given ____

5. Another inherited trait in hamsters is *size*, represented by the letter A. Large size is the dominant phenotype. Both Billy and Suzy are big, but they had 3 big and 1 small offspring.

A. Based on the information above, which genotype does Suzy have? _____
B. Based on the information above, which genotype does Billy have? _____
C. Another class in your school wants to have hamsters of their own. They have asked for baby hamsters with a particular color. Please use the information below to help you decide which hamsters to breed.

Hamster characteristics: D = Dominant (brown) d = Recessive (white)

Female hamsters		
Meime  **Genotype: DD**	Suzy  **Genotype: Dd**	Kaya  **Genotype: dd**

Male hamsters		
Bill  **Genotype: DD**	Ogun  **Genotype: Dd**	Hiro  **Genotype: dd**

A. Which pair of male and female hamsters will produce:
100% brown hamsters? _____

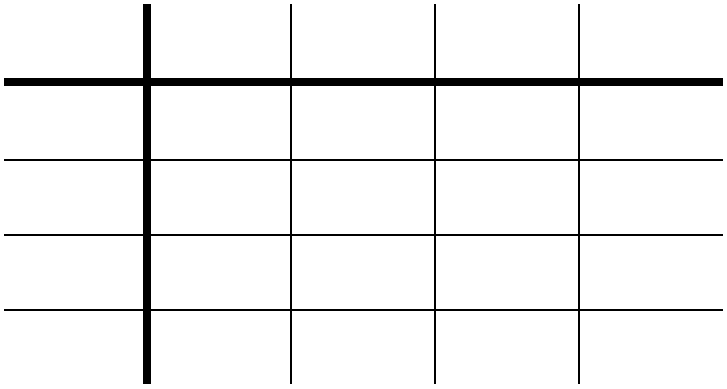
100% white hamsters? _____
50% brown and 50% white hamsters? _____

B. You are also required to produce hamsters of specific size and color.

Size Trait:	A = Dominant (big)	a = Recessive (small)
Color Trait:	D = Dominant (brown)	d = Recessive (white)

Fill in the Punnett square below with the AADD and AaDd genotypes.

Genotypes:



C. How many of the following phenotypes are possible if you breed AADD and AaDd?

Big brown_____ Big white _____ Small brown _____ Small white _____

1. Draw a line to match a term to the example given.

Term	Definition
allele	F
phenotype	FfYy

genotype	color
trait	green

2. Laura and Tim hamster both have brown fur. But their baby, Tabitha, has white fur.

    a. Use all or some of the terms given in the box to explain how Tabitha has white fur.

phenotype
genotype
recessive
dominant

    b. Use all or some of the terms given in the box to explain why Tabitha the hamster's parents BOTH have brown fur.

phenotype
genotype
recessive
dominant

Post Test

Name: _____ Date: _____

SECTION B

1. The pet store in your neighborhood just received six new cats. Their names are Mark, Layla, Ling, Menos, Jin and Hime. The chart below shows what we know about cat genes. Use your knowledge on genetics to find out more about the cats.

Cat Genes		
Fur length	**Long: BB or Bb**	**Short: bb**
Tail	**Tail: RR or Rr**	**No tail: rr**
Color	**Brown: DD or Dd**	**White: dd**

Mark the cat genotypes
Bb **RR** **dd**

Study the chart on cat genes. Look at Mark the cat's genotypes and answer the following questions.

F. What type of fur does Mark have? _____

G. Does Mark have a tail? _____

H. What color is Mark? _____

Layla the cat phenotypes
Long fur **No tail**

Study the chart on cat genes. Circle ALL the genotypes that might match Layla the cat's phenotypes:

I. Layla has long fur.

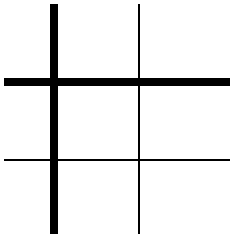
J. What might her *fur* genotype be?

BB Bb bb

K. Layla has no tail. What might her *tail* genotype be?

RR Rr rr

2. Put dots in the spaces that represent OFFSPRING on a Punnett Square.



3. Ling and Menos are going to have babies. Use the chart below to answer the questions about their offspring.

Cat Genes		
Tail	**Tail: RR or Rr**	**No tail: rr**
Color	**Brown: DD or Dd**	**White: dd**

Ling the cat genotype
Dd

Menos the cat genotype
dd

Use the Punnett Square on the right to answer the question. You can also use the information in the chart above.

