2013-10-02

A Descriptive Case Study of Meaningful Online Learning Experiences in the 3D Virtual Game “Quest Atlantis”

Louis, Robert

UNIVERSITY OF CALGARY

A Descriptive Case Study of Meaningful Online Learning Experiences in the 3D Virtual Game "Quest Atlantis"

by

Robert Louis

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE

DEGREE OF MASTER OF ARTS

GRADUATE DIVISION OF EDUCATIONAL RESEARCH

CALGARY, ALBERTA

SEPTEMBER, 2013

Abstract

In this case study, the relationship between middle school student engagement, motivation and development of 21st century competencies through a 3D virtual online digital game "Quest Atlantis" was examined. Data collection included surveys, focus groups interviews, and classroom observations. Participants were 12 to 13 years old grade 7 students and their classroom teacher. This research found that seventh grade students were motivated, were engaged and displayed 21st century competencies during game play in the Quest Atlantis environment. Quest Atlantis provided students with an interactive, technology enabled learning environment in which to engage with Mathematics concepts of statistics that was facilitated by the teacher who provided support and guidance. No significant gender differences in terms of performance in statistics were found. Findings from this study can enrich our understanding about the use of digital game based learning for learning Mathematics in schools.

Acknowledgements

This Master's thesis would not have been possible without the support of many people. I wish to express gratitude to my supervisor, Dr. Michele Jacobsen who was abundantly helpful and offered invaluable assistance, support and guidance. Also, I would like to thank the participants who took part in the surveys and have willingly shared their precious time during the interview process. I would also like to thank the teacher and principal for their assistance.

I would like to thank my mom, dad, brother, and sister for believing in my capabilities and for their unending support.

Last but not least I would like to thank my wife, Shveta, for her patience, love and support when writing out my thesis.

Finally, I would like to thank all the people who directly or indirectly guided me to the successful completion of my Master's study.

Dedication

This one goes out to my family. I dedicate this work to my wife Shveta Malhan Louis and children—Nyssa and Suveen. I also dedicate this thesis to my parents Prema Louis and Antony Louis as well as siblings Sushil Louis and Sumita Louis.

Table of Contents

List of Tables

List of Figures

CHAPTER 1 INTRODUCTION

In today's fast paced, technology oriented and socially networked lives, students and educators are both finding that teaching and / or learning through new interactive methodologies and technologies are fast becoming a reality. Classrooms and how teachers and students interact are changing in the wake of new approaches to teaching and learning in the digitally mediated worlds of social networks, virtual classrooms, and pervasive use of laptops and mobile devices. The "Digital Natives" terminology coined by Prensky (2001a) are children who have grown up in a technological savvy environment and are unaccustomed to learning in surroundings where there is lack of technology use. Prensky (2001a) suggests that these children or students are therefore not fully engaged when learning is facilitated without technology in the classroom. A study by Pastore and Falvo (2010) revealed that games should be seriously considered as a tool to engage and teach students in schools, and in their study concluded that usage of digital games in the classrooms would grow.

This study addresses the learning problem "How does playing a digital game support meaningful learning in the school?" and provides a deeper understanding of how digital games might be used effectively at school. Due to the generation gap between teachers and students, not only in age but in the manner that they grew up with or without digital technology, video games can open new communication channels between them by bridging this gap and fostering partnering between them (Prensky, 2010). Control needs to be given to students while the harness or facilitator role should be in the hands of the teacher—this is an integral part for the success of the gaming environment (Prensky, 2010).

The commercialization of the Internet in the 1990's allowed global access to digital games that revolutionized digital game play on the Internet. According to the Annual Horizon

Report by Johnson et al. (2013), digital game play is not only a leisure activity available in the commercial market but has of late made inroads as a tool for learning and motivation in the education sector. Game-based learning is the term used to describe learning through games to fulfill educational objectives (Johnson, Adams, & Cummins, 2012). Unlike earlier horizon reports in 2010, 2011 and 2012 that referred to game usage in the education sector as game-based learning, the 2013 report offered a new term "games and gamification" (Johnson et al., 2013). This new term acknowledges the fact that digital games through their immersive environment can support students in their learning with an emphasis on how the blueprints for educational games are made and how game players interact with one another. Education can benefit from digital games due to the conduciveness of such technologies with building 21st century competencies like collaboration, communication, critical thinking and problem solving (Johnson et al., 2012; Johnson et al., 2013).

The earlier Horizon Report in 2010 by Johnson, Smith, Levine, and Haywood (2010) reported that children born in the early 1980s, the early 1990s, and the early 2000s have grown up in an environment where digital games are easily accessible and widespread. In addition, children born since the early 2000s tend to use mobile phones to access global information and play digital games (Johnson et al., 2010), which makes the digital game portable and console independent. The children born in the early 2000s define our school population for this study. Digital video games are believed to be second nature to them, close to their hearts, and provide a comfortable and most familiar platform (Barab, Arici, & Jackson, 2005a; Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005b; Barab, Gresalfi, & Ingram-Goble, 2010b; Barab, Gresalfi, & Arici, 2009; Gee, 2003; McGonigal, 2011; Prensky, 2001a). As discussed in the next section,

the increasing popularity of digital games for entertainment and educational purposes has also been noted in Canada.

The Entertainment Software Association of Canada (2012) reported that 95 percent of Canadian households own a computer, and 61 percent of Canadian households have at least one video game console such as an Xbox, Wii, or PlayStation 3. Children in the age group between 6 and 12 years had the following profiles: 1) 35% girls play most often on a computer and 41% boys play most often on a game console, 2) 17% girls play every day and 41% boys play every day, 3) 30% girls play most often on a cell phone or mobile device and 24% boys play most often on a handheld game system. Commercial digital games appear, therefore, to be popular with both boys and girls.

Educational games can be broadly grouped into three categories: games that are not digital; games that are digital, but not collaborative; and collaborative digital games (Johnson et al., 2010). Quest Atlantis (QA) falls into the third category—collaborative digital games where players learn academic curriculum objectives during the process of gameplay and interaction in the physical as well as virtual domain.

Studies of commercial digital games that are popular to both genders have led researchers to understand popular game characteristics for engagement. These characteristics related to engagement are problem solving, collaboration, socializing, attainment of goals, and appealing storyline (Johnson et al., 2010). In addition, educational content embedded in games make it seamlessly merge with the game rather than being attached that makes players readily engage with the learning material to accomplish the goal of the game and learning objective (Johnson et al., 2010).

A study by Plante and Canada (2004) reported the median of student-to-computer ratio in all elementary and secondary schools in Canada as five. In this present day and age, the student-to-computer ratio would be even less with the likelihood of each student having access to a computer both at home and at school. Since almost every school student has access to a computer the probability of interacting with digital media is high. Research supports the use of digital games as a tool for learning and maintaining students' interest (Pastore & Falvo, 2010).

Quest Atlantis (QA), a three dimensional (3D) immersive virtual online multi-player game, is designed to offer a new pedagogy of meaningful learning by engaging and motivating students (Barab et al., 2005a). The 3D environment allows students to create their own Avatars and interact online with students and digital game characters to complete quests in a realistic virtual world. In terms of engagement characteristics, Prensky (2001a) lists two key engagement characteristics found in digital games namely, fun and play which are displayed by students during game play and completing activities in the QA environment.

QA was chosen as the technology enabled learning environment for this study because it is a digital game-based learning tool that has been found to provide meaningful, engaging, and motivating contexts for learners (Barab et al., 2005a; Barab et al., 2005b; Barab et al., 2010b; Barab et al., 2009). Quest Atlantis was chosen by the researcher and teacher to support student learning in relation to academic objectives specified in the Alberta program of studies with regard to Statistics in Mathematics. Furthermore, the QA environment has been found to foster the development and display of 21st century competencies when students play the online virtual game.

Some students appear to be immersed and totally engaged by virtual environments, described in psychology as the flow state (Csíkszentmihályi, 1990). Students who seem

genuinely engaged in virtual games tend to support the view that 'Digital Natives' minds are wired to learn and play through digital games (Prensky, 2001b). Research on student learning in high schools has found evidence of intellectual engagement when students' inquiry-based and problem based learning was linked with authentic and challenging learning tasks, a collaborative, technology enabled learning environment and responsive and flexible teaching (Jacobsen, Friesen, Daniels, & Varnhagen, 2012). The QA environment also appears to favor knowledge building through the subject matter content embedded in the missions and activities as well as by having students learn collaboratively with one another and through the teacher in the social interactive virtual game environment

QA appears to provide a real world environment to engage and stimulate the learner. The social interaction and engagement of students in technology enabled learning experiences, like QA, allows students to strengthen and think about the knowledge gained when learning (Jacobsen, 2010; Schank, 2011). Engagement therefore appears possible in the QA environment between students and between the teacher and students, and is one of the areas of focus in the present study.

Digital Games and Learning

This study builds on the multiple motivations framework by Tuzun (2004) and highlights the link between learner motivation and digital game play. Tuzun's research resulted in 13 identified motivational elements in digital game play. Earlier studies on middle and primary school students also discovered positive motivational effects of educational digital games in mathematics (Klawe, 1999; Rosas et al., 2003).

Research by Simpson (2005) and Squire (2005) argued that digital games can develop new skills in students by providing meaningful situations where students have to collaborate and

problem solve in the real life environment. The effect of Information and Communication Technology (ICT) on our daily lives is converting our communities to an informative society from the earlier industrial society (Voogt, 2008). An analysis of existing frameworks by Voogt and Roblin (2010) provides the 21st century competencies of technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness.

Richard Van Eck (2006) generated the relationship between digital games and the learning process. In general, educators have adopted three approaches for integrating games into the learning process: 1) have students build games from scratch; 2) have educators and/or developers build educational games from scratch to teach students, and 3) integrate Commercial Off-the-Shelf (COTS) games into the classroom (p. 6).

Purpose of Current Study

This study corresponds with the second approach, where students make use of an educator designed digital online virtual 3D meaningful educational game for learning. Based on previous studies by Tuzun (2004) and Smith (2011) the purpose of this study is to first investigate whether the use of an online educational 3D virtual game "QA" as a tool to learn mathematics results in positive learning benefits such as greater motivation and increased engagement by students. This study also aims to determine if digital game based learning leverages students' natural curiosity to make sense of the virtual world environment by using narratives and storylines as well as display 21st century competencies to accomplish the desired goal. In a nutshell this study seeks to deeply understand how playing an online virtual 3D digital game "QA" supports meaningful learning when learning Mathematics in the classroom.

Research Questions

This case study was designed to address the following three research questions:

1. In what ways can student engagement in learning be supported by playing Quest Atlantis in the classroom?

2. Do students feel more motivated about their learning and about mathematics when learning is supported by Quest Atlantis?

3. In what ways can the development of 21st century competencies be supported by Quest Atlantis in the classroom?

A study site was sought and found in Southern Alberta. In the months of February and March 2013, the researcher worked with 59 students from two grade 7 classes (ages 12 to 13 years), one mathematics teacher and the school principal from an urban school in a major school district in Alberta, Canada to carry out this case study.

Significance of the Study

This study contributes to the current understanding of how student engagement, motivation and the development of 21st century competencies can be impacted through meaningful learning and digital game play. Educators and researchers like Marc Prensky, James Gee, Kurt Squire, Sasha Barab, Yasmin Kafai, and Jane McGonigal, are still compiling evidence on the effectiveness of digital games as a tool for learning. The present case study will add to the growing body of research exploring whether new innovative methods such digital games are an effective medium of instruction especially for students who are 'Digital Natives'. Based on such research, educators may acknowledge that with changing times and new generations of students that more technology and Digital Game Based Learning (DGBL) should be incorporated into their schools, especially as evidence grows about how DGBL supports the use of innovative learning methods in classrooms today.

Furthermore, this research study aims to determine whether students are changing in their learning patterns and may be more meaningfully engaged in learning from new and innovative educational formats such as educational digital games—in this case QA. The findings of this case study can help to better understand the learning patterns of children who fit the digital native profile. These children have likely grown up in an environment where they are comfortable with interactive digital media and may therefore benefit most from classrooms using the same medium as a tool for instruction. Educators, Elearning companies, curriculum designers, and researchers will be interested in the findings from this case study to better understanding the advantages or disadvantages of using a video game as an instructional tool in a classroom.

Organization of the Study

The study is organized as follows: Chapter 2 is a literature review on engagement, QA learning environment, gender differences, motivation, and 21st century competencies. Chapter 3 describes the triangulation mixed methodology of the study. Chapter 4 presents the results and analysis of the data. Chapter 5 presents discussions, conclusions, and recommendations for future researchers in this field.

CHAPTER 2 LITERATURE REVIEW

This chapter presents a review of historical and current research literature to better understand the value of 3D digital immersive games as part of the classroom learning environment. The purpose of this review is to explore how 3D digital immersive games like "Quest Atlantis" provide a meaningful environment for learning in terms of student engagement, motivation, and the development of 21st century competencies. Through this literature review, gaps in the current knowledge base are highlighted, the idea of using 3D digital games like QA to support meaningful learning in classrooms is explored, and the research questions that frame this study are presented.

Digital Games are Engaging

According to McGonigal (2011), computer and video games provide people with access to microworlds that satisfy a human need for accomplishment. McGonigal (2011) argues that the microworld provided by the game nurtures a sense of belonging by inspiring and engaging people in ways the real world cannot. Today's students, commonly referred to by Marc Prensky as 'Digital Natives,' are born into social environments where digital technologies are all-encompassing (Eck, 2006; Prensky, 2003). Unlike their students, many teachers did not grow up with digital technology and are usually considered "Digital Immigrants" (Prensky, 2001b, p. 2). Some argue that technological savvy students can pose an interesting challenge to educators due to their interdependence with technology. For example, Prensky (2001b) is of the opinion that "our Digital Immigrant instructors, who speak an outdated language (that of the pre-digital age), are struggling to teach a population that speaks an entirely new language" (p. 2) and that students engage in the world differently than their teachers. Educators may have to address different skill sets, interests, and needs that today's students bring to the classroom and also may need to find

different instructional approaches and to design instruction or curriculum to be responsive to different learners.

Video games can open new communication channels between teachers' and students' by fostering partnering between them through Commercial Off The Shelf (COTS) games, learning games, and game creating tools (Prensky, 2010). Control is given to students by allowing them to use technology while the teacher facilitates their learning with instruction related to utilizing technology (Prensky, 2010). Video games can be an engaging part of 21st century pedagogy and learning compared to traditional delivery and learning by rote; in contrast, with games students learn by transformation of reality brought about by contextual role play (Barab, Gresalfi, Dodge, & Ingram-Goble, 2010a). Many young people enjoy playing computer and video games as a leisure activity. Digital games provide a highly interactive and engaging virtual world of simulation and pleasure, which can be contrasted to the types of learning experiences many students encounter at school. Since video games are immersive in nature, appeal to students, and appear to provide an effective pedagogy for the easy assimilation of game content (Barab et al., 2010b), more educators may be considering the viability of using educational games in a similar context to impart curricular content in school. Prensky (2001a) argues that the same level of engagement and intrinsic motivation of Digital Natives in commercial digital games can be replicated in a game environment with educational content called DGBL. He also considers the matrimony of digital video games with educational content holds a key to better engaging students in school.

Learning in Classrooms

Research by Simpson (2005) and Squire (2005) shows a substantial increase in the use of video games in the last ten years in the classroom. According to several studies in the last

decade, Digital Games are a medium or platform to promote learning and bring out the best in learners (Aldrich, 2004, 2005; Gee, 2003; Prensky, 2006). McGonigal (2011) is a passionate supporter of "blissful productivity' which is a state of being mentally immersed in a digital game environment while completing tasks towards the realization of outcomes. In her research, McGonigal (2011) has demonstrated that players of massively multiplayer online role-playing games (MMORPG) like World of Warcraft work together with other players as a community to solve problems using the tools provided in an online collaborative environment. Prensky (2001a) argues that one of the main characteristics of DGBL is that it creates a learner-centered approach and provides interaction with a digital gaming medium during the process of learning. Passionate supporters of DGBL maintain that this mode of learning can be more enjoyable, more interesting, and, therefore, more effective than traditional learning modes (Gee, 2003; Prensky, 2001a).

Collaborative Digital Games for Learning

Recent research has shown that games can be used as a tool to sustain interest as well as maintain students' attention at school (Pastore & Falvo, 2010). According to the Horizon Report published in 2010, game-based learning is a more effective platform to assimilate knowledge when compared to textbook based learning for children in schools today due to their familiarity with video games (Johnson et al., 2010). Johnson et al.'s (2010) Horizon report also broadly groups educational games into three categories: 1) non-digital; 2) non-collaborative digital games; and 3) collaborative digital games. Johnson et al. (2010) also stated that digital games:

> When embedded in the curriculum… offer a path into the material that allows the student to learn how to learn along with mastering, and truly owning, the subject matter. These

> games lend themselves to curricular content, requiring students to discover and construct knowledge in order to solve problems (p. 18).