	D	**d**
d		
d		

Could one of Ling's and Menos' offspring be white?
Yes ____ No ____

E. Ling has the Rr genotype for tail while Menos has no tail. Use the space below to show your work and answer questions C and D.

F. Could one of Ling's and Menos' offspring have a tail?

Yes ____ No ____

G. If Ling and Menos have 4 offspring, how many will have no tail?

0 ____ 1/4 ____ 2/4 ____ 3/4 ____ 4/4 ____

4. Jin and Hime are going to have babies. Use the chart below to answer the questions about their offspring. You may use the Punnett Square below to help you.

Cat Genetics		
Fur length	**Long: BB or Bb**	**Short: bb**
Tail	**Tail: RR or Rr**	**No tail: rr**

Hime the cat genotypes
Bb
Rr

Jin the cat genotypes
bb
rr

A. Using the Punnett Square above, could one of Gin and Hime's babies have **long fur** and AND a **tail**?

Yes ____ No ____

B. If Jin and Hime have 16 babies, how many will have **long fur** AND **no tail**? Circle the correct answer.

1/16	**2/16**	**3/16**	**4/16**	**5/16**	**6/16**	**7/16**	**8/16**
9/16	**10/16**	**11/16**	**12/16**	**13/16**	**14/16**	**15/16**	**16/16**

OR, impossible to tell from what's given ____

5. Another inherited trait in cats is *size*, represented by the letter A. Large size is the dominant phenotype. Both Mark and Layla are big cats. But they had 3 big and 1 small offspring.

   D. Based on the information above, which genotype does Mark have? _____
   E. Based on the information above, which genotype does Layla have? _____

3. Customers at the pet store want kittens with a particular fur color. Use the information below to help you decide which cats to breed.

Cat characteristics: D = Dominant (brown) d = Recessive (white)

Female cats		
Layla  **Genotype: DD**	Lin  **Genotype: Dd**	Hime  **Genotype: dd**

Male cats		
Mark  **Genotype: DD**	Menos  **Genotype: Dd**	Jin  **Genotype: dd**

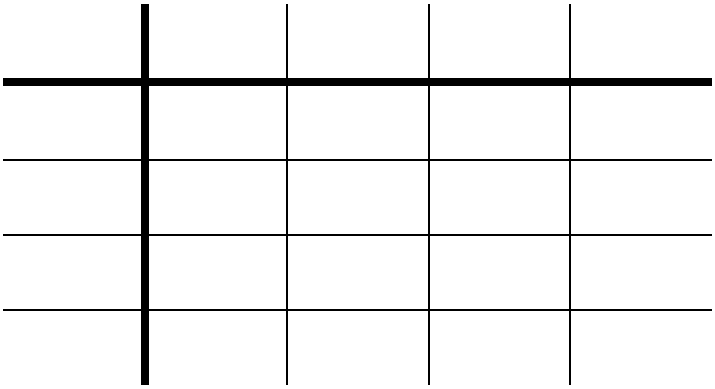
D. Which pair of male and female cats will produce:
   100% brown cats? _____
   100% white cats? _____
   50% brown and 50% white cats? _____

E. You also need to produce cats of specific size and color.

Size Trait: A = Dominant (big) a = Recessive (small)
Color Trait: D = Dominant (brown) d = Recessive (white)

Fill in the Punnett square below with the AaDd and AaDd genotypes.

Genotypes:



F. How many of the following phenotypes are possible if you breed AaDd and AaDd?

Big brown_____ Big white _____ Small brown _____ Small white _____

4. Draw a line to match a term to the example given.

Term	Definition
allele	F
phenotype	FfYy
genotype	color
trait	green

5. Kym and Jack cat both have brown fur. But their baby, Melinda, has white fur.

   a. Use all or some of the terms given in the box to explain how Melinda has white fur.

phenotype
genotype
recessive
dominant

b. Use all or some of the terms given in the box to explain why Melinda the kitten's parents BOTH have brown fur.

phenotype
genotype
recessive
dominant

APPENDIX B

Teacher Survey Results and Survey Statements

This appendix contains the tally of responses by Quest Atlantis teachers to the online survey. The table shows responses to the Likert-style statement. Following the table are the responses to the an additional open-ended question which concludes the survey.