Collaborative digital games have the capability to transform education due to their exploratory and competition based game play brought about in the environment (Johnson, Smith, Willis, Levine, & Haywood, 2011). These kind of digital games are challenging to design but can build competencies for "research, writing, collaboration, problem-solving, public speaking, leadership, digital literacy, and media-making" (Johnson et al., 2011, p. 22). The integration of course content with digital games provides students with an opportunity to engage with the material positively leading to higher cognition (Johnson et al., 2012). Educators are therefore interested in seeking out avenues to include this tool in the K-12 curriculum. Computer games have been proposed as a potential educational learning tool by game designers (Aldrich, 2004; Prensky, 2001a), educational scholars (Gee, 2003; Squire, 2005) and educational researchers (Barab et al., 2010b; Gee, 2003; Kafai, Franke, Ching, & Shih, 1998; Li, 2010; Simpson, 2005) that can be integrated into the classroom. Modern educational game studies related to students' emotions and traits in Mathematics and Science (Li, 2010) as well as abilities and attitude in Mathematics (Ke, 2008) have been examined to study the effects of games on learners and on learning. In both studies a majority of students felt positive sentiments during the process of game building and playing web -based Math games, respectively. Out of 21 elementary students only a faction did not feel positive sentiments and the themes of creativity, engagement, and new identity emerged during the process of game building (Li, 2010). The study by Ke (2008) had 15 students in the age group of 10 to 13 years where the pre and post test results did not show a significant difference in the GSAT math test and Jr. Mai metacognitive survey that led to there being no significant effect on the cognitive test performance and metacognitive awareness

development. But a significant difference between the pre and post-test scores in ATMI attitudes measure showed a positive attitude in Math learning.

Games that encompass educational objectives and subject matter are believed to hold the potential to render learning of academic subjects more learner-centered, easier, more enjoyable, more interesting, and, thus, more effective (Prensky, 2001a). Specifically, games constitute potentially powerful learning environments for a number of reasons (Oblinger, 2004): (a) they can support multi-sensory, active, experiential, problem-based learning, (b) digital games favour activation of prior knowledge given that players must use previously learned information in order to advance, (c) they provide immediate feedback enabling players to test hypotheses and learn from their actions, (d) they encompass opportunities for self-assessment through the mechanisms of scoring and reaching different levels, and (e) they increasingly become social environments involving communities of players. Apart from knowledge acquisition, game playing can also favour the development of various skills, such as critical thinking and problem-solving (Mcfarlane, Sparrowhawk, & Heald, 2002).

Relationship between Digital Games and Learning

Richard Van Eck summarizes the relationship between digital games and learning with three approaches. According to Eck (2006)

> In general, educators have adopted three approaches for integrating games into the learning process: have students build games from scratch; have educators and/or developers build educational games from scratch to teach students; and integrate commercial off-the-shelf (COTS) games into the classroom (p. 6).

The first approach deals with designer-students learning the subject matter and new software by making their own games and problem-solving respectively (Eck, 2006). Li (2010) conducted a

study where students in an elementary school designed and built digital games to teach one another Isaac Newton's Three Laws of Motion through a visual programming software called 'Scratch'. The study proposes that student engagement when building digital games increases the learning capabilities with regard to subject matter and generic skills. The learning by game building approach through technology use allows students to build, learn and problem solve. Furthermore, students displayed a rise in understanding mathematics as well as a positive attitude when creating their own games (Li, 2010).

The second approach involves educators designing games from scratch for students (Eck, 2006). Recent research by Barab et al. (2010a) as well as Barab et al. (2009) supports the transformational potential of video games that allow students to play real life roles like reporters, scientists, mathematicians, and doctors. Students can use specific area knowledge particular to their character in the game to answer personally engaging and scenario specific queries (Barab et al., 2010a; Barab et al., 2009). This new 21st century pedagogy takes learning into a new dimension where the transformation of prior conceptual knowledge occurs according to the real life situation presented in the game (Barab et al., 2010b).

A study by Tüzün, Yılmaz-Soylu, Karakuş, İnal, and Kızılkaya (2009) showcased how video games were used to teach geography to fifth and sixth grade students by increasing the motivation and fun factor leading to the goal of identifying continents and countries. A review of the literature on educational video game design by Dondlinger (2007) summarizes findings from a number of studies on the positive effects of cognition in video games that develop skills related to attention, spatial concentration, problem-solving, decision making, collaborative work, and creativity. These 21st century skills are necessary to take part in the global economy of today (De Aguilera & Mendiz, 2003). Educators therefore, should be encouraged to integrate

digital game based learning into the K12 curriculum to bridge the gap between the manner knowledge is represented and learnt by digital natives and how knowledge is imparted and needs to be taught to acquire 21st century competencies.

Finally, the third approach for integrating games into the learning process involves incorporating commercial off-the-shelf (COTS) digital-games into classrooms (Eck, 2006). For example, Squire (2005) chose the commercially available digital video game Civilization III to teach geography and history in middle school.

This study coincides with the second approach, whereby students will make use of an educator designed digital virtual 3D meaningful learning environment, QA, for learning while playing an educational game.

Social Constructivism and Digital Game Based Learning

According to Vygotsky (1978) social constructivism involves both active teachers and older or experienced children playing very important roles in learning. He believed that culture gave the child the cognitive tools required for knowledge building where teachers acted as mediums through which tools of the culture provided a child with cultural history, social context, and language. His brand of social constructivism stressed the importance of culture and social context for cognitive development. Nowadays the learning context includes electronic forms of information access similar to educational games like QA. Vygotsky (1978) argued that students with the help of children and teachers could master concepts and ideas that they could not understand on their own. Vygotsky names this concept the Zone of Proximal Development (ZPD), which is the difference between what could be accomplished individually and what could be accomplished with the help of a collaborative effort. QA's brand of learning is designed to scaffold weaker students through compelling activities and interaction with their peers and the

teacher. Once the student experiences the benefits from the ZPD, Vygotsky argues, the student can continue to learn individually. QA is also based on investigative or experiential learning that allows the learner to explore and interact with the environment for learning.

Quest Atlantis

Experiential learning is advocated by learning theorists who believe the essence of learning stems from relationships between experience and education, and that deep learning occurs from reflection and action in a real life scenario (Kolb, 1984). According to Barab et al. (2005b), meaningful learning is supported in a digital game based learning environment, such as QA, through the use of collaborative and social game strategies for engaging and motivating students with educational content.

'Quest Atlantis' is the brainchild of Sasha Barab at Indiana University. QA uses a collaborative and social gaming environment to foster formal learning communities (Barab et al., 2005a; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007a; Barab et al., 2005b; Barab, Warren, & Ingram-Goble, 2008a). The QA brand contains the following main attributes: (a) mythological backstory that forms the basis for QA activities, (b) 3D immersive world through which students, teachers, and fictional QA council members interact, (c) community of global participants, (d) pedagogical centered activities to promote formal learning, entertainment, and social commitments (Barab et al., 2005a). QA integrates inquiry-based as well as experiential activities to accomplish learner objectives in academic curriculum and also provides a conducive environment specially for girls and boys to explore ways to make the world a better place (Barab et al., 2005b). Certainly, digital games have several advantages over other instructional media, the main one being their extremely compelling and engaging nature (Malone, 1980). Furthermore, the obstacles encountered in digital games induce a positive stress called eustress,

which provides the motivation and rigor to solve the problem (McGonigal, 2011). McGonigal explains that eustress does not have a negative connotation and actually induces a positive framework of mind leading to confidence and optimism to enjoy the stress and work at hand. According to Squire (2005) digital games provide immersive environments conducive for experimentation and problem solving. Besides their engaging nature, educational games like QA provide an avenue to test not only extrinsic motivation but intrinsic motivation too (Tüzün et al., 2009).

Quest Atlantis Environment

A combination of the gaming framework with content and inquiry-based pedagogy in school is the basis of a 3D multi-user virtual meaningful learning environment, QA (Barab et al., 2005a).

Figure 1. Quest Atlantis Opening Web Page

QA provides a teaching and learning environment for children between the ages of 9 to 16 years. The Website is http://atlantisremixed.org/ and Figure 1 displays the opening page. QA is now part of the Atlantis Remixed project where 50,000 students over six continents and 18 countries have participated in the project. The project allows parents, teachers, and researchers to download a test version of the game. At the heart of the project is a role-playing game where students have to complete learner objectives related to a task list of a mission. The completion of multiple tasks leads to fulfilling the requirements of educational activities known as Quests while learning the subject content. When completing Quests students have to involve themselves in virtual and real life activities that are academically meaningful. Students can take part in these activities in a secure password protected 3D environment where they embark in Quests, chat with students and teachers, and contribute to the evolving story of QA. The Atlantis Remixed project combines strategies used in commercial games with research based motivation and learning lessons.

A Professional Development (PD) course is mandatory for new teachers who want to use QA in their classrooms. The online PD module allows teachers to voice their concerns to successfully incorporate this curriculum in their classrooms ("Atlantis Remixed," n.d.).

The Atlantis Remixed project is based in the Learning Sciences Institute of Arizona State University (ASU) ("Sasha A. Barab," n.d.). In December 2010, the Bill and Melinda Gates foundation provided a grant of $2,366,734 till November 2013. The grant's main aim was to get traditional academic disengaged students to engage with mathematics science and language arts ("Gates Foundation Funds QA," 2010.)

Students in the QA world use their virtual representations or Avatars to manipulate content in real contexts by taking up the role of scientists, writers, reporters, and other

responsible roles. QA is built on research design core components, online multiuser virtual environment, narratives, storylines, social commitments, and several missions encompassed in a unit constantly facilitated by a teacher. The backstory of Atlantis and how the student can help Atlantis get back to its former glory is viewed as an animation before they start playing the missions. Students get involved in situation based learning through the storyline while attempting missions and exploratory play allows them to be part of the evolving story (Barab, Dodge, Thomas, Jackson, & Tuzun, 2007b).

There are seven social commitments: compassionate wisdom, creative expression, environmental awareness, personal agency, healthy communities, social responsibility, and diversity affirmation in QA. The tasks marked for completion in the social commitments help students become knowledgeable, responsible, and empathetic adults (Barab et al., 2007b).

In order for teachers to cater to today's students it is essential to understand whether digital games as an intervention are a suitable tool for learning in classrooms. The relationship between engagement, motivation, and digital games are vital for educators to consider when implementing digital games as a tool for learning. As will be explained in a section that follows, it is important to understand if there are significant gender differences when using digital games in the classroom. In addition, it is necessary for educators to help students develop 21st century skills to prepare them for the future.

Gender Differences

There may be differences in how boys and girls engage with commercial and educational digital games. The Entertainment Software Association of Canada in 2012 reported that 90 percent of Canadian kids and teens are gamers who own a computer, and 61 percent of Canadian households have at least one video game console such as an Xbox 360, Wii, or PlayStation3.

Female gamers constitute 38 percent and male gamers 62 percent (Entertainment Software Association of Canada, 2012)

The two seventh grade Math and Science classes that took part in this research study were a mix of male and female students. Male and female students in the age group of 12 to 13 have played some type of commercial games through computers as well as Wii, Xbox, and PlayStation gaming consoles. Educational games unlike commercial games are neither widespread nor widely used in educational settings. It is therefore important to understand the findings of previous studies in relationship to gender, computer games, and performance in mathematics to place the results of this study.

Gender Differences in Educational Games

There may be gender differences in educational digital games depending on the age groups. A recent empirical study by Papastergiou (2009) in Trikala, Greece had 88 students, 46 boys and 42 girls between the ages of 16 and 17 split into two groups—Group A gaming (n=47) and Group B non-gaming (n=41). A Computer Memory Knowledge Test (CMKT) was used as the pretest and post-test and the findings suggested that the gaming approach was not only more motivational but effective in promoting students' knowledge of computer memory concepts compared to the non-gaming approach. In addition, with regard to gender there was no statistical significant difference in terms of learning gains and motivation. Another recent study by Kaufman, Sauvé, and Renaud (2011) in a senior secondary health education program in Canada involved the impact of an online educational digital game on cognitive learning. The study had 133 secondary school students in grades 9, 10, and 11, ages 14 to 18, out of which 73 students were from Quebec and the remaining 60 in the francophone school district of British Columbia. The results of the paired t-tests showed significant improvements in different types of cognitive

skills and no statistical significant differences between males and female after playing the video game for 40 to 60 minutes.

An empirical study by De Jean, Upitis, Koch, and Young (1999) described the experiences of students with the Phoenix Quest (PQ) computer game that consisted of a case study with 6 girls and a second supplementary large-scale study involved the participation of 41 boys and 57 girls, aged 8 to 12 years from grade 4, 5, and 6 in a mid-sized Ontario city in Canada. The findings provided claims that PQ interested girls due to the engaging puzzles and searches and due to the main character being of their age and gender. PQ showcased substantial gender differences with regard to game characteristics when learning mathematics through an educational game: 1) more girls than boys used the postcard writing feature in PQ and enjoyed the adventures of the female character, 2) more boys than girls were reported to offer advice to other students, discuss the game during their free time, and observe others playing the game, 3) more boys than girls recognized the mathematics embedded within the game, and 4) even though the study did not focus on teacher student interaction since 25% of participating students were not able to grasp the mathematics in PQ, there was the need for a teacher to make the mathematics visible.

In the electronic games for education in Math and Science (E-GEMS) project, males and females appeared to have different preferences for games, males performed better than females by progressing faster but there were insignificant differences between males and females with regard to accomplishing the goal (Klawe, 1999). According to Ke (2009) in terms of learner characteristics in computer games gender differences were found in qualitative studies but not in comparative and experimental studies. A review of the literature on computer and video games for learning posited an identical liking by both genders with the components of fun and challenge

(Mitchell & Savill-Smith, 2004). A mixed-method case study by Ke (2008) explored fourth and fifth grade elementary school students'(n=15) reaction to educational math drill games where males preferred to report game related activity and females preferred to emote feelings and interact socially. Gender differences were not observed in terms of computer game preference and both males and females enjoyed playing the computer games.

A report by Mcfarlane, Sparrowhawk, and Heald (2002) on the educational use of games, through a survey of teachers' experiences with game use in classrooms and students experiences with game use at home found out that digital games led to a higher level of engagement. Adventure genre digital games were most popular where students learned to work in teams. The different levels of challenge along with their relevant knowledge and absence of pressure due to time in the game affected their levels of engagement.

Consequently, research regarding gender issues in educational games is limited and mostly deals with game preferences and characteristics of males and females.

Gender Differences in Learning in Schools

According to Fennema (2002) the following were problems regarding gender differences in mathematics: 1) large variations between groups of females exist, 2) gender differences vary by school and teacher, 3) males and females have personal beliefs about mathematics, and 4) intervention can make a difference. In North America there were insignificant gender differences with regard to performance in Math, Science, and Technology in early elementary grades (McLester, 1998). But in the higher grades of elementary school the gender differences in Mathematics and Science performance begun to emerge and were significant in senior high when females did not complete their advanced Mathematics and Science courses (Ma, 1999). From a historical perspective, some gender differences in computer use and interest appears to

originate in middle school and increases for females with age. According to Fiore (1999) females tended to view the computer as a means through which assignments were completed whereas males viewed computers as leisure playthings that led to the emergence of gender differences in middle school. Fiore also believed that in terms of game characteristics females wanted rich reality-based visuals where characters, clothing, colors, and scenery looked real and three dimensional. Females also enjoyed interactive conversations with characters in the game to decide and respond to in-game questions (Fiore, 1999).

The latest Programme for International Student Assessment (PISA) 2009 reported the academic performance of 15 year old students in the Organisation for Economic Co-operation and Development (OECD) countries. In Maths and Science, Canada performs significantly above the OECD average (OECD, 2010). And with regard to OECD countries, girls outperform boys in reading skills whereas "on average across OECD countries, boys outperform girls in Mathematics by 12 score points while gender differences in Science performance tend to be small" (OECD, 2010, p. 14).

The 2009 PISA assessments for 15 year olds in Canada showcased males outperform females by 12 and 5 score points respectively in Mathematics and Science. Carrying on, in the province of Alberta, males performed significantly higher than females in Mathematics and there were no significant differences between males and females in grade 10 Science (Knighton, Council of Ministers of Education, Canada, Brochu, & Gluszynski, 2010).

Empirical studies in educational digital games did not show gender specific significant statistical differences in terms of learning gains and motivation in Mathematics. In terms of game characteristics females preferred games with a female lead character whereas males offered advice to other students and compared to females were able to better recognize the Mathematics

implanted in the game. In Math drill games, males preferred being vocal and described activities while playing the game whereas females favored to interact socially and exude feelings. A research report concluded that digital games led to a higher level of engagement and both genders liked adventure genre digital games that provided them with the opportunity to work in teams.

In this study, QA provided an opportunity for grade 7 students to learn Mathematics—mean, median, mode, and range. The study aims to find out whether QA appeals to students of both genders due to the 3D immersive virtual digital environment and favorable game characteristics. In addition, the study intends to find out if there are gender specific significant statistical differences based on the results of the Independent sample t tests on the pre and post-tests in Mathematics. The intervention could not be compared in terms of effectiveness as the research design did not include a control group.

Teachers Perceptions of Educational Games

The 'digital natives' world of technological prowess and easy access to mediums for online social interaction appear to make teachers think that digital games could be a favourable tool for teaching and learning for students. It is therefore important to understand teachers' perceptions about using digital games before implementing them in classrooms. Unfortunately, there are few studies that have explored teachers' beliefs and perceptions of integrating games into education (Can & Cagiltay, 2006). Ritzhaupt, Higgins, and Allred (2010) argue it is important to study teachers' experiences before integrating modern educational games into K-12 settings on a large scale. This study consisted of middle school Mathematics teachers and two computer resource teachers (n=10) from two different school districts in southeastern USA with a range of 2 to 40 years of teaching experience in the K12 environment. The average number of

years of teaching experience was 11.83 with an average of 6.13 years in K12 teaching experience with computers. The ten Mathematics teachers taught pre-algebra courses to grade six, seven and eight students and the computer resource teachers assisted in the technology and curriculum integration. DimensionM^{TM} was the modern educational game used in the study where students were taught pre-algebra and algebra concepts in a 3D immersive game environment. The ten Mathematics teachers found that all students interacted with the computer on a one to one basis and played the game in a single player mode. The only requirement by the researchers was to allow the students play the game once a week for one class period in a 16 week period. The main findings of the study were first, all the ten teachers found it easy to integrate the digital game in the classroom. Second, nine of the ten teachers used the digital game as a reward system. Third, eight of the teachers used the digital game to reinforce mastery concepts. And fourth, seven teachers encouraged competition between students to foster motivation.

Pre-service teachers in four separate Computer Education and Instructional Technology (CEIT) departments in Turkish Universities (n=116) took part in a study along with four volunteer students from each University (n=16) (Can & Cagiltay, 2006). A questionnaire (n=116) and semi-structured interviews (n=16) were used to collect data. The major positive perceptions of the study with regard to computer educational games were: 1) students should be engaged in activities during game play, apply their knowledge and through a process of investigation learn by doing, 2) students can learn more useful things compared to traditional learning and this learning would be more permanent, 3) students' critical thinking skills may become better due to the logical progression in the game, 4) students skills should develop in terms of creativity, imagination, and visualization by playing games, 5) students previous knowledge would be reinforced by making the course content more understandable through

games, and 6) 96% of the respondents agreed with the statement that computer games have the capability to help students fulfill cognitive goals. In addition, a majority of the participants, 83%, were of the opinion that they would use computer games with educational features in their courses in the future (Can & Cagiltay, 2006).

In a study in the USA, Niederhauser and Stoddart (2001) implemented surveys in the form of questionnaires on in-service elementary school teachers (n=1093) to examine the relationship between teachers' instructional perspectives and their use of technology in instruction. The major results portrayed that teachers' made their students use skill based software (for example, Reader Rabbit) alone or in tandem with open ended software (for example, Carmen San Diego) in most of the classrooms. Another result showcased the immersion of teachers' pedagogical beliefs in games further led to the type of software propagated by the teachers for use by students. In addition, computers may have the potential to transform learning but it is up to teachers to achieve this potential.

Two important studies by Can and Cagiltay (2006) and Niederhauser and Stoddart (2001) have informed educational researchers with regard to teachers' beliefs about games in classrooms, but have still left much to ponder. Can and Cagiltay (2006) examined pre-service teachers' approach and prejudices regarding the immediate integration of educational games in classrooms which is not conclusive. On the other hand the study by Niederhauser and Stoddart (2001) catered to Math drill and educational games and attempted to combine in-service elementary teachers' experiences for future use. Recent research by Ritzhaupt et al. (2010), showcased the use of new educational games that provide the impetus to change the relationship among students and between teachers and students due to their mode of instruction.

In the present case study, the teacher used the educational 3D immersive virtual digital game, QA, to teach statistics in Mathematics—mean, median, mode, and range. The teacher's role was more that of a facilitator than a teacher where students were given an autonomous means to learn at their own pace through an exploratory approach. Students collaborated with one another and problem solved and used critical thinking skills while attempting activities in the Ander City unit. Learning through peers was therefore permitted in the QA educational digital game environment. Students only asked the teacher for help if their peers could not provide the solution to a question. The teacher, being an avid gamer and having earlier implemented QA with another class of students, was comfortable with the functioning of the educational digital game and understood the workings of the software for learning in the classroom. The teacher's experience and beliefs about the benefits of students learning through digital gameplay are explored in the present study.

Engagement and Learning

It may be a challenge to engage 'digital natives' in conventional classroom activities that are less engaging than the digital game environments that are so readily used by today's learners at home (McGonigal, 2011). It is the contention of this study that teachers may find benefits from the use of digital game technology to teach and maintain students' interest, engagement and attentiveness when learning curricular concepts, like Mathematics, in the classroom.

According to Jacobsen, Friesen, and Saar (2010) some 21st century learning environments allow students to engage in inquiry based tasks that challenge the student and adds value in their day to day lives. Csíkszentmihályi (1990) believed that people learn best when engaged in the task and enter a state of flow where they are oblivious to time and matter. This kind of

engagement is required in classrooms today where digital natives may be disconnected due to their brains being wired differently (Prensky, 2001b).

Engagement is essential for learning and can be divided into three subsections: First, intellectual engagement, which interests the learner to want to examine and interpret knowledge. Second, deep thinking that allows interpreted knowledge to be assimilated by the learner. Third, situated cognition, which provides the learner with a context and situation for mastering the knowledge absorbed.

Intellectual Engagement

Intellectual engagement provided a rationale for learners to want to learn by maintaining their attention and keeping them immersed in the content. Jacobsen et al. (2012) argued that student intellectual engagement is essential for learning in a collaborative digital environment and that designs for learning need to involve challenging and authentic work in disciplines of study. They are also of the opinion that intellectual engagement is demonstrated when students are both cognitively and emotionally engaged in their learning. Jacobsen and Friesen (2011) argue that knowledge building processes, which involve continual improvement of knowledge and knowledge building in community, are the most important skills for 21st century learners. Interactive technologies can provide fertile ground for students to reflect and connect while learning and by allowing them to express and share their developing knowledge through online publication (Jacobsen et al., 2010). Means, Toyama, Murphy, Bakia, and Jones (2009) have observed gains when learners take part in collaborative interactive learning experiences and are allowed to take control of their learning. These researchers have also found in a meta-analysis of studies that online learning had stronger learning outcomes than teacher or instructor-led

training. In addition, the researchers found that more learning time and collaboration provided these results.

According to Jacobsen (2010) high level critical thinking skills can be experienced in an online learning environment where the teacher and students collaborate and interact mutually with the assistance of digital content and technology. Knowledge building through a collaborative work environment can foster teaching and the sharing of this knowledge publicly and through discussions which is becoming the norm in some schools (Jacobsen et al., 2010).

Educational researchers believe that the following factors are instrumental to understand the relationship between student engagement, learning environment, and teaching practices: 1) different types of teacher instructional practices, 2) complexity of student work, 3) various technologies for use when learning, and 4) amount of feedback and assessment types for students (Jacobsen et al., 2010; Willms, Friesen, & Milton, 2009). Research by Jacobsen et al. (2010) shows a connection between these factors and the various levels of student engagement in the classroom. The Learning Sciences and Brain Research project funded by OECD (2002) and OECD (2007) is consistent with the findings of the researchers (Jacobsen et al., 2010):

> "The more closely the goals of teachers, learners and educational systems are matched, the more effective the learning will be… the more closely this learning is linked to external stimuli of 'real world environment', the more it will engage and stimulate the learner" (OECD, 2007, p. 200).

The QA collaborative game environment provides learners with an environment for learning that not only stimulates students mentally but also engages them emotionally to want to progress through the four missions of the Mathematics world—Ander City (Barab et al., 2005a; Barab et al., 2007a; Barab et al., 2005b; Barab et al., 2008a; Barab, Dodge, & Ingram-Goble, 2008b;

Barab et al., 2007b; Barab et al., 2010a; Barab et al., 2009; Barab et al., 2010b). Ongoing study of student engagement and motivation while playing QA will add to the research literature on digital game based learning.

Deep Thinking

The basis for deep thinking is the knowledge gained through the cognitive process of learning by reflection. Schank (2011) argues that engaging work allows students to get into the mode of deep thinking through 12 conceptual, social, and cognitive processes. Challenging and authentic classroom work can set the stage for peer collaboration, developing deep understanding, the building of knowledge and intellectual engagement (Jacobsen, 2010). In her study of situated cognition, Arici (2008) argues that students are dissatisfied with school and do not perform well because content and curriculum are not correlated with their everyday lives. There is in fact a loss of student engagement and learning due to the decontextualization of content (Barab et al., 2008b). By means of social collaboration real world inquiry, and contextualization in the online game, Quest Atlantis can provide an environment where the achievement of subject mastery occurs through an ongoing reflective process on knowledge gained. Knowledge and 21st century skills gained through cognitive processes, such as teamwork, negotiation and decision making, actually make students think instead of having teachers teach (Schank, 2011). Students through QA interact with one another and the content. They also learn 21st century competencies at an early age that is required for success in the workplace.

Situated Cognition

According to Mitchell and Smith (2004) retrieving information from memory encourages the construction of cognitive skills in a learner. The importance of co-relating content and

curriculum to context is important especially for generation Z students, born in the new millennium. To relate content with context, Gee (2003) believes that virtual environments may engage students while learning by immersing students in situations where they can learn from their peers through collaboration or distributed cognition. Barab et al. (2008b) and Arici (2008) argue that immersive environments situated in real world activities and involve the human senses can make participants relate to the content by interacting with the characters and situational challenges. As a result of immersion in the semiotic domain of a learner there is a level of mastery achieved in pockets of knowledge areas (Gee, 2003). Furthermore, Gee (2003) mentions that this knowledge gain and level of mastery is not brought about by rote memorization but through meaningfully integrated knowledge that can be retrieved for use anytime from that domain.

QA provides a background and ongoing storyline that maintains the learners' attentions spans and keeps them immersed in the online game. The situational contexts also provide scenarios for the learner to accomplish learner outcomes by fulfilling their role-playing commitments.

Motivation and Learning

According to Gee (2003) motivation is the main force that propagates learning in a digital game. The lack of learner motivation can prevent learning and stops the learner from playing the game. Kirriemuir and Mcfarlane (2004) argue that playing computer games can increase the motivation levels of learners. This finding is supported by Malone's (1980) earlier research connecting intrinsic motivation in games to concepts like fantasy, challenge, and curiosity (Malone, 1980). A review of the literature on the use of computer and video games for learning

claimed enjoyment, motivation, and engagement as the prime advantages (Mitchell & Savill-Smith, 2004).

Uses and Gratification Theory: Motivation in Commercial Games

Lucas and Sherry (2004) applied uses and gratifications theory to playing computer games and identified six principal reasons or motivating factors: 1) competition, 2) challenge, 3) social interaction, 4) diversion, 5) fantasy, and 6) arousal. Lucas and Sherry also found that males rated all six of these reasons for playing games as more important than females. Their most important motivation was the self-challenge that males or females felt by beating the game or going to the next level. This was followed by competition to beat other game players. Third came game playing for diversion and fourth for arousal. At the bottom of the motivation list was the fantasy of doing something that cannot be done in real life and social interaction with friends.

Motivation in Educational Games

The Electronic Games for Education in Math and Science project (E-GEMS) was created in 1992 to find out if students in the age group between grades 4 to 8 would profit in learning Mathematics and Science through specially designed digital games for Human and Computer Interaction (HCI). Two collaborative game prototypes were developed—Avalanche and Island. Even though children found both networked games highly motivating, field trials of the game were not completed due to stability issues. In educational games, the E-GEMS project demonstrated increased motivation and academic achievement within Mathematics and Science education in upper elementary and high school (Klawe, 1999). The purpose of a study by Rosas et al. (2003) in economically disadvantaged schools in Chile (n=1274) for grade 1 and 2 was to assess the effects in terms of learning, motivation, and classroom dynamics when educational video games were introduced in the classroom. The sample also consisted of 30 school teachers

and six directors. Students were divided into three groups— Experimental Group (EG), Internal Control Group (IC), and External Control Group (EC). There were three phases that took place: 1) pre-implementation where teachers and directors were trained in the use of the software, 2) implementation of the educational video games in the experimental group where students could play the game for 20 to 40 minutes every day in the classroom, and 3) assessment where the pre-test was done before the implementation and post-test was conducted after the implementation. Separate analysis of covariance was done to test the effect of the intervention on Math, reading comprehension and spelling. The Math results showed that post test scores had a significant differences in mean scores between the EG and IC group on one side and EC group on the other but no mean differences were found between the EG and IC groups. Similar results were found with the spelling post-test. In reading comprehension there were no significant differences between the groups. In terms of motivation two indicators were used—results from preference survey and classroom observations. Both indicators confirmed that the EG and IC groups were highly motivated to play with the video games. Classroom observations showed that a higher percentage of students paid more attention and behaved well when playing the video game as compared to the classroom without the video game. Students playing video games were also more autonomous in their learning leading to less involvement of teachers. Teachers who used the video game in the classroom spoke positively about the intervention and found it an effective resource. Teachers reported an improvement in attention, concentration levels, and self-esteem of students who played the video game in the classroom. Teachers who did not believe that the intervention would make a difference at the end of the implementation had a change of heart and agreed that the video game had a positive influence on the teaching and learning environment. The observations and teacher reports also suggested that the video game promoted peer

collaboration, accountability and determination (Rosas et al., 2003). A study by Virvou, Katsionis, and Manos (2005) compared a virtual reality game or VR-ENGAGE Intelligent Tutoring System (ITS) to an educational software which did not have a virtual reality component named simple ITS and lacked the gaming aspect. Fourth grade elementary school students (n=180) learning geography in Greece were targeted in this study. The study was divided into four participation groups with the first group having 90 students and the remaining three groups also having a total of 90 students. All these students were 9 to 10 years old, taught the same syllabus on Geography and computer literate. The selection of students in the remaining three groups was based on their prior term teacher score results. The results further categorized students into three groups, A, B, and C based on their performance. Group A was for good performers, group B for mediocre performers, and group C for poor performers. The 90 students in the first group were divided into two groups of 45 students each. Students in the remaining three groups were further sub-divided to contain 15 students each. A pre and post-test of 100 questions as well as an interview was administered at the end of the research activity. The post-test results of first group of students (n=90) divided into two sub-groups showed less mistakes using VR-ENGAGE compared to the pre-test by 43.15%. The other sub-group using simple ITS showed 32.48% less mistakes compared to the pre-test. Therefore the players of VR-Engage showed an improvement of 10.67% in comparison to the students who used simple ITS. An independent samples t test also showed a statistical significant difference in favor of VR-ENGAGE over simple ITS. Similarly in the post-test of the remaining three groups VR-ENGAGE students in Group C and Group B made 48.97% and 38.5% less mistakes respectively than in the pre-test. The results of 31.57% and 31.64% when compared to their simple ITS counterparts showed an improvement. Students in group A that used VR-ENGAGE showed a

33.8% improvement while the students that used the simple ITS showed 32.84% improvement. Independent samples t tests showed a statistical significant difference for group C and B students but did not show statistical significant differences for group A students. Of all the sub-groups group C or poor students benefited the most from the educational game. Interview data showed that students were very excited to have the game in the classroom but experienced game players did not find the game as good as commercial adventure games. Teachers were fascinated with the good results of poor performing students and students with discipline issues being disciplined when playing games in class.

Multiple Motivations Framework

Malone and Lepper (1987) "taxonomy of intrinsic motivations for learning" has pioneered research on motivation in educational computer games. In their study of educational games, Malone and Lepper (1987) gathered feedback from remote individuals and found that four motivational elements, challenge, curiosity, control, and fantasy, influenced players' motivation levels. However, Weiner (1990) argued that studies relying on individuals would restrict the scope of motivation in educational games in which larger frameworks were needed. Weiner (1990) also contemplated benefits to the future generations by broadening motivational constructs as well as not limiting learning to individuals. Tüzün (2006) was fascinated by Weiner's futuristic ideas as well as the significance of social and contextual factors in the learning process. Tüzün (2006) was particularly interested in developing motivation constructs leading to a new motivation framework called "Multiple Motivations Framework". The "Multiple Motivations Framework" captures both intrinsic and extrinsic motivators and resulted in an endeavor with the QA brand, which provided the perfect setting for the assimilation of data and development of the framework (Tüzün, 2006). The purpose of Tüzün's study was to identify

motivational elements through an online multiplayer educational computer game—Quest Atlantis. The qualitative research study contained naturalistic interpretations and also used design ethnography, which includes ethnographic and action research. Data was collected through ethnographic methods that included interviews, observations, document analysis, observations, and a demographic questionnaire to support the interviews. Data was analyzed using an adapted version of the constant comparison method of grounded theory. After data analysis there were 13 major categories that came out as motivational elements for playing QA: 1) identity presentation, 2) social interaction, 3) playing, 4) learning, 5) ownership and control, 6) fantasy, 7) immersive context, 8) curiosity, 9) creativity, 10) achievement, 11) rewards, 12) uniqueness, and 13) context of support.