Because some statements were designed with a negative phrasing, those statements' numbers were reversed in the analysis. For example, the statement '*My students do not understand how to sort information according to validity and truthfulness*' expresses a critical thinking observation in a negative phrasing which requires a *Strongly Disagree* response to express a positive connotation. For statements 10, 14, and 18, results were rearranged for the purposes of tabulation. For example a response of Strongly Disagree was translated to Strongly Agree for statements 10, 14, and 18. These are marked with an asterisk *.

Statement **n = 18**	Strongly Agree 44%	Agree 41%	Neither Agree or Disagree 13%	Disagree 1.9%	Strongly Disagree 0.1%
Technology Skills 1-4					
1. I observed my students using computer menus to select working activities.	14	3	1		
2. My students used a directional navigation system for movement in the virtual world.	15	3			
3. My students managed a virtual Q-pak of items and artifacts collected during missions.	9	9			
4. My students used icons, interactions with virtual characters, and active links to process questions and information.	14	4			

Critical Thinking 5-10					
5. I observed my students considering ethical dilemmas.	12	6			
6. I observed my students gathering information from interviews and making ethical decisions.	13	3	2		
7. I observed my students dealing with ethical situations concerning the environment.	8	7	3		
8. I observed my students interpreting language or word differences to understand a situation.	5	10	3		
9. My students understand reasons for caution in online environments.	13	4		1	
*10. My students do not understand how to sort information according to validity and truthfulness.	3	10	4	1	
Problem Solving 11-14					
11. I observed my students practicing problem solving techniques.	9	9			
12. I observed students using knowledge from Quest Atlantis to solve new problems.	4	9	5		
13. I observed my students openly discussing solutions to problems.	11	7			
*14. I did not observe problem solving skills transfer from Quest Atlantis to other uses in the classroom by my students.	7	3	6	2	
Collaboration 15-20					
15. My students helped each other understand how to complete scientific experiments in Quest Atlantis.	5	6	7		
16. My students understand that collaborating leads to problem solving.	9	8	1		
17. I observed my students co-questing (helping each other through the mission).	10	5	3		
*18. My students do not understand they are accountable for their behavior in Quest Atlantis.	10	7			1
19. I observed an increase in collaboration skills among my students in one or more areas of	6	9	2	1	

Quest Atlantis.					
20. I observed leadership skills as a result of collaboration among my students.	5	10	3		
Communication 21-25					
21. I observed my students using the chat feature to ask questions and socialize with other students and teachers in Quest Atlantis.	13	4	1		
22. I observed written responses on a variety of topics such as math, science, character education, art, and ecology among my students.	8	8	2		
23. My students readily shared and taught each other what they learned in Quest Atlantis.	14	4			
24. I observed increased effort on reading related to accomplishing goals of the missions among my students.	9	8	1		
25. I observed my students expressing ideas of compassion and understanding in their writing.	2	13	2	1	
Creativity 26-30					
26. I observed artistic expression by my students working in missions.	2	11	5		
27. My students manipulated dimensions and placement of 3D structures.	4	7	5	2	
28. I observed my students creativity in written responses to missions.	4	10	4		
29. I observed my students' responses to art forms, colors, or concepts.	2	8	7	1	
30. I observed the creative use or interpretation of language by my students.	2	9	6	1	
Global Awareness 31-35					
31. I observed examples of my students' understanding of another location in the world.	10	7	1		
32. I observed my students write or discuss how students from other cultures are different in many ways, but also the same in many ways.	5	9	4		

33. I observed my students working on problems that affect other communities.	8	9	1		
34. My students understand that Quest Atlantis has students from all over the world who may or may not speak English.	8	9	1		
35. My students understand how human actions can affect the entire planet.	7	10	1		
The socioeconomic status of my class would best be described as:	Low 6		Middle 10		Upper 2

Open-ended Survey Question:

What did you observe or discover about students working in Quest Atlantis that you would like to share with this study?

It had more impact when I introduced Quest Atlantis with an immigrant unit of study. They began to explore QA as immigrants eager to find out about their new world and sharing discoveries with one another. It was also interesting how they learned to play tag and hide n'go seek in the virtual world.

They loved to come in and share new adventures many about meeting students from other countries.

Excellent way to have students understand the etiquette they must have in this collaborative online society we have today. I have only had one minor infraction the college had to tell me about this year about spamming with too many exclamations! I have done this for two years now and I find it worthwhile both, academically and socially with my students. Planning on more next year. It is the best motivational tool. No one ever balks at homework. All in all this is a very real and practical tool for teaching 21st century students.