New studies that adopt Tüzün's (2006) "Multiple Motivations Framework" in different contexts, audiences, and conditions would extend and contribute to deeper understanding of the link between learner motivation and playing digital games. Thus, the present study builds and extends upon the multiple motivations framework in order to add to the current knowledge on the relationship between grade seven learner's motivation while using a 3D digital immersive game, QA, to learn about statistics in Mathematics.

21st Century Competencies and Learning

21st century skills are believed to be vital for students to learn and succeed in today's global economy ("PARTNERSHIP," 2012). A study by De Aguilera and Mendiz (2003) states the following:

> Arguments in favour of the cognitive importance of video games are based on a number of studies indicating that many video games are conducive to the development of specific

> skills: attention, spatial concentration, problem-solving, decision-making, collaborative work, creativity, and, of course, ICT skills. (p. 8)

These ICT skills are actually 21st century skills necessary for educators to impart for students to master the learning process ("PARTNERSHIP," 2012). Recent research by Barab et al. (2010a) supports the transformational potential of video games that allow children to play real life roles like doctors, lawyers, scientists and so on. Children can use specific area knowledge particular to their character to answer personally engaging and scenario specific queries. This new 21st century pedagogy takes learning into a new dimension where the transformation of prior conceptual knowledge occurs according to the real life situation propagated by the game.

Research by Simpson (2005) and Squire (2005) argue that video games can develop new skills in students by providing meaningful roles that not only offer peeks but also allows visual views to real life situations. The effect of information and communication technology (ICT) on our society is slowly transforming it from an industrial society to an information or knowledge society (Voogt, 2008). A position paper by Voogt and Roblin (2010) postulates the lack of 21st century skills or competencies reference with regard to a specific educational level. This leads to the conclusion that a recent clear definition of 21st century skills or competencies has not been decided by scholars. The New Media Consortium in 2005 defines 21st century skills or literacies as

> ...the set of abilities and skills where aural, visual and digital literacy overlap. These include the ability to understand the power of images and sounds, to recognize and use that power, to manipulate and transform digital media, to distribute them pervasively, and to easily adapt them to new forms (Consortium, 2005, p. 2).

An analysis of existing frameworks by Voogt and Roblin (2010) provides the 21st century competencies of technology skills, critical thinking, problem solving, collaboration, communication, creativity, and global awareness.

The 21st century competencies framework proposed by Voogt and Roblin (2010) form the basis to examine whether QA provides learners with opportunities to develop 21st century competencies. In the following sections, examples of students demonstrating these 21st century competencies in QA are specifically described.

Technology Skills

Voogt and Roblin (2010) describe Information and Communication Technology (ICT) as the core of 21st century skills. ICT not only provides the basis for having 21st century skills but also the means or tool that sustains the attainment and validation of these skills.

Students in QA learn about using the chat space appropriately and not to give out personal information. Questers interact with different characters, assimilate information, and form their own opinions as well as give advice for a particular situation. Students maintain their username and password, regularly update their Qpods, and navigate the multiuser virtual environment. They also use the teleport function to move back and forth between different worlds. Every task on the mission list involves meeting a non-playing character in a particular location. Students are able to navigate their Avatar to this location through the use of a directional tool that pinpoints the Avatars location when stationary and in motion. Questers due to their involvement with commercial games understand that technology allows them to interact with characters in the 3D virtual environment for the learning experience in the virtual game.

Critical Thinking

Voogt and Roblin (2010) do not provide a definition for critical thinking. Therefore, a definition is provided from http://www.p21.org. Critical thinking can be described as the skill to: 1) formulate clear / precise vital questions / problems, 2) gather / assesses relevant information to effectively interpret and conclude a solution, 3) open-mindedly thinks about alternate systems of thought to reach a practical conclusion, and 4) communicates effectively with others to solve a complex problem ("PARTNERSHIP," 2012).

Ander City is a world where students conduct statistical data analysis to find out whether the present mayor or mayor in contention can keep up their part of the bargain to make the best decisions for the children of Ander City. The Ander City unit requires Questers to use available statistical tools and knowledge gathered from meeting various characters to make their own decisions based on the data. These decisions form the basis for students understanding of the different situations encountered in each mission.

Problem Solving

Problem solving can be described as a skill that: 1) shows multiple approaches to solve a problem, and 2) uses multiple resources to reach a solution ("PARTNERSHIP," 2012).

Every mission contains situations that students need to interpret by problem solving. The situations that require problem solving include for example, finding out the safest bike by working out which brand of bike has a better braking distance and whether being allowed to listen or not listen to music while playing in a park leads to more children playing for longer time periods. The absence of only one correct answer provides the Quester with a means of interpreting the content and answering it accordingly. Many solutions can work in this

environment especially since the teacher knows their students and can correct answers depending on the students' aptitude.

Collaboration

Voogt and Roblin (2010) do not provide a definition for collaboration. Therefore, a definition is provided from http://www.p21.org. Collaboration can be described as the skill to: 1) work effectively and respectfully with other students towards a common goal, and 2) exercise flexibility in making necessary compromises to accomplish a common goal ("PARTNERSHIP," 2012).

The environment provided by the QA game and reinforced by the teacher encourages collaboration between students. Students are so absorbed in the environment that they are not aware of the teacher providing feedback to their responses in the missions but think that characters in QA are writing back to them. Thinking the teacher to be free, the students approach and interact with the teacher asking all kinds of questions related to technical issues, activities in Ander City as well as why their responses were not getting accepted. This brings about a whole new collaborative scenario between the students and teacher thus taking the relationship a notch higher.

Communication

Voogt and Roblin (2010) do not provide a definition for communication. Therefore, a definition is provided from http://www.p21.org. Communication can be described as the skill to be able to: 1) articulate thoughts and ideas clearly and effectively through speaking and writing, and 2) listen effectively to understand meaning, knowledge, values, and attitudes towards a common goal ("PARTNERSHIP," 2012). The two modes for communication in QA are writing and reading. Students can interact with non-playing characters as well as understand the

storyline by reading the contents in screen. Students also choose (out of two choices) their responses when interacting with non-playing characters by clicking on one of the two choices displayed in the text pane of the screen. Students write their responses to the questions asked in each mission and the teacher responds to them on behalf of one of the characters in QA. There is no fixed way of writing out responses and the teacher makes the call in accepting the responses according to the capability of each student.

Creativity

Voogt and Roblin (2010) do not provide a definition for creativity. Therefore, a definition is provided from http://www.p21.org. Creativity can be described as the skill to be able to: 1) develop, implement and communicate new ideas to others, and 2) find patterns / relationships and make connections among ideas ("PARTNERSHIP," 2012).

Students are encouraged to share their creative ideas with their peers. For instance, in this study, one student in a group of five decided to calculate the mean, median, mode, range and write it down on a piece of paper. The student propped up this piece of paper beside the laptop and referred to it while writing out subsequent responses. The other students in the group followed the student's lead and similarly wrote out the calculations in order to respond to the questions.

Global Awareness

Voogt and Roblin (2010) do not provide a definition for global awareness. Therefore, a definition is provided from http://www.p21.org. Global awareness can be described as the skill to: 1) collaboratively work with students from diverse cultures, religions, and lifestyles, and 2) use mutual respect and open dialogue in personal, work and community contexts ("PARTNERSHIP," 2012).

Students in excess of 50,000 spread over six continents and 18 countries have participated in the Atlantis Remixed project. The Atlantis Remixed project allows students from all these locations to meet virtually in one central location, QA (Barab et al., 2005a). Students from different parts of the world can also collaborate and co-quest with each other as one virtual classroom through a co-questing tool in the teacher toolkit. QA provides a breeding ground for the interaction of cultures, communities, and languages.

Though there may not be a specific, agreed upon definition for 21st century skills it is an emerging area of focus that can be studied as a part of innovative learning designs with students in schools. The 21st century skills are one means of defining and therefore designing tasks that provide students with the necessary skillsets to succeed in the global economy of the workplace. These 21st century skills are believed to be vital for children to learn at an early age and therefore should be one of teachers' concerns when designing lessons and activities for their students. This study, therefore, explores how an online virtual game QA can provide opportunities for learners to develop 21st century skills in a suitable learning environment that also accommodates a framework to cater to individual learning differences.

Universal Design for Learning

Universal Design for Learning (UDL) supports the use of technology to not only master content but master the learning process itself — a fundamental goal for learners' in the 21st century (CAST, 2011). QA creates an environment for autonomous and asynchronous learning in the classroom. In addition, QA appeals to all students irrespective of their learning needs and abilities. The principles of UDL are well represented in DGBL.

Orkwis and McLane (1998) defined UDL as:

> The design of instructional materials and activities that allows the learning goals to be achievable by individuals with wide differences in their abilities to see, hear, speak, move, read, write, understand English, attend, organize, engage, and remember. UDL is achieved by means of flexible curricular materials and activities that provide alternatives for students with disparities in abilities and backgrounds (p. 9).

According to Simpson (2009), digital video games provide a learning environment that can be customized and further designed to support UDL by allowing numerous means of interpreting instruction and different ways of accomplishing the goal.

The center for applied special technology (CAST) lists three main principles of UDL: 1) provides numerous ways of representation, 2) provides various means of action and expression, and 3) provides multiple means of engagement (CAST, 2011). Since all three UDL principles are supported in video game environments the design of the curriculum does not need to be altered to cater to different learner groups in the same class (Simpson, 2009).

Simpson (2005) and Squire (2005) are also are in consensus with video game learning environments having the potential to support video game-based lesson plans as an alternative to the traditional method of learning curriculum objectives. These lesson plans can cater to the assimilation of 21st century skills as an integral component of game-based learning which caters to the development of critical thinking, problem solving, and interpretative analysis skills (Squire, 2005).

Chapter Summary

The key themes explored in this literature review are gender, engagement, motivation, and 21st century competencies. However, there is still much to be learned. The present study aims to address gaps in the literature on student engagement, motivation, and the development of

21st century competencies by studying the use of Anders City, a QA unit / game focused on introductory statistics concepts, by grade seven learners. Three research questions frame this study:

1. In what ways can student engagement in learning be supported by playing Quest Atlantis in the classroom?
2. Do students feel more motivated about their learning and about mathematics when learning is supported by Quest Atlantis?
3. In what ways can the development of 21st century competencies be supported by Quest Atlantis in the classroom?

In chapter three, the research design and research methodology chosen to enact this study, along with the research setting and participants, will be described.

CHAPTER 3 RESEARCH METHODOLOGY

Type of Study

Building on the work of (Tuzun, 2004) and (Smith, 2011), this research uses a descriptive case study approach to examine the interactions between students and a teacher in class when playing an educational 3D virtual game "Quest Atlantis" to learn Mathematics. As this is a descriptive study, the goal is to determine the usefulness of "Quest Atlantis" as an educational technology for teaching in class and whether the 3D virtual game provides a meaningful and conducive learning environment in terms of motivation, engagement, and the development of 21st century competencies. There are three research questions that frame this study:

1. In what ways can student engagement in learning be supported by playing Quest Atlantis in the classroom?
2. Do students feel more motivated about their learning and about Mathematics when learning is supported by Quest Atlantis?
3. In what ways can the development of 21st century competencies be supported by Quest Atlantis in the classroom?

This case study employs both quantitative and qualitative data collection methods, making it a mixed-methods case study, and triangulates several data sources in making knowledge claims about student engagement, motivation and the development of 21st century competencies through the use of QA, an online, digital game, for learning in Mathematics.

Participants

The Mathematics teacher and seventh grade students who were participants in this study were recruited from a large urban school district in Alberta, Canada. The teacher recruited in

this research study was already a certified QA teacher who had implemented the virtual learning game in other classes that he had taught. The principal (Appendix J and L) and teacher (Appendix I and F) had to go through a split consent process to participate in the research study as two consent forms needed to be signed— one for the QA participation from Arizona State University and one for the University of Calgary Ethics protocol. The signed Arizona State University consent form gave the school and the teacher permission to use the proprietary software. The signed University of Calgary consent form provided the researcher permission to consider and analyze teachers' data in the research study as well as obtain permission from the principal to conduct research in the school. Two grade seven classes currently taught by this teacher were approached by the researcher to take part in the research. Engagement with QA was expected as part of the regular learning activities in the class, while participation in the research was not compulsory. The total number of students in both classes was 66 (ages 12-13)—33 each in two sections, Class A and B. There were a total of 20 students identified as English as a Second Language (ESL) learners of which 3 were beginning ESL in Class A. In Class B, 17 were ESL students for a year. In each Class, there were four students who had identified learning disabilities and had an Individualized Program Plan (IPP). Out of these 66 students, 59 students provided consent to participate in QA. Consent was not provided from parents / guardians for seven students to participate in any aspect of the researcher's study, and parents / guardians of another three students did not provide consent for their child to take part in certain aspects of the research study.

There was a two pronged consent process to participate in the research study as students had to return two consent forms signed by their parents— one for the QA participation (Appendix H) and one for the University of Calgary Ethics protocol (Appendix G). The signed

QA consent form gave students permission to use the proprietary software and the signed University of Calgary consent form provided the researcher permission to consider and analyze students' data in the research study. Students could take part in QA and not participate in the researcher's study but not the other way around wherein take part in the research's study and not QA. In other words, the researcher's study was dependent on participants first providing consent to use QA. A third part of the ethics process was to invite students to give their personal consent to participate in the research study by signing an assent form (Appendix K). In all, there were seven students whose parents / guardians did not give consent to participate in QA and these students were provided alternate instructional activities for success in meeting curriculum requirements.

The researcher asked the teacher whether the Ander City unit would be a good fit for teaching statistics in Mathematics. The teacher after careful deliberation felt that the Ander City unit would benefit the students, which led to use of the Ander City unit to teach and learn statistics. The purpose for participation in QA was both educational and social. Students were asked to complete 4 missions in the Ander City unit that were designed to engage learners with the statistics concepts of mean, median, mode, and range. The statistics concepts in QA align with the Alberta Program of Studies grade seven Mathematics learning outcomes for mean, median, mode, and range. In particular, the Ander City unit in QA covered the contents mentioned in two specific outcomes in grade seven Mathematics program of study data analysis strand. The specific outcomes were:

1. Demonstrate an understanding of central tendency and range by:
    - determining the measures of central tendency (mean, median, mode) and range.
    - determining the most appropriate measures of central tendency to report findings.

2. Determine the effect on the mean, median, and mode when an outlier is included in a data set.

Selection Procedure

The sampling methods for this case study can be described as both purposeful and convenience sampling. According to Merriam (2009) "purposeful sampling is based on the assumption that the investigator wants to discover, understand, and gain insight and therefore must select a sample from which the most can be learned" (p. 77). Purposeful sampling is also applicable to individuals and sites (Creswell, 2012). The participants recruited for this research study fit the category of generation Z students or "digital natives", in this case young people specifically born between 2000 and 2013. Individuals described by Prensky (2001b) as digital natives have grown up in a social environment of digital technology from an early age and it is assumed that learners of this age are well versed with different technological formats. Thus, it was anticipated that a class of grade seven students would provide a favourable sample for a study that aimed to understand motivation, engagement, and 21st century competencies through a 3D virtual game, QA.

Given the nature of the intervention, playing the 3D virtual game, QA, and the effort, skill and training required of teachers who want to use this digital game with students, a particular kind of teacher was desired for this study. The teacher who possessed the expertise and enthusiasm for using QA with students was known to the researcher, and was purposefully recruited for this study. The teacher who was recruited in this study was both certified as a QA teacher and was already enthusiastic about using the digital game with students and with getting involved in the research study. For the purposes of this case study, the targeted sub-group, or purposeful sample were learners in the category of generation Z. The two classes of grade seven

students taught by the grade seven teacher who was recruited for the study also constitute a convenience sample. According to Creswell (2012) in convenience sampling "the researcher selects participants because they are willing and available to be studied…the sample can provide useful information for answering questions and hypotheses" (pp. 145-146). The students were chosen because of their membership in the classes taught by this particular teacher (convenience sampling), and also because of their membership in the category of generation Z (purposeful sampling).

Research Design and Procedures

A mixed methods case study methodology using both quantitative and qualitative data collection methods was the research design utilized in this study. A case study is an effective research methodology when the desire is to understand real life scenarios in a natural bounded setting (Yin, 2009). First, this case study explored a new and innovative form of learning, namely DGBL, and whether the use of QA and engaged teaching methods in a classroom can lead to meaningful learning for grade seven students in Mathematics. Second, this study specifically strived to identify and document motivational elements, 21st century competencies, and student engagement factors when QA was used as an approach to learning statistics with grade seven students. And third, this study also aimed to describe whether and how grade seven students changed their learning patterns and tended to learn in more meaningful ways from a new and innovative educational format such as an online educational digital game. This study therefore collected data on students' experiences of using QA as a new and innovative form of learning. According to Merriam (2009) the case study is defined as "an in-depth description and analysis of a bounded system" (p.40). In this case study the bounded system consisted of two

classes of grade seven students and a teacher from a large urban school district in Alberta, Canada, who used QA for learning concepts in the Alberta program of studies.

A case study is highly beneficial when addressing questions like "how" or "why" that deal with a contemporary set of events as well as provide the investigator with little or no control (Yin, 2009). This case study adds to the growing body of research that explores how new innovative methods such as digital games like QA may be an effective medium of instruction, especially for students who are defined as 'digital natives' and generation Z.

Flyvbjerg (2006) argued that, contrary to the misconception that the generalization of a single case does not add to scientific development, natural and social sciences can be advanced by a single-case study. This case study explores a new and innovative form of learning, DGBL, and whether the use of the 3D game, QA, accompanied by engaged teaching methods in a classroom can lead to meaningful learning. Thus, while this study involves a single case as a bounded system, it is expected that findings will be useful beyond this case study.

This descriptive mixed-methods case study research methodology was designed to collect both qualitative and quantitative data as the activities evolved over the course of the study. Yin (2009) argued that "the most important advantage presented by using multiple sources of evidence is the development of converging lines of inquiry, a process of triangulation and corroboration " (p.117). In this study, multiple sources of data were collected over time using methods from pre and post statistics tests in the form of surveys, student and teacher observations, technology and engagement surveys, a teacher 21st century competencies survey, a teacher interview and student focus group interviews. A descriptive case study provides an in depth depiction of the phenomenon through an attractive and insightful narrative to bring out the essence of the case (Merriam, 2009). This case study triangulates several data sources in making

knowledge claims about learning with QA and provides descriptive answers to the research questions.

Yin (2009) describes that "for case studies, five components of a research design are especially important" (p. 27). The five components are: 1) the study's questions, 2) its propositions, 3) its unit of analysis, 4) the logic linking the data to the prepositions, and 5) the criteria for interpreting the finding. The following sections are organized using Yin's components of a research design.

The Study's Questions

This study explores and reports on the motivation and engagement of students using QA to learn core curriculum topics. This study aims to specifically identify motivational elements, 21st century competencies and whether QA fostered student engagement in learning statistics using an online educational 3D digital immersive game. As detailed at the beginning of this chapter, three research questions were posed to frame the study, and to guide data collection and analysis.

Propositions

The students played the 3D virtual game QA that the teacher and researcher identified as related to completing learning outcomes specified in the Alberta Education program of studies in Mathematics. The students were asked to play 4 missions that were part of a unit called "Ander City" to learn the statistical concepts of mean, median, mode, and range.

According to Barab et al. (2005b) meaningful learning is supported in a learning environment like QA that uses commercial game strategies for engaging and motivating students with educational content.

Units of Analysis

Building on the work of Tuzun (2004) and Smith (2011) this research constitutes a descriptive case study for examining the interactions between students, the teacher, and game play in QA to learn concepts in the core curriculum topic of Mathematics, and the outcomes as measured by concepts of student motivation, student engagement and the development 21st century competencies. Thus, the units of analysis were motivation, engagement, and 21st century competencies.

Logic Linking Data to the Prepositions

In order to have the widest range of data possible for analysis and triangulation, there were seven main types of data collected in this case study. The seven main types of data were: 1) student pre and post-tests surveys provided in the lesson plan of the Ander City unit (Appendix E), 2) observations of teacher and students during their interactions with QA, 3) student focus group interviews examining motivation, engagement and 21st century competencies (Appendix B), 4) teacher survey observing 21st century competencies in students (Appendix C), 5) teacher interview about the affordances and constraints to do with DGBL as well as motivation, engagement and 21st century competencies in QA (Appendix C), 6) student surveys on computer technology use (Appendix A), 7) student surveys on engagement (Appendix D). All of these data collection methods allowed for a triangulation of the data for answering the research questions.

The Criteria for Interpreting the Findings

The strength of this mixed methods study is that it combines the advantages of each form of data, both qualitative and quantitative. Specifically, qualitative data was collected from student focus group interviews as well as a teacher interview and classroom observations.

Quantitative data was collected via student pre and post-test surveys, engagement survey and computer technology survey. Both forms of data offered in-depth information that was triangulated to yield findings in relation to the research questions.

Yin (2009) states that statistical analysis can provide some insight to a study's findings by considering a *p* level of less than 0.05 for observed changes to be statistically significant. He also identified three criterions for interpreting quantitative findings from an experimental or correlational study, such as: 1) construct validity, 2) external validity, and 3) reliability. While quantitative data is one form of collected information used for analysis in this study, the findings are interpreted both descriptively and with one test to determine statistical significance. Criteria that are most appropriate to a mixed methods study include trustworthiness, credibility of findings and verifiability, which will be described in the sections that follow.

Trustworthiness

Russell, Gregory, Ploeg, DiCenso, and Guyatt (2005) argue that to achieve trustworthiness researchers have a responsibility to ensure that: 1) the case study research question is clearly written, propositions are provided, and the question is substantiated, 2) case study design is appropriate for the research question, 3) purposeful sampling strategies appropriate for case study have been applied, 4) data are collected and managed systematically, and 5) the data are analyzed correctly.

In addition, the triangulation of data sources worked as a major approach that provided multiple perspectives towards the in focus phenomenon bounded by the case study (Baxter & Jack, 2008). Baxter and Jack (2008) as well as Creswell (2012) also argued that during the time of data collection and analyses an active dialogue with one or more participants to check the

accuracy of the researcher's interpretation could bring new perspectives on the issue being studied, also known as the process of "member checking".

Credibility

Greene, Caracelli, and Graham (1989) argue that mixed methods studies formed the basis for a significant and meaningful research purpose. Five purposes were found for mixed methods models in their empirical studies: "1) triangulation, 2) complementarity, 3) development, 4) initiation, and 5) expansion" (p. 255). Out of these purposes, triangulation and complementarity were the primary purposes for the use of mixed methods for data collection and analysis in this case study. According to Johnson and Onwuegbuzie (2004) the complimentary nature of quantitative data where words inform numbers and qualitative data where numbers inform words brought about forceful confirmation through the triangulation of findings. When qualitative and quantitative data are used together for analysis, the associated biases and weaknesses may be balanced out and the resultant triangulation may offer a more meaningful and purposeful study than the use of just a single method (Greene et al., 1989).

Verifiability

Creswell (1998) identified eight procedures for verifying qualitative research findings and recommends that any research study employ at least two of these procedures. The procedures selected and used purposefully in this mixed methods case study were: 1) thick description, and 2) triangulation. Lincoln and Guba (1985) describe thick description as a procedure to achieve a type of external validity. They believed that describing a phenomenon in detail could gauge the degree the findings were valid in other contexts and participants. Creswell (2012) argues that "triangulation is the process of corroborating evidence from different individuals, types of data, or methods of data collection in descriptions and themes in qualitative

research" (p. 259). Out of the four types of triangulations identified by Patton (1999) this case study adhered to the methods triangulation. Methods triangulation compares qualitative and quantitative data to bring out complimentary insightful aspects of the same phenomenon in the context of the study (Patton, 1999).

To address verifiability, multiple sources of evidence to address the research questions will be used in order to make credible and defensible knowledge claims. The triangulation of data from multiple sources, such as the student focus group interviews, teacher interviews, student pre and post-tests surveys, student engagement surveys, student computer technology surveys, teacher 21st century competency survey, and student and teacher observations, is aimed at providing a rich and detailed understanding of the phenomena of interest and to verify insights and observations that are yielded from each form of data alone. Interview and survey questions also included questions on the Mathematics core curriculum objective—statistics and data analysis.

The affective domain of learning especially motivation was gauged through the student computer technology surveys, student focus group interviews, and student as well as teacher observations. Engagement was ascertained through the student engagement surveys, student pre and post-tests surveys, and student as well as teacher observations. Student 21st century competencies were determined through the teacher 21st century competency survey, teacher interview and student as well as teacher observations. Interviews, observations, and surveys were used to better understand students' experiences with and perceptions of meaningful learning in QA. Briefly described is the concept of external validity.

External Validity

This study took place in a school and purposefully sampled students in grade seven (12 to13 years old) and their teacher, who had experience with the digital game. The study investigated the impact of playing a digital game to learn Mathematics concepts in statistics and data analysis on student engagement, the use of 21st century skills and motivation. The case study sought to provide results from a classroom based investigation that would provide insights of use and value to practitioners and researchers beyond this one classroom. A detailed Case Study Protocol (Appendix M) was developed so that other researchers in the future might choose to replicate this study in other settings.

Constant Comparison Method

The researcher begins with open coding where categories are formed by preliminary coding of data. The use of this data in the next step develops axial coding by centring on one open coding category where the researcher goes back to the data to find categories relating to this main phenomenon (Creswell, 2007). According to Strauss and Corbin (1990) the type of categories around the main phenomena are "casual conditions, strategies, contextual and intervening conditions and consequences" (pp. 64-65). They also stated that when the formation of new properties of a category was not possible then that category was considered complete. The third and final step, selective coding provides a story that interconnects the various categories together with relation to the main phenomena or category (Creswell, 2007).

The researcher therefore describes below the three stages of the constant comparative method followed in the research study: 1) open coding, 2) axial coding, and 3) selective coding.

Open Coding

The researcher imported the student focus group interviews matrix excel document and teacher and students observation word documents into analysis software, NVIVO 10 for data analysis. NVIVO 10 provided the researcher a manual and usable technique to code data. Before starting the open coding stage the researcher read the interviews and observations to keep the content in mind. The researcher first read the interview question and then the answers to it. Only the first four questions related to motivation were openly coded in the software. The whole answer was coded as a paragraph. High level open coding was done to prevent the emergence of hundreds of codes, which would require the merging of open codes. As expected, the majority of codes came out during the open coding of the focus group interviews. These existing codes were also used during the open coding of the students and teacher observation documents. The open coding of the interview documents took six days and resulted in 85 codes. Since most of the codes of the observations were similar to the interviews the resultant open codes from the observations was just one code. These codes are listed in Appendix O.

Similarly the constant comparison method was used for the teacher interview as well as teacher and student observations related to 21st century competencies. Some of the major difference compared to the previous open coding data was that 10 open codes emerged from the teacher interview and the remaining 39 codes from the teacher and student observations. These codes are listed in Appendix P.

Axial Coding

During the axial coding stage, subcategories and categories were developed based on the codes that emerged through open coding. The iterative relationship between open and axial coding kept the researcher constantly checking the outputs of both stages. In this stage the 85

codes were organized into four categories. The four categories were accomplishment, immersive context, learning, and social relations.

Similarly axial coding of the teacher interview as well as teacher and student observations related to 21st century competencies resulted in six categories. The six categories were problem solving, critical thinking, creativity, collaboration, global awareness, and communication.

Selective Coding

The emergence of four categories in relation to the core category motivation was similar to the categories mentioned in Tuzun's research (Tuzun, 2004). The frequencies of codes in the axial coding or sub-category stage were used to show the thickness or hits received per category with the data sources in this study.

Research Context

To carry out this case study, the researcher had to carry out several steps to secure permission to use the online game, complete training to use the online game, secure ethical approval from the University of Calgary, and also ethical approval from the school jurisdiction in which the study was to take place.

Arizona State University IRB Approval

In order to carry out this case study, the researcher had to approach researchers at Arizona State University (ASU) to obtain permission to use its proprietary software QA also known as Atlantis Remixed. There were two pre-requisite steps required for permission to use QA: 1) the researcher had to score 80 percent or higher in the Arizona State University's Institutional Review Boards (IRB) approval Collaborative Institutional Training Initiative (CITI) exam and 2) the researcher had to complete QA online teacher training (with the teacher if the

teacher was not already a certified QA teacher or if you were a researcher and not a teacher). After completion of both steps the researcher sought and received permission to use QA from ASU.

Conjoint Faculties Research Ethics Board Approval

An application for ethical approval was submitted to the research ethics board at the University of Calgary. The Conjoint Faculties Research Ethics Board (CFREB) at the University of Calgary granted ethics approval (Appendix N) within two and a half weeks.

Board of Education Approval

It took a significant amount of time to secure ethical approval to conduct this case study from the school jurisdiction (Appendix Q). From application to approval, the ethics review process with the school jurisdiction took six weeks. There were at least five issues upon which the research office in the school jurisdiction sought clarity and protocol modifications before permission was granted to conduct the research: 1) the research office's initial requirement, that was later dropped, that QA ASU researchers submit an application to conduct research in the school jurisdiction, 2) a requisition that the Arizona Research team modify their consent letter to indicate that only online data would be collected and that no ASU researcher would perform classroom visits and interviews, 3) the non-approval at the school jurisdiction level of QA research, 4) the potential identification of individual students due to ASUs' access to letters of informed consent, and 5) the contingency plan for the exclusion of students whose parents / guardians did not provide consent from QA.

The researcher and his supervisor clarified and addressed the five issues: 1) ASU IRB approval made the researcher a co-investigator under ASU seeking permission to conduct the research study it was also sufficient to the ASU team that the University of Calgary Research

Ethics Board had given ethics approval for the researcher's research protocol, 2) clarification that the servers in the U.S were designed to only store the online, anonymous "in game" data collected via QA from individual players, 3) that QA research has received ethical approval from several states in the U.S. and ASU's IRB process is similar to the Canadian Tri-Council Ethics practices, 4) that the ASU research team would have access to the signed letters of consent for the ASU project; however, there is no intent in their research protocol to link anonymous online data with the identities of students from the consent forms and the ASU research team would not have access to the Consent Forms from the present researcher's case study, nor have access to any of the data collected for the case study, and 5) that children whose parents do not give consent had other instructional activities which provided an opportunity for success in meeting the stated curriculum requirements.

In response to the elaborated protocol provided by the researcher and his supervisor, the research office of the school jurisdiction provided conditional approval (Appendix R) based on the following requirements:

1. That in the University of Calgary letters of informed consent for parents, students, teachers and the principal, the researcher include the following information:
    a. the Arizona State University (ASU) Team will have access to the signed letters of consent for the ASU project,
    b. personal data will be stored in the United States and subject to their laws, such as the Patriot Act
    c. while there is no intent in the ASU research protocol to link anonymous online data with the identities of students from the consent forms, absolute confidentiality cannot

be guaranteed, and personal information may be disclosed if required by the laws of the United States.

2. That an information letter be included with the consent package from the graduate student researcher at the University of Calgary outlining the relationship between the researcher's project and the Arizona State University research project and highlighting the fact that informed consent to participate in the ASU Project is a necessary component of participation in the digital game, and thus in the researchers case study research.

The researcher included the information as requested in an information letter and the consent form to address each requirement and the researcher's supervisor provided a letter on behalf of the University of Calgary to address the second requirement. The research office in the school jurisdiction then provided permission to conduct the research study on the basis that the final decision to participate rests with the school administration, teachers, students, and parents involved.

Given the complexity of this case study, and the approvals needed from an American University to use a proprietary online game, ethics approval from the researcher's University, and permission from the school jurisdiction, there was significant time invested in preparation for the classroom based intervention. A key learning gained from the permission and ethical approval process that the researcher can share with future researchers is to plan well ahead and to allocate plenty of time for the ethical approval processes required by various stakeholders in a study of this type.

Learning Context

In the months of February and March 2013, the researcher carried out the case study using QA with 59 of the 66 grade seven students in a public middle school under the jurisdiction

of a Board of Education. The 59 grade seven students were in two classes taught by the same teacher, and were classified as Class A and Class B, which consisted of 27 and 32 students, respectively. Of these 59 students whose parents provided consent to play QA, there were 52 students whose parents provided consent to the researcher for their child's participation in the research and to consider and analyze the data they produced. Student and teacher interaction with QA took place in the learning commons or library of the middle school due to network bandwidth constraints. The teacher and students travelled to the learning commons to use the digital game, which was deployed on Macintosh computers. To prevent an upsurge in network activity, 20 laptop computers were wired directly into the school's Local Area Network (LAN) while the remaining computers were wirelessly connected to the LAN. At the beginning of almost each class in which QA was used, the students had to wait for permission from the teacher to pick up their common Mac laptops from the computer cart. The teacher provided free seating to both Class A and B students so that they could form social groups during their interactions with QA.

The teacher assigned 12 days in total between February 11 and March 05 for students to interact with QA; however, one day had to be ruled out due to technical difficulties with QA. Therefore the total number of days students engaged with QA was actually 11 with each day consisting of a morning and afternoon session, one for Class A and one for Class B. Out of the 11 days, two sessions did not work out for Class A and Class B in school due to scheduled celebrations and a dance session in the afternoon as well as technical difficulties with QA software in the morning, respectively. The impact of these events led to achieving a total of 10 sessions each with QA for Class A and Class B. Out of these 10 sessions, the total time allotted for nine morning sessions was one hour and fifty-five minutes and nine afternoon sessions was

one hour and fifty minutes. In the remaining one session the total time assigned for the morning session was one hour and 25 minutes and afternoon session was one hour and twenty minutes as class period durations were shorter on Friday (see table 1).