My students who used Plague last year have consistently returned to that touchstone experience in other conversations, including, but not limited to, other types of persuasive writing and ethical dilemmas involving the rights of individuals versus the needs of the community.

Where to begin? Perhaps I should confess that I have NEVER been pleased with the published curriculum provided for my use, but instead have always developed my own. Otherwise, the response to a questionnaire of this type above would have been totally abysmal. Then along came Quest Atlantis, about which I cannot say enough. This program has provided the contact and relationship I needed both between my distance

education students and myself. The focus and quality of the curricular content means that I now have 18 years worth of paper curriculum in storage. The format of this platform has transformed my students from being unengaged isolates, to enthusiastic collaborators. They are no longer my students, but part of a team (my digital jedis) (*independent learners*) who are determined to change the world for the better through personal development and the social activism that this prepares them for. The success implementation of this program will depend upon a number of factors to do with the technology and personnel involved. However, learning through Quest Atlantis has been a life-changing experience for my students and taken my own professional development to a whole new level. While the "gamification" of education seems to be gaining ground, programs of this caliber need to be held up as an exemplar of what can/should be accomplished through the utilization of virtual worlds in education. Indeed, Quest Atlantis has become a stepping stone to much, much more. I will not give my email address out, in case that should disqualify this survey, but I will let Dr. ____ know that I would be glad to respond in greater depth to any further questions.

QA engages students who are disaffected, disengaged, gifted, or support students.

Students were more engaged with the materials than in regular classroom studies.

My students are now understanding that they are not just playing a game, they are relating their own experiences to real-world situations presented in the quests and missions.

Students ask for help so many times to teacher and their friends.

I observed engaged learners.

I was surprised how quickly the kids found their way around the world using the real time directions.

They began to describe the world as though they were really in it like showing each other how to go up the hill to Otak's cave and describing how to walk past the wall and look to the right. It was a great shared experience for them.

The idea of knowing that the world is a big connected place was a realization for my kids from QA. Now they can collaborate internationally.

Having to provide written responses in order to progress saw students improving their writing.

Students were very adventurous and made and shared many new discoveries in the worlds.

Kids took control of their learning and shared what they learned. Behavior problems were less with QA.

That they are increasingly willing to take appropriate risks, to explore, to revise work, to

innovate and question the value of traditional learning.

That they are increasingly willing to take appropriate risks, to explore, to revise work, to innovate and question the value of traditional learning. My students work on Quest Atlantis transferred to their class work. Their writing and understanding in class was evident of their work in Quest Atlantis.

APPENDIX C

Participant Informed Consent (e-mail)

Dear Participant,
My name is Terry Smith and I am conducting a study under the supervision of my faculty supervisor, Dr. Paul Sparks of Pepperdine University. This research is part of my dissertation in partial fulfillment of the requirements for my doctorate in education from Pepperdine University.

Study Purpose
The purpose of this study is to obtain an understanding of how selected 21st century competencies are exhibited by elementary students as a result of learning experiences in the virtual worlds program, Quest Atlantis. This study is directed toward benefiting K-12 students and educators, while helping to clarify authentic learning situations for educational virtual world game designers.

Number of People Taking part in the Study
If you agree to participate, you will be one of up to 30 participants worldwide who will be involved in this research.

Procedures for the Study
Your participation will require about ten to fifteen minutes to complete an anonymous online survey which can be done at your convenience. A desired time frame for responding would be within two weeks of receiving your email invitation to participate. The findings of the study will be published in my dissertation and possibly other scholarly journals.

Risks of Taking part in the Study
There are no known risks to participants. Your professional abilities or methods are under no scrutiny in this study, and only a small amount of your time is lost in participation. Participation involves no loss of benefits to which participants are otherwise entitled.

Benefits of Taking part in the Study
Possible benefits of the study include identifying new strategies of teaching for differentiated learning with virtual worlds technology in elementary schools.

Alternatives to Taking part in the Study
Your participation in the survey is voluntary and you are free to withdraw from participating at any time.

Confidentiality
Your identity will be kept confidential. All email addresses and survey data will be stored on a password protected disk drive and will remain secure for 3 years. destroyed at the end of the project, or within three years, whichever comes first.

Costs
Taking part in this study involves no costs to you.