Table 1

Quest Atlantis Sessions and Allotted Durations

Session No.	**Date of Session**	**Morning Class**	**Duration**	**Afternoon Class**	**Duration**
1.	Feb-11	**Class B-Quest Atlantis down**	1 hour 55 minutes	Class A-took place	1 hour 50 minutes
2.	Feb-12	Class A-took place	1 hour 55 minutes	Class B-took place	1 hour 50 minutes
3.	Feb-13	Class B-took place	1 hour 55 minutes	**No session**	
4.	Feb-19	Class A-took place	1 hour 55 minutes	Class B-took place	1 hour 50 minutes
5.	Feb-20	**Class A-Quest Atlantis down**	1 hour 55 minutes	**No session**	
6.	Feb-21	Class A-took place	1 hour 55 minutes	Class B-took place	1 hour 50 minutes
7.	Feb-22	Class B-took place	1 hour 25 minutes	Class A-took place	1 hour 20 minutes
8.	Feb-26	Class B-took place	1 hour 55 minutes	Class A-took place	1 hour 50 minutes
9.	Feb-27	Class A-took place	1 hour 55 minutes	Class B-took place	1 hour 50 minutes
10.	Feb-28	Class B-took place	1 hour 55 minutes	Class A-took place	1 hour 50 minutes
11.	Mar-04	Class B-took place	1 hour 55 minutes	Class A-took place	1 hour 50 minutes
12.	Mar-05	Class A-took place	1 hour 55 minutes	Class B-took place	1 hour 50 minutes
Total Number of Sessions		**Class A = 10**		**Class B = 10**	

The teacher asked the students to select usernames to log in to QA and then gave these usernames to the researcher in a Microsoft Excel worksheet. The researcher made passwords for

both sections— Class A and Class B students. These passwords were verbally communicated to the students in class with the help of a teacher announcement that told students to meet the researcher in person to learn their passwords after completing the student engagement survey on the first day. After creating passwords for students the researcher registered them on QA before commencement of the research study. On the first day of class on February 11 two students in Class A had not provided passwords so they could not be registered beforehand but were registered in class after providing their usernames. In the same manner, there were five Class B students who had not provided usernames on their first day of class February 12 (due to no class on the first day because of technical difficulties with Quest Atlantis). These students were registered in QA as soon as they provided their usernames in the classroom.

There were technical difficulties encountered during the sessions especially on February 11, 12, and 20. In the first QA Class session on the morning of February 11, students in Class B encountered the error message "reason 404" (see Figure 2) which did not allow them to log in to QA using their username and password.

Figure 2. Technical Difficulties: reason 404 (Error Message)

When contacted by the researcher, the QA Buoy indicated that it was a server problem that was also happening in the USA. The QA Buoy promised that an email would be sent when a solution was found to the server problem. In the morning session of February 12, the students in Class A complained that as soon as they entered their credentials to log in to QA, they were not able to get into the QA world. An error screen was displayed that asked them to reboot their computers due to a cache problem (see Figure 3).

The teacher came up with a solution to the problem by deleting the cache contents from the path by right clicking on QA in Applications/Select "Show Package Content"/Resources/Drive C/Active World/Cache. The teacher's action seemed to solve the login problems as students were able to use their usernames and passwords to access their respective QA accounts.

Figure 3. Technical Difficulties: reason 17 (Error Message)

On February 20, Class B students in the morning session encountered navigation problems as soon as they logged into QA. Students could not see their Avatars and instead saw cartoon speech bubbles with a Stop sign inside it. The text pane on the right hand side of the Quest Atlantis interface displayed a 404 – Not Found (see Figure 4) error instead of the text that is normally displayed on this side of the screen. The researcher contacted the QA Buoy who confirmed that some users in the East coast of the USA as well as Canada were facing the same error. The QA Buoy offered the opinion that there could be a lag in the system and the system may be up in an hour or so. Students were therefore not able to use QA in this session.

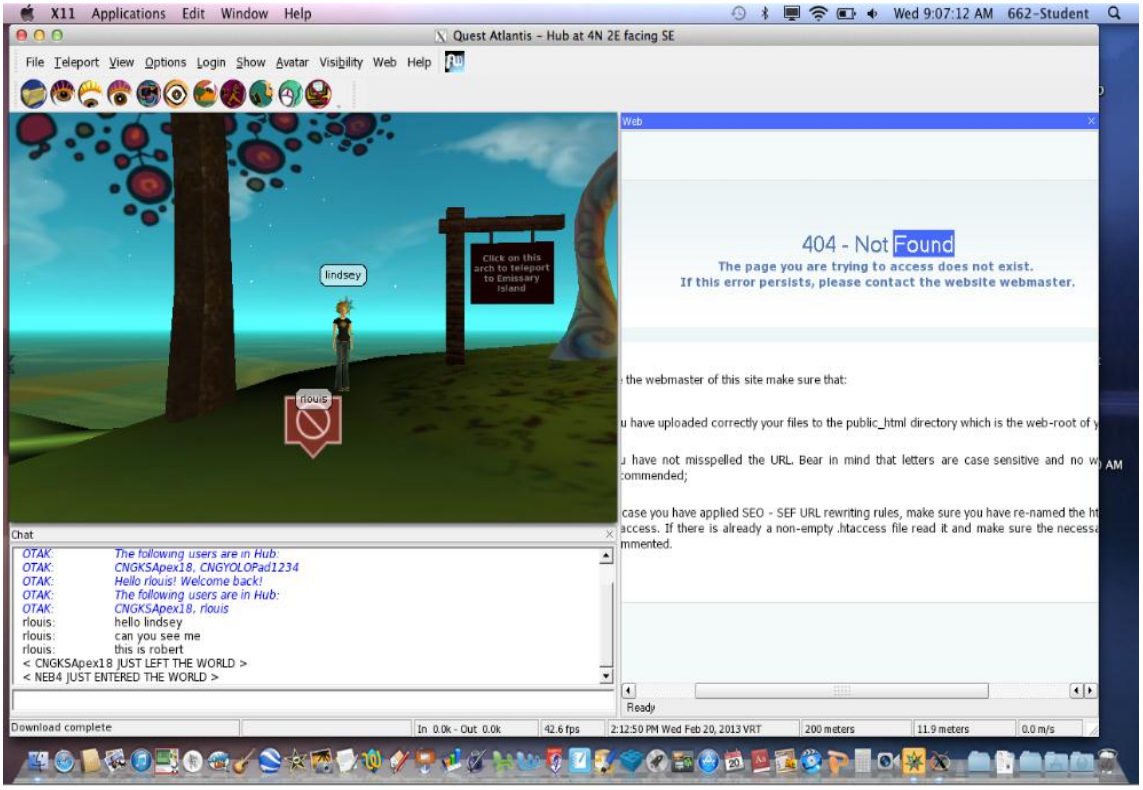


Figure 4. Technical Difficulties: 404 – Not Found (Error Message)

This section on the errors and technical difficulties encountered by the students and the teacher is included to demonstrate how a complex network system in a school combined with a

complex, online 3D game, may not run as smoothly as expected and that researchers and teachers need to plan for potential lag time and have a strategy for responding to technical difficulties. In this school and classroom, there was IT support and the teacher had used the QA 3D game before, so there was some resident expertise to deal with technological issues.

Chapter Summary

This chapter described details on how this case study research was designed and carried out. The chapter also explains how the data was collected in order to gain a more valid and reliable understanding of QA as a DGBL tool and whether the 3D virtual game provides a meaningful and conducive learning environment in terms of motivation, engagement, and the development of 21st century competencies. In chapter four, illustrations of student engagement and the presentation of data analysis, will be described.

CHAPTER 4 ANALYSIS OF DATA

The purpose of this chapter is to accomplish two things: 1) to illustrate how the learners were engaged in QA, and 2) to present an analysis of the data.

To provide context for the analysis of data, a description of the online interaction in the digital game is provided. Students logged in regularly to QA, the online virtual game and 3D immersive environment. After typing in their usernames and passwords, students entered QA at a common entry point called the Hub, which served as the gateway to all the worlds (see Figure 5).

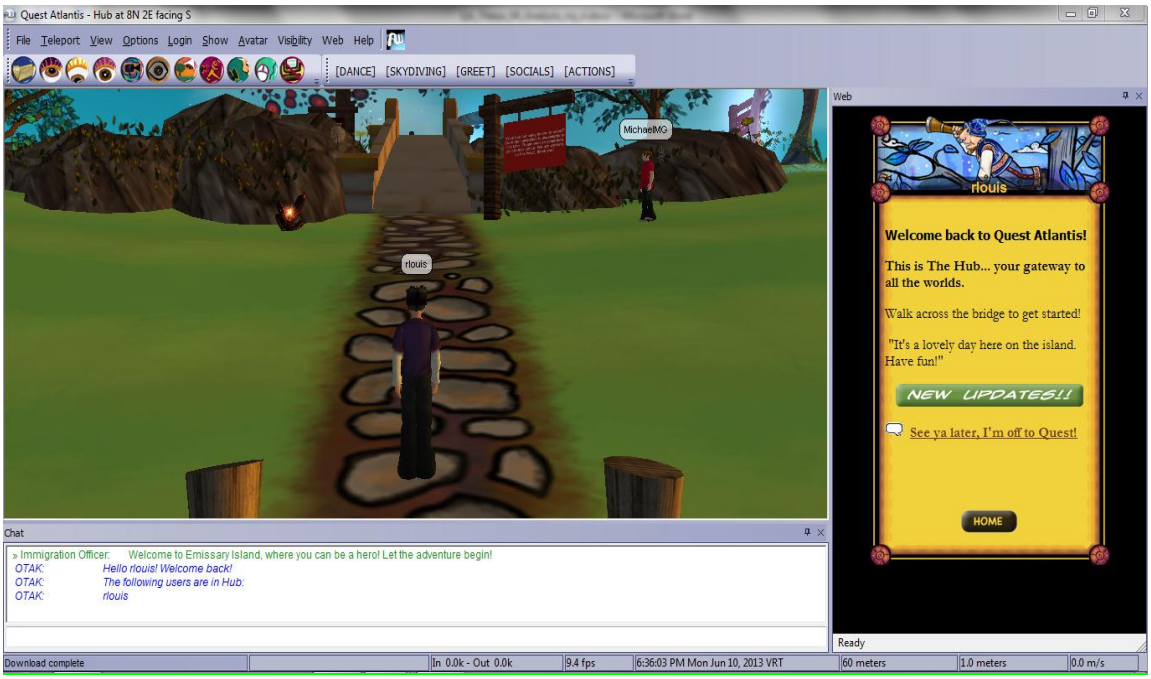


Figure 5. Quest Atlantis Hub (Start Screen Quest Atlantis)

After crossing the bridge into the Hub, students have the option to make changes to their Avatars and select from two arches to teleport to different worlds.

After completing an introductory Quest in the Emissary Island, where the students had to complete a minimum of one social commitment and the "Light the Arch, Wake the World" mission, students were able to view one another's avatars in the virtual environment. Students were excited when they first saw other students' avatars and gestured to each other physically in the classroom and interacted with each other through the chat tool in the virtual world. Since the arch facing the bridge was dedicated to the Emissary Island, students had to use the arch adjacent to the bride to access the Math world or Ander City world. Once students had made their selection, they were teleported inside Ander City's City Hall, which was the starting point for all students in the Ander City unit (see Figure 6).

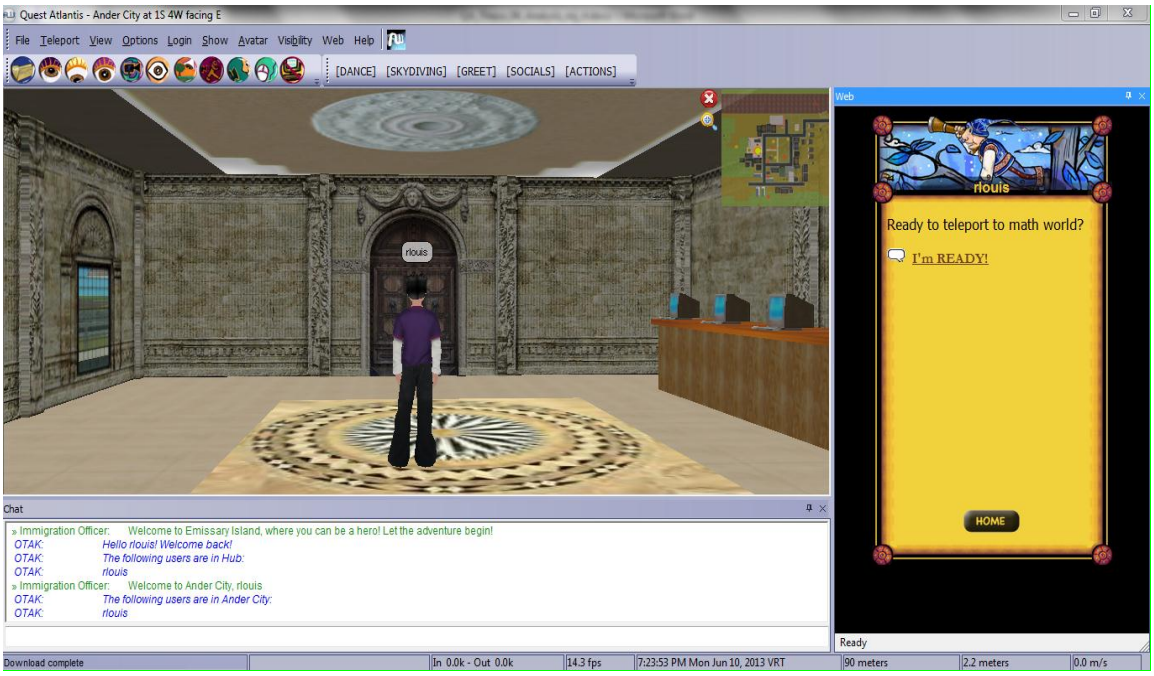


Figure 6. Ander City's City Hall (Start Screen Ander City)

Non-playing characters serve as guides throughout the game. Students' interaction with non-playing characters in the form of active role-play provided them with a context for problem

solving in the Math world. After meeting one of the main non-playing characters 'Tukey', students were asked to help the children of Ander City decide whether to support the present Mayor who is up for re-election or to support the candidate in running. Students as Questers were required to make sense of descriptive statistics concepts like the mean, median, mode, and range to help the children of Ander City decide which of the candidates' arguments make more sense. In a secret club in a cave, a secret organization of statisticians interacted with students and helped them understand the fundamentals of statistics (see Figure 7).

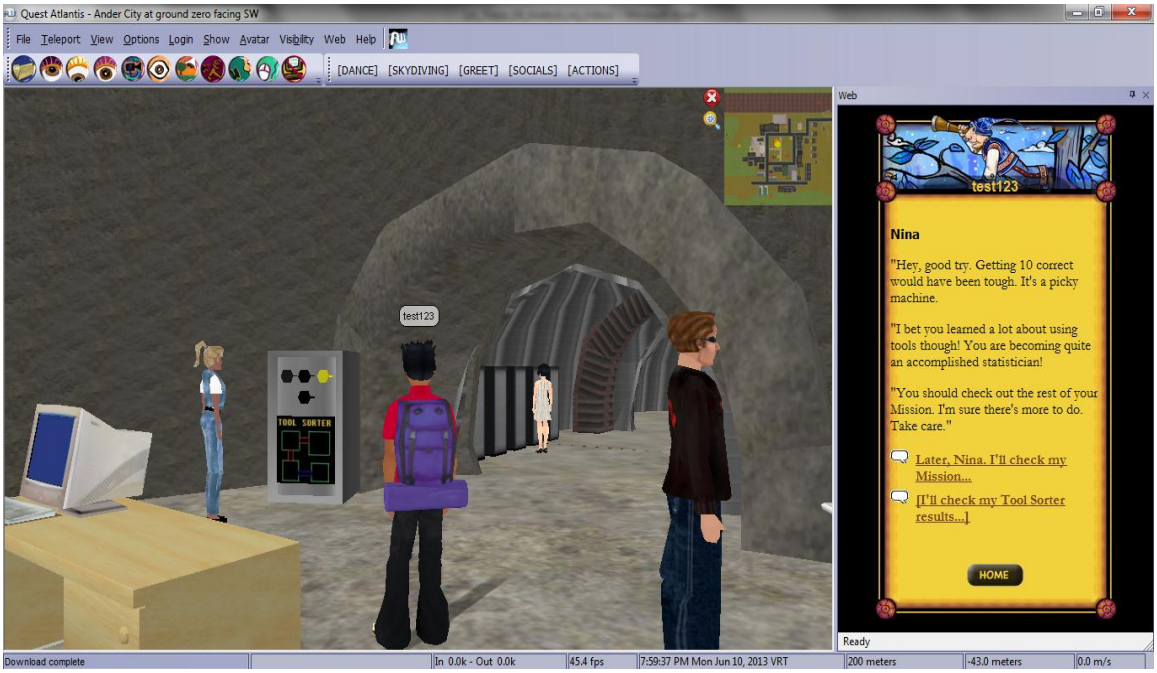


Figure 7. Secret Club of Statisticians

The analysis of data presented in this chapter is related to the study's three research questions: 1) In what ways can student engagement in learning be supported by playing QA in the classroom?, 2) Do students feel more motivated about their learning and about mathematics

when learning is supported by QA?, and 3) In what ways can the development of 21st century competencies be supported by QA in the classroom?

The sections in this chapter are presented in the order of the research questions, as summarized in Table 2. Each section begins with an overview of the findings and then presents the analysis.

Data Sources

The sources of data for this study include both quantitative and qualitative forms. Table 2 shows how the seven data sources collected for analysis in this case study map to the three research questions. The classroom observations of student and teacher interaction with the online game and with each other were common to all data sets, and map to each question.

Table 2

Research Questions Mapped to Data Sources

Research Questions	Data Sources
1. In what ways can student engagement in learning be supported by playing Quest Atlantis in the classroom?	• Student engagement survey • Student pre and post-tests survey • Classroom observations
2. Do students feel more motivated about their learning and about mathematics when learning is supported by Quest Atlantis?	• Student focus group interviews • Student computer technology survey • Classroom observations
3. In what ways can the development of 21st century competencies be supported by Quest Atlantis in the classroom?	• Teacher 21st century competency survey • Teacher interview • Classroom observations

On the initial day of the study, which was February 11th, the students in both the morning and afternoon sessions completed the computer technology survey before commencing game play with QA. Students who were absent on the first day took the test on a later date before starting the missions in QA. The total number of students that took part in the computer technology survey was 51. The purpose of the survey, entitled Computer Technology Survey, was to gauge the current level of experience that the students have with computer technology. The survey was adapted from the instrument used by the Learning & Performance Support Laboratory (2001) and can be found in Appendix A.

Students attempted the statistics pre-test after completing the QA introductory mission and before entering the online Ander City unit to learn more about statistics. There were instances of a couple of students attempting the pre-test after entering the Ander City unit, which was likely due, in part, to the excitement generated by the 3D virtual game. Students completed the statistics post-test and engagement survey one day after the last session with QA, which was March 6th. The students in class A morning session, first completed the statistics post-test after which they completed the engagement survey. Students in class B also completed the post-test followed by the engagement survey in the afternoon session.

A total of six student focus group interviews took place after the completion of the allotted game time for QA. There were three focus group interviews assigned per class, and there were three students in each focus group (n=18 students in 6 focus groups). On March 07, two Class A focus group interviews took place in the morning. Similarly, on the same day two Class B focus group interviews took place in the afternoon. On March 12, the remaining focus group for Class B took place in the morning and Class A in the afternoon. In class A, there was a total of 8 girls and 1 boy that took part in the focus group interviews, similarly in class B there

was a total of 3 girls and 6 boys. The teacher completed the 21st century competencies survey on March 09 and the teacher's interview took place on March 28.

The Ander City unit in the QA virtual game involves both political and statistical concepts. Students take on the role of Questers whose task it is to help children in Ander City decide whether to support an opponent or the Mayor who is up for re-election and plans to make changes to city policy. The Ander City children do not have a say in the matter and need to decide to help support the candidate whose arguments make the most sense. The grade 7 Questers' task, therefore, is to help the children of Ander City to make sense of the data in meaningful ways which they do by learning descriptive statistics concepts, such as the mean, median, mode, and range.

Statistics Concepts in Ander City

Questers in the Math world met Tukey who is one of the game characters. Tukey explained the current situation where a mayoral race is going on and the candidates were arguing about everything. The kids in Ander City were worried, because the decisions that the candidates made would directly affect them, and they wanted to make sure that the right man would be elected for the job.

In the first mission "Finding the Safest Bike" Questers had to decide the safest brand of bike to offer for rent in the park—Mayor Enoch's (Speedy Spokes) or Mr. Grant's (Rollin' Steady). The data analysis of bike trials through the measurement of breaking distance helped Questers make decisions on their choice of the safest bike. Therefore, the emphasis in this mission was on Questers performing an analysis with the use of the mean, median, mode, or range and link the analysis to their decision. During the course of the mission Questers met another game character Rollin' Reba from whom they learn a lot about collecting data. Rollin'

Reba helped Questers conduct a total of 10 bike trials of the Rollin' Steady brand of which 4 trials had been done earlier (see Figure 8).

Figure 8. Rollin' Steady Bike Trials

After successful completion of the bike trials, the braking distances of both brand of bikes Rollin' Steady and Speedy Spokes were presented in inches to Questers for data analysis

The goal of the mission was to write a letter to the kids of Ander City about which brand of bike is safer and whose opinion Questers supported—Mayor Enoch or Mr. Grant. The letter had to include the following information to be conclusive: 1) an introduction stating the Quester's recommendation, 2) an explanation of how the Quester analyzed the data, 3) an explanation of how the Quester decided what to do for his / her analysis, and 4) an explanation of how the Quester's analysis helps the Quester decide which brand of bike is safer (see Figure 9). .

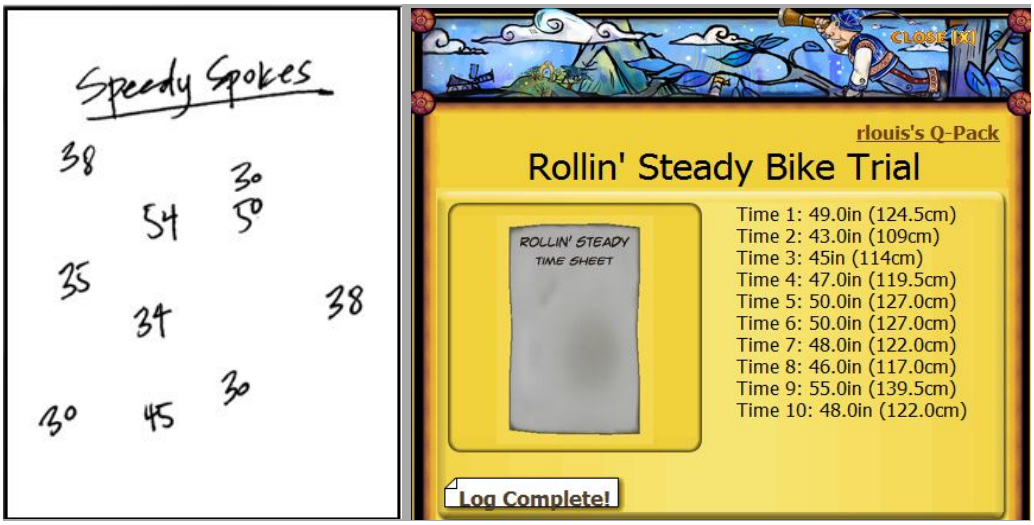


Figure 9. Braking Distance of Bikes

Questers made use of the mean, median, mode, and range to support their recommendation. Some Questers analyzed data and came to a conclusion that the Rollin' Steady bikes all stopped between 43 and 55 inches while the Speedy Spokes bikes stopped between 30 and 54 inches. Rollin' Steady bikes therefore had a smaller range than Speedy Spoke bikes and were more reliable. In addition, the Speedy Spokes bikes had three bike braking distances of 30 inches for a mode of 30 and Rollin' Steady had 2 breaking distances at 48 and 50 inches and therefore had two mode values. Therefore the mode and range was used by some Questers to conclude that the Rollin' Steady bike brand and sides with Mr. Grant. Some Questers decided to calculate the mean of Rollin' Steady and Speedy Spokes bikes with the intent that the lesser value would mean that the bike would stop quicker. In this analysis, Speedy Spokes bikes stopped faster with a value of 38.4 as compared to Rollin' Steady bikes with a value of 48.1. So some Questers believed that Speedy Spokes bikes were safer and sided with Mayor Enoch. Technically both answers were correct and provided a breeding ground for students in both

schools of thought to share their analysis and perceptions that led them to think deeper and reflect on what they had learned.

Research Question 1: Engagement in Quest Atlantis

To better understand and to describe student engagement, the first research question asks: In what ways can student engagement in learning be supported by playing QA in the classroom? This section presents a view of engagement through an analysis of student responses; that is, their expression of engaged learning during work in the QA virtual world during ten sessions of play. In addition, better understanding in the context of research question 1 is also informed by the findings of pre and post-test data as well as the classroom observations of students and teacher interactions with QA.

Student Engagement Survey

During the ten sessions, grade seven students were observed while they interacted with QA to learn about statistics. The teacher was experienced with QA but the students were interacting with it for the first time. After completing the introductory missions (OTAK missions) that comprised of unlocking one social commitment and completing the "Light the Arch, Wake the World" mission, students were able to see their Avatars in QA and interact with each other virtually.

The teacher made an announcement before game play that all of the students should attempt the pre-test after completing the introductory mission. The pre-test was supplied by ASU (Appendix E) and the researcher activated the Ander City unit after the first student completed the statistics pre-test for entry into the Mathematics world. In the study, students spent approximately two continuous hours online each day during the 10 session periods working on the Ander City unit in the presence of the facilitating teacher. The day after students

completed 10 sessions in the virtual world, the researcher administered an engagement survey (Appendix D). A total of 50 students took part in the engagement survey with 22 students in class A and 28 students in class B. In class A there were 11 boys and 11 girls and class B had 15 boys and 13 girls. Table 4 shows the number of participants as well as the cumulative value of the mean, median, mode and standard deviation for all 15 items. The responses were numerically valued as follows: Strongly Agree (5), Agree (4), Neither Agree or Disagree (3), Disagree (2), and Strongly Disagree (1). Descriptive statistics were calculated using both an Excel spreadsheet and IBM SPSS software. Table 3 shows the responses for all 15 questions.

Table 3

Student Engagement Survey Results (N = 50)

Statement	**SA**	**A**	**NA/D**	**D**	**SD**
Percentage of Student Responses from Both Classes	**17%**	**39%**	**27%**	**10%**	**7%**
1. I was involved in learning in the Ander City Unit.	22	18	6	2	2
2. I was concentrating during the Ander City Unit.	12	26	7	3	2
3. I felt in control while learning in the Ander City Unit.	15	22	8	2	3
4. The Ander City Unit was challenging.	8	22	13	6	1
5. I was skillful when learning in the Ander City Unit.	6	21	18	3	2
6. The Ander City Unit was important to me.	9	17	20	1	3
7. I was succeeding in what I was doing in the Ander City Unit.	9	29	7	2	3
8. I was satisfied with how I was doing in the Ander City Unit.	18	19	9	1	3
9. I felt as if I were inside the gaming environment in the Ander City Unit.	5	20	16	5	4
10. I felt as if the gaming environment was real.	4	12	14	15	5
11. I felt as if the characters in the Ander City Unit were real.	2	9	20	13	6
12. I felt as if I and the characters in the Ander	3	15	20	8	4

City Unit were together in the same place.					
13. I felt as if I could associate myself with the game characters.	4	20	16	7	3
14. I felt as if I were participating in the Ander City Unit events.	4	27	12	4	3
15. I felt as if the events were really happening in the Ander City Unit.	4	16	20	5	5
Response Frequency (750)	125 (5)	293 (4)	206 (3)	77 (2)	49 (1)

Table 4

Student Engagement Survey Statistics Results

Participants (N)	50
Mean	3.49
Median	3.53
Mode	4.00
Std. Deviation	0.78

The engagement survey was adopted from an earlier study titled "Cultivating 21st century competencies in a virtual worlds learning environment" (Smith, 2011). The descriptive statistics results have been interpreted in the same manner as the earlier study by Smith (2011). Using the approach established by Smith (2011), the frequency of responses to the likert values were calculated, and these show that Strongly Agree occurred 125 times, Agree 293 times, Neither Agree or Disagree 206 times, Disagree 77 times, and Strongly Disagree occurred 49 times. This pattern shows the majority of student responses (56%) were Strongly Agree and Agree. The mean was 3.49, and a < 1.0 standard deviation of 0.78 reflects how closely grouped the values were to the mean. The most frequent answer in the survey, the mode, was 4 (Agree). The median value for this survey was 3.5.

The student engagement survey question items were rearranged in table 5 by rank order using the mean, and are presented in descending order.

Table 5

Student Engagement Survey Results Rank Order by Mean (N = 50)

Statement	**Mean**	**SD**
1. I was involved in learning in the Ander City Unit.	4.12	1.04
8. I was satisfied with how I was doing in the Ander City Unit.	3.96	1.09
3. I felt in control while learning in the Ander City Unit.	3.88	1.08
2. I was concentrating during the Ander City Unit.	3.86	0.99
7. I was succeeding in what I was doing in the Ander City Unit.	3.78	1.00
4. The Ander City Unit was challenging.	3.60	0.97
6. The Ander City Unit was important to me.	3.56	1.01
5. I was skillful when learning in the Ander City Unit.	3.52	0.93
14. I felt as if I were participating in the Ander City Unit events.	3.50	0.97
9. I felt as if I were inside the gaming environment in the Ander City Unit.	3.34	1.06
13. I felt as if I could associate myself with the game characters.	3.30	1.02
15. I felt as if the events were really happening in the Ander City Unit.	3.18	1.06
12. I felt as if I and the characters in the Ander City Unit were together in the same place.	3.10	1.02
10. I felt as if the gaming environment was real.	2.90	1.13
11. I felt as if the characters in the Ander City Unit were real.	2.76	1.02

The statements of the student engagement survey results are explained in the rank order by mean as numbered in table 5. In response to the item, number 1, "I was involved in learning in the Ander City Unit", 80% of students from the two classes indicated agree to strongly agree. The mean = 4.12, SD = 1.04, so there was not much variance. This finding is echoed by observation data of the students actively on task when playing the situational based Quests in Ander City and constantly interacting amongst themselves in groups or even within the game while working independently. Some students provided running commentary on their whereabouts all the while describing how they solved activities and missions.

In response to the item, number 8 "I was satisfied with how I was doing in the Ander City Unit", 74% of students from the two classes indicated agree to strongly agree. The mean = 3.96, SD = 1.09 so there was little variance. The students were eager to complete the missions and when their responses got accepted were overjoyed and exclaiming in delight. Some students were of the opinion that the Ander City unit was a fun way to learn statistics and they were doing really well.

In response to the item, number 3 "I felt in control while learning in the Ander City Unit", 74% of students from the two classes indicated agree to strongly agree. The mean = 3.88, SD = 1.08 showing slight variance. As the learning was self-paced and not led by a teacher students felt in control of their learning. The students felt free to explore the world and learn at the same time as the teacher had provided a timeline to complete the missions. Collaboration played a pivotal role in their learning by providing various means to accomplish tasks. The teacher played the role of a facilitator and the students took centre stage in learning statistics.

In response to the item, number 2 "I was concentrating during the Ander City Unit", 76% of students from the two classes indicated agree to strongly agree. The mean = 3.86, SD = 0.99

so there was very little variance. Concentration levels in the learning commons were observed to be high as students were focused with the tasks provided in the virtual environment. The non-playing characters in Ander City helped to build situational contexts that asked students for help and drew them into the 3D virtual world and the problem to be solved. Students became immersed in the role-play, and seemed to be fascinated that their opinions were important to the children of Ander City and this work kept them engaged.

In response to the item, number 7 "I was succeeding in what I was doing in the Ander City Unit", 76% of students from the two classes indicated agree to strongly agree. The mean was 3.78 and the standard deviation 1.00 leading to low variance. Constant encouragement from the characters in Ander City helped the students feel a measure of success in their missions. Feedback from the teacher (who participated in the guise of some of the main characters) to students' responses also seemed to provide students with a sense of accomplishment and a degree of success. The students' experiences of success seemed to be related to observed student motivation and engagement when playing the four missions of the Ander City unit.

In response to the item, number 4 "The Ander City Unit was challenging", 60% of students from the two classes indicated agree to strongly agree. The mean was 3.60 and the standard deviation 0.97, which meant variance was low. Students appeared to be stimulated while working in the statistics unit and appeared to be inspired to learn within the 3D virtual game. Students made an effort to get their responses accepted even though they could attempt the next mission without having their prior mission validated by the teacher. Collaboration played a big role whereby students developed the correct responses by discussing with peers what they thought was the answer or best strategy. Students kept re-writing their responses when they were not accepted and the experience of failure did not keep them from re-trying until they

succeeded in getting their mission accepted. In fact, when the students' first responses were incorrect, it seemed to engage them even further to face the challenge and keep trying till they got their responses accepted.

In response to the item, number 6 "The Ander City Unit was important to me", 52% of students from the two classes indicated agree to strongly agree and 40% neither agreed or disagreed. The mean was 3.56 and the standard deviation 1.01 which showed low variance. Students knew that the Ander City unit would teach statistics and was therefore important to them. The mean, median, mode, and range were constantly discussed in all the sessions with only the context being different according to the scenario and mission being undertaken. Students were also told that the marks in the post-test would be counted towards their unit test in statistics in school.

In response to the item, number 5 "I was skillful when learning in the Ander City Unit", 54% of students from the two classes indicated agree to strongly agree and 36% neither agreed or disagreed. The mean was 3.52 and the standard deviation 0.93 so there was not much variance. Students demonstrated skill when re-writing responses to the missions in the statistics unit. They demonstrated understanding of relevant statistical calculations in terms of the mean, median, mode, and range, and presented a rationale when answering questions posed in their missions. Some students re-attempted the tool sorter to understand the basics of the mean, median, mode, and range on which to build a solid foundation. Students also learned to collaborate not only amongst themselves but also with the teacher to succeed in their missions.