Payment
You will not receive payment for taking part in this study.

Contacts for Questions or Problems
For questions about the study, contact the researcher, Terry Smith, or the Graduate School of Education and Psychology at Pepperdine University.

For questions about your rights as a research participant, contact Pepperdine University Graduate and Professional Schools Institutional Review Board (GPS IRB).

Participant's Consent
If you would like to participate in this study, then please go to __(URL)____. The opening page of the online survey states that if you take the survey, you are giving your informed consent to take part in this study. Please proceed to the online survey.

Sincerely,

Terry K. Smith

APPENDIX D

Student Engagement Survey

NAME _____ DATE _____
Reflect on the activity that you completed. Please respond to the sentences below by checking the box that most describes how you thought and felt about the activity.

	Agree a Lot	Agree	Agree a Little	Disagree a Little	Disagree	Disagree a Lot
1. I was engaged in this activity.	☐	☐	☐	☐	☐	☐
2. I was concentrating during this activity.	☐	☐	☐	☐	☐	☐
3. I felt in control of the situation.	☐	☐	☐	☐	☐	☐
4. This activity was challenging.	☐	☐	☐	☐	☐	☐
5. I was skillful at this activity.	☐	☐	☐	☐	☐	☐
6. This activity was important to me.	☐	☐	☐	☐	☐	☐
7. I was succeeding at what I was doing.	☐	☐	☐	☐	☐	☐
8. I was satisfied with how I was doing.	☐	☐	☐	☐	☐	☐
9. I felt as if I were inside the environment.	☐	☐	☐	☐	☐	☐
10. I felt as if the environment were real.	☐	☐	☐	☐	☐	☐
11. I felt as if the characters were real.	☐	☐	☐	☐	☐	☐
12. I felt as if I and the characters were together in the same place.	☐	☐	☐	☐	☐	☐
13. I felt as if the events were happening at the same time as I was there.	☐	☐	☐	☐	☐	☐

14. I felt as if I were participating in the events.	☐	☐	☐	☐	☐	☐
15. I felt as if the events were really happening.	☐	☐	☐	☐	☐	☐

16. What was interesting and enjoyable about what you did today?
17. What was frustrating or not enjoyable about what you did today?
18. Because of this activity, do you find yourself more interested in genetics? Why?

APPENDIX E

Student Engagement Open-Ended Responses

Open Response 1

What was interesting and enjoyable about what you did today?
What I like about Drakos is when you have to catch dragonflies.
The interesting and enjoyable part is when I went to Ekons cave and I got to look in the splice-o-scope.
I liked that this quest has dragonflys and I liked when I got to breed the blue and red dragonfly.
I like when you get to make your own dragonfly's.
Getting to learn all about dragonflies and their habitat.
It was fun I like dragonflys.
We got to catch Drakos.
It was interesting to use the splice-o-scope. It also was enjoyable because you got to catch dragonflies.
I caught 1 big red and 1 little blue to breed drakos. I liked being a quester in the 3d world.
I thought it was really fun and exciting catching the Drakos.
It was great because you get to be a scientist and work with people and breed drakos in the design-a drakos-pod.
It was interesting to talk to a big dragonfly.
It was so fun when my teacher had me doing it. I thought I was the avatar.
I got to talk to Delon the dragonfly.

Open Response 2

What was frustrating or not enjoyable about what you did today?
The most frustrating about the Drakos mission is when you have to get items for Uther.
I have not made it to a not enjoyable or frustrating part in Drakos yet.
What was frustrating was when you had to use the splice-o-scope to put genotypes together.
When I had to deliver the packages.
I didn't really like it when I had to go back and forth to different people.
It was hard to find Ekon but it was cool that he was in a cave. When you clicked on a rock you entered the cave.
The frustrating thing that was hard is when you have to find their houses.
I think nothing was frustrating about drakos.
We got lost and the mouse didn't work. It was hard.
The hardest part was when I couldn't find Uther he is the person who breeds the Drakos.
The only thing that was frustrating was when you had to find Ekons cave. The rest was easy.
I think that the hardest part was answering Xinga's question.
The thing that was frustrating to me is that it was hard to find the cave to find Ekon.
When you couldn't find the places where you needed to go or you couldn't catch the dragonflies.

When I had to breed the dragonfly's.

Open Response 3

Because of this activity, do you find yourself more interested in genetics? Why?
I do find myself interested in genetics because you learn more and you will be very good at phenotypes and genotypes for your job.
Sometimes because it seems like a alsome thing to do.
Yes. I felt like I am smarter. The first time I did QA I wasn't that smart.
Maybe when I grow up I will know about genetics because maybe I want to be a teacher.
I think it makes me want to be a scientist because it is fun and interesting and I love learning about animals and genetics.
No.
I want to be a scientist now because I know more about genetics.
I found myself more interested in genetics because I did not know how to clone dragonflies and did not know what genetics were either.
Yes it taught me when you have b on the top right and a B on the bottom right if you do this.
Yes because it's fun, challenging, and interesting in school.
I just like cloning in the lab because you can make more than you have instead of waiting over and over again.
I'm more interested in genetics from this activity because why I was really interested in talking to the different people.
Yes because I learned a lot about genetics and I learned it was fun.
Yes I do find myself more interested in genetics because I know more about them.
Yes because I want to know how to breed so I can be a scientist.

APPENDIX F

IRB Certificate of Completion

Certificate of Completion

The National Institutes of Health (NIH) Office of Extramural Research certifies that **Terry Smith** successfully completed the NIH Web-based training course "Protecting Human Research Participants".

Date of completion: 06/27/2009

Certification Number: 250291

APPENDIX G

Pepperdine IRB Approval Letter

PEPPERDINE UNIVERSITY

Graduate & Professional Schools Institutional Review Board

May 13, 2011

Terry Smith
[redacted]

Protocol #: E0311D16
Project Title: *Cultivating 21st Century Competencies in a Virtual Worlds Learning Environment*

Dear Mr. Smith:

Thank you for submitting the revisions requested by Pepperdine University's Graduate and Professional Schools IRB (GPS IRB) for your study, *Cultivating 21st Century Competencies in a Virtual Worlds Learning Environment.* The IRB has reviewed your revisions and found them acceptable. You may proceed with your study. The IRB has determined that the above entitled project meets the requirements for exemption under the federal regulations 45 CFR 46 - http://www.nihtraining.com/ohsrsite/guidelines/45cfr46.html that govern the protections of human subjects. Specifically, section 45 CFR 46.101(b) (2) states:

> (b) Unless otherwise required by Department or Agency heads, research activities in which the only involvement of human subjects will be in one or more of the following categories are exempt from this policy:
>
> **Category (2) of 45 CFR 46.101**, research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: a) Information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and b) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

In addition, your application to waive documentation of consent, as indicated in your **Application for Waiver or Alteration of Informed Consent Procedures** form has been **approved**.

Your research must be conducted according to the proposal that was submitted to the IRB. If changes to the approved protocol occur, a revised protocol must be reviewed and approved by the IRB before implementation. For any proposed changes in your research protocol, please submit a **Request for Modification Form** to the GPS IRB. Because your study falls under exemption, there is no requirement for continuing IRB review of your project. Please be aware that changes to your protocol may prevent the research from qualifying for exemption from 45 CFR 46.101 and require submission of a new IRB application or other materials to the GPS IRB.

A goal of the IRB is to prevent negative occurrences during any research study. However, despite our best intent, unforeseen circumstances or events may arise during the research. If an unexpected situation or adverse event happens during your investigation, please notify the GPS IRB as soon as possible. We will ask for a complete explanation of the event and your response. Other actions also may be required depending on the nature of the event. Details regarding the timeframe in which adverse events must be reported to the GPS IRB and the appropriate form to be used to report this information can be found in the *Pepperdine University Protection of Human Participants in Research: Policies and Procedures Manual* (see link to "policy material" at http://www.pepperdine.edu/irb/graduate/).

Please refer to the protocol number denoted above in all further communication or correspondence related to this approval. Should you have additional questions, please contact me. On behalf of the GPS IRB, I wish you success in this scholarly pursuit.

Sincerely,

Jean Kang, CIP
Manager, GPS IRB & Dissertation Support
Pepperdine University
Graduate School of Education & Psychology
[redacted]

cc: Dr. Lee Kats, Associate Provost for Research & Assistant Dean of Research, Seaver College
Ms. Alexandra Roosa, Director Research and Sponsored Programs
Dr. Yuying Tsong, Interim Chair, Graduate and Professional Schools IRB
Ms. Jean Kang, Manager, Graduate and Professional Schools IRB
Dr. Paul Sparks
Ms. Christie Dailo