In response to the item, number 14 "I felt as if I were participating in the Ander City Unit events", 62% of students from the two classes indicated agree to strongly agree and 24% neither agreed or disagreed. The mean was 3.50 and the standard deviation 0.97, which showed a low

variance. The two groups of students took part in almost all of the available events in the statistics unit. The main events, quests, or missions that students took part in presented authentic contexts for using statistics, from making a recommendation about whether Speedy Spokes or Rollin' Steady were the safer brand of bike for rental in the park, to using the median and the mode to decide whether kids allowed to listen to music while playing increases the amount of time spent at the park, and examining data to determine whether basketball courts or a baseball diamond would include a broader age range of people. Students immersed themselves in these roles and took seriously the tasks they were asked to complete.

In response to the item, number 9 "I felt as if I were inside the gaming environment in the Ander City Unit", 50% of students from the two classes indicated agree to strongly agree and 32% neither agreed or disagreed. The mean was 3.34 and the standard deviation 1.06 so the variance was low. Many students indicated that they felt that they were in a virtual world and interacted with real characters in an alternate reality. During observations, students shared the opinion that they were in an immersive exploratory virtual environment that allowed them to learn and play at the same time.

In response to the item, number 13 "I felt as if I could associate myself with the game characters.", 48% of students from the two classes indicated agree to strongly agree and 32% neither agreed or disagreed. The mean was 3.30 and the standard deviation 1.02 so there was not much variance. Students explained that the game characters were life like and that the non-playing characters exhibited traits of a normal human being. Students observed that some of the characters were nice and cordial while others were arrogant and mean. The mix of characters appeared to provide a real-life experience for students and helped them to associate further within the online game.

In response to the item, number 15 “I felt as if the events were really happening in the Ander City Unit”, 40% of students from the two classes indicated agree to strongly agree and 40% neither agreed or disagreed. The mean was 3.18 and the standard deviation 1.06 so there was little variance, but clearly a greater range than on other items. Many students appeared to be absorbed in the storyline and indicated that game play was as if the events were unfolding in front of their eyes in an alternate real world. The scenario put forth by characters in Ander City also played a crucial role in getting the students involved in the tasks. The opinions of the characters with the background of the storyline led to a scenario where students were made to decide the best option in terms of a recommendation to help the students of Ander City.

In response to the item, number 12 “I felt as if I and the characters in the Ander City Unit were together in the same place”, 36% of students from the two classes indicated agree to strongly agree and 40% neither agreed or disagreed. The mean was 3.10 and the standard deviation 1.02 that led to a low variance. Students did indicate that they felt they were playing an online game and could also associate themselves with the characters in Ander City. Avatars or digital representations represented students in the virtual environment and made the association with the game characters realistic to some extent. The virtual interactivity between Avatars and characters by navigating to a particular location and interacting with a character through reading text and choosing one of the two options led to good involvement between the students, storyline, situation, and characters. Students were allowed to make decisions towards an outcome and made learning autonomous.

In response to the item, number 10 “I felt as if the gaming environment was real.”, 32% of students from the two classes indicated agree to strongly agree, 28% neither agreed or disagreed, and 30% disagreed. The mean was 2.90 and the standard deviation 1.13 so there was

not much variance. Students did indicate that due to the virtual environment and their digital Avatars that they felt that the gaming environment was somewhat real. Students encountered game characters in the form of people and virtual representations of their fellow students. The landscape was also similar to the real world with the presence of shops, buildings, parks, and people that made the environment realistic. Exciting elements were also present in the form of a secret cave full of statisticians that could only be accessed by dialing a particular number in a phone booth. Students were also clearly aware that this was a virtual or constructed world.

In response to the item, number 11 "I felt as if the characters in the Ander City Unit were real", 22% of students indicated agree to strongly agree, 40% neither agreed or disagreed, and 26% disagreed. The mean was 2.76 and the standard deviation 1.02 leading to a low variance. Characters in Ander City were made to look as realistic as possible using current graphics and animation technology, and the scenarios presented authentic problems. The text that emanates from characters by clicking on them was kind of similar to the jargon spoken by students amongst themselves. The similar contexts between the real and virtual world made it seem as if the characters were authentic in the statistics unit.

Student Pre and Post-tests Survey

Given that there were two grade seven classes, Class A (n=23) and Class B (n=26), an analysis of data comparing the findings based on gender and potential differences between results on the pre and post-tests was done. A common test to compare the mean scores of two groups is the Independent Samples t test (Gay, Geoffrey, & Airasian, 2009). An Independent Samples t Test was conducted in both classes to analyze whether there were any statistically significant differences between the pre and post-tests scores of boys and girls. Class A had 11 boys and 12 females while class B had 15 boys and 11 females. Both before and after working

in the Ander City unit, the seventh grade students were tested on their knowledge of statistics. If the value of $p < .05$, it means that the mean difference between the two groups is statistically significant. Alternatively, if the value of $p > .05$, then the result signifies No Significant Difference (NSD) between the two groups. The two pre and post Independent Sample t Tests for Class A and B between males and females did not show any statistical significant differences:

1. In the Class A pre-test, NSD for gender, $t(21) = -0.68$, $p = 0.50$.
2. In the Class A post-test, NSD for gender, $t(21) = -1.855$, $p = 0.08$.
3. In the Class B pre-test, NSD for gender, $t(24) = 0.176$, $p = 0.86$.
4. In the Class B post-test, NSD for gender, $t(24) = -1.154$, $p = 0.26$

The overall NSD for gender appears to indicate that the Ander City unit worked in a similar way for male and female grade 7 students. Given that this research design did not include a control group, the intervention was not compared in terms of effectiveness. Also since this was an exploratory study a follow up on gender differences should have an experimental design. In addition, it should be noted that there were different questions in the pre and post-tests in the Ander City unit that may have impacted scores achieved by students.

In a brief follow-up interview about the analysis, the teacher did identify several mistakes in the pre and post-test that may have impacted results. For example, question 5 in the post-test needed to be deleted from the results as the answer provided in the answer key section was incorrect and the most rational answer was another answer—option d. Second, answers to question 7 a and b in the pre-test could be answered without using statistics as the questions referred to one watermelon (single) dealing with weight whereas questions 7 a and b in the post-test needed statistics to answer the question, which referred to tomatoes on the whole (plural) dealing with time. So while marking the pre and post-tests, question 5 as well as question 7 had

to be taken out of contention and removed from both the pre and post-tests since they were not equal comparisons on the whole.

Students and Teacher Observations

The researcher observed the teacher and students in each of the 10 QA sessions with Class A and Class B. The researcher observed the interaction between the teacher and students, teacher and students activities, and with regard to students—display of 21st century competencies, and attributes of engagement and motivation.

At the beginning of each session, the researcher would keep a print out of the class observation protocol (Appendix M) to document the observations made in the classroom. After students took their laptops from the computer cart and logged in to QA, the researcher would walk multiple rounds of the library and observe students working in a group or individually, listen in on conversations and note how the teacher interacted with the students. At times, the students asked the researcher questions that dealt with the QA environment. For example, students asked how to navigate the environment in order to meet characters at particular locations. The researcher answered all questions to the maximum extent possible or directed the student to the teacher.

The researcher took down notes based on the observation protocol sheet after observing a student or a group of students from behind. At times, the researcher would ask students questions based on their activities, and the students eagerly responded to the questions. For example, when the researcher asked the student if QA was engaging the student replied in the affirmative and mentioned that she / he also found it fun. Students did not seem to be bothered by the researcher observing them and were often eager to engage with the researcher and to talk about what they were doing in QA.

At the end of each session, the researcher would sit down in the staff room to review the notes and write out the observations, add any new notes and begin to consolidate ideas. More intense analysis was conducted at the conclusion of all sessions and observations.

Over the 10 sessions each of classroom observations with Class A and Class B, it was determined that key themes emerging from the observation data seemed to be in alignment with the three main themes chosen to structure and present results: 1) engagement, 2) motivation, and 3) 21st century competencies. With regard to engagement, students were actively involved in the tasks related to complete each mission. It appeared that many students were engaged due to the Math challenge and the fun provided in the game. An example that demonstrates this observation is that a bunch of five students who were seated next to each other kept prodding and informing each other about their whereabouts in the game as well as encounters with different Math concepts.

A group of students called the teacher to their table since the missions they had finished earlier were not displayed as completed in the Mission list on their Qpods. The teacher showed them the location of the email responses on the Qpod and took them through some of the responses that were in some cases one-liners (for example, the children of Ander City should use the Speedy Spokes bikes as they brake better), which according to the teacher lacked conviction and rationale. After the discussion with the teacher, the students appeared to understand the reason for the Mission being incomplete, and were motivated to reattempt the assignment.

The student engagement survey, pre and post-tests, as well as classroom observations all point towards engagement as a major theme when playing QA in the classroom. The QA immersive virtual environment not only kept the students involved, satisfied, and put them in control of their learning but QA also provided an interactive environment that appeared to have

enhanced concentration levels and allowed students to succeed at their own pace. A positive outcome in the pre and post-tests, although not significantly different, portrayed a step in the right direction even though the questions were different in both tests. In addition, the classroom observations noted that students were engaged while attempting the tasks involved in the Ander City unit.

Research Question 2: Motivated About Learning and Mathematics in Quest Atlantis

To describe student motivation, research question two asks: Do students feel more motivated about their learning and about Mathematics when learning is supported by Quest Atlantis? This section presents a view of motivation through student focus group interviews, and from the findings from the computer technology survey, and also the classroom observations of students and teacher interactions.

Student Focus Group Interviews and Classroom Observations

According to Ryan and Bernard (2003), themes in a study can be formed in two ways: 1) from the data and 2) from the researcher's earlier understanding of the phenomena under study also known as an *a priori* approach. In this research study, the phenomena under scrutiny was whether DGBL and engaged teaching methods in a classroom can lead to meaningful learning. An *a priori* approach was followed from earlier studies done by Tuzun (2004) that addressed motivation and Smith (2011) that focused on 21st century competencies and engagement.

Attributes of the phenomena being studied as well as definitions from the literature review lead to the emergence of a priori themes (Maxwell, 1996). According to Ryan and Bernard (2003) the numerous frequent occurrences of a notion leads to the creation of a theme. In this study the researcher approached the intervention with three a priori themes and looked for evidence in engagement, motivation, and 21st century competencies. The researcher transcribed

the six student focus group interviews and formed a matrix in an excel sheet. The column headings contained the interview questions and sub-questions as well as columns for student responses. Questions were depicted row wise, and since student responses were displayed on a column by column basis the excel sheet provided easy viewing and readability of the data from focus group interviews. The matrix also provided an efficient means for looking at the student focus group interviews thematically as well as question by question. Different font colors were assigned to each theme to showcase their expressions. However, while analyzing the student focus group interview transcripts the researcher also noted constant student remarks on the benefits of technology that led to the naming of another theme "technology benefits". Direct quotes from interviews with students that illustrate views that are grouped in this emergent theme:

> *"If you just type out the question on the Internet it would just give you the answer but that's not really fun you just read the answer… in your notes. But here you just have to like work to get your answers and then you don't have to make any notes."*

> *"It was like playing in the game but doing work so it kind of inspired me."*

> *"I felt I learned way better this way just probably because you get to read everyone's perspectives and you get to read the Quests."*

> *"Here you are interacting with people and have fun it's like a video game. It's like you do not feel like you are actually working but it's coupled like it's a lot more fun especially when you are researching."*

"Mainly because it was visual and fun not just on a piece of paper or anything you write down like questions of anything."

Similarly, while analyzing the teacher interview transcript, the researcher noted the emergence of two *new* themes "technology benefits" and "technology constraints". During the interview, the teacher commented on technology benefits, as demonstrated in the following excerpts:

"Being able to go through the material at your own pace as opposed to the pace that is driven by the task master in front of the room. I find that it is generally really powerful and positive."

"It is really cool because I am still doing all the assessing so I can keep in mind their academic level, their IPP goals and all of those things so if you look at some of the Quests that I have accepted you would say they haven't mastered any of the material that they were supposed to and I'll be like well for this particular student the fact that she was able to add the numbers together was really the best that we could hope for by having that modification available that's a really powerful tool so she can also feel success even if it is academically paced a little higher."

"The storylines have more application, more of the moral dilemmas and questioning that puts kids in a richer thinking area."

"They don't get that I am the reviewer and the person helping them. And I think that dissociation from the evaluator and the teacher is actually really valuable…In Quest Atlantis there was no preconceived notion they were giving it to some nebulous set of characters and it was getting returned to them and then incorporating the feedback became something that they would ask their friends to help them with or ask ultimately a teacher to help them with and that just completely flips the relationship on its head."

In contrast to the a priori themes, Creswell (2007) argued that grounded theory provided "for the generation of a theory of actions, interactions, or processes through interrelating categories of information based on data collected from individuals" (p. 63). The researcher followed the systematic procedure of the constant comparison method developed by Strauss and Corbin (1990) in the research study. The collection of interview data acted as a primary basis of information and starts the analysis of data (Creswell, 2007). The formation of evolving categories through the procedure of collecting data and comparing it to the category is known as constant comparative method of data analysis (Creswell, 2007).

As described in chapter three, NVivo version 10 software was used for open coding of the focus groups interview data and teacher and students classroom observations. The focus group interview data in the form of an excel spreadsheet and classroom observations in word documents were imported into the software. Nodes were made in the Nvivo software to create and represent open codes. Data from the focus group interviews and classroom observations were selected with the mouse pointer and dropped into these open codes to attribute the data. Open coding of all the data sources for a period of 6 days resulted in 85 codes (Appendix O). In the next stage of axial coding iterative coding between the categories and codes was repeatedly

done. These codes were placed into four categories found earlier in a study by Tuzun (2004). These categories were accomplishment or achievement, immersive context, learning, and social relations. By selective coding, these categories were part of the 13 elements or categories that emerged in Tuzun's Multiple Motivations Framework.

As a result of the data analysis, four categories emerged as the motivational elements to play QA. These categories are accomplishment, immersive context, learning and social relations. These categories also contained sub-categories. The motivational elements categories and sub-categories along with their number of references are displayed in the table below (see Table 6).

Table 6

Four Categories and Sub-categories as Motivational Elements

Category	Sub-category	No. of References Sub-category	No. of References Category
Accomplishment	Challenge	18	54
	Points	21	
	Competition	15	
Immersive Context	3D World	32	46
	Storyline	14	
Learning	Fun	46	104
	Meaningful Learning	28	
	Technology	30	
Social Relations	Interact with Others	43	50
	Stating Opinions	7	

In the following sections, each of these categories will be explored further in relation to the observation data.

Accomplishment

Students participated in the Ander City unit of QA to learn the mean, median, mode, and range in statistics. During the course of play the students reported that they felt challenged in the

missions, activities, and competition due to peer pressure. The act of collecting lumins provided the students with a means of comparison in terms of points and rivalry.

Challenge

Many students completed the missions due to the challenge involved in finishing the activities and Quests. When absorbed in the narrative and perspectives of characters in the game it was difficult for the student not to feel challenged. Here is an excerpt about how two students felt about the challenge in the game.

> *Researcher: "How does the Math unit motivate you?"*
>
> *Student 1: "Like in Quest Atlantis it was involving me because it was fun to go on all the Quests and figure out how to solve certain like Math equations. It was just fun it was a challenge for me it was proof to me to do my best I guess."*
>
> *Student 2: "It was nice to know the Quests and stuff because you like got to talk to people and you could state your opinion …and it was challenging."*

The researcher probed student 1 a little more along the same lines and got more information related to challenge.

> *Researcher: "How was it motivating? Would you like to talk about it a little more?"*
>
> *Student 1: "It was motivating because it wasn't like all you have to do is click a button you actually had to do the stuff and like since it was a challenge you wanted to do it because you want to show how to do it."*

Students appeared to try to do their best when completing missions to avoid having to write responses again. They kept on going and maintained a set pace to complete the quests and appeared to be motivated by the challenge presented by the quests.

Points

Every Quest was connected to one of the seven social commitments. When students completed Quests they earned a fixed number of lumins that represented their work on a

particular commitment and difficulty level of the Quest. For each completed Quest, students received an equal number of lumins. Lumins cannot be spent, traded, or given away and lumins are like small units of energy that represent each student's personal accomplishments or achievements. Students were able to view the lumins of other students by clicking on their Avatars. At threshold points or after students earned a set number of lumins, shards of the Shardflower would illuminate, energized by students' accomplishments. Lumins depicted the number of points for each student and it was sometimes like a race for students to get more points. Some students did not give much importance to lumins until they had completed the missions while others accepted it as a score. Here are some excerpts from a couple of students:

> *Researcher: "What do lumins mean to you? Do you care about getting lumins?"*
>
> *Student 1: "I think it is cool to collect them because you kind of like see how far you've gone."*
>
> *Student 2: "It's like your personal score and see if you can get a higher score than your friend."*

External feedback, in the form of points / lumins, appeared to keep some of the students absorbed in the game as they wanted to outdo one another by getting more lumins. Experience counts and the accumulation of lumins was one way of showing the students' expertise in the game.

Competition

Some students were motivated to finish the Quest and be first among their peers to reach this level, so they were in constant pursuit of completing their missions. Students sitting next to each other were also able to see each other's screens and sometimes the knowledge that the other student is ahead may have provided the impetus to catch up and to compete. Here are some exchanges between the researcher and students:

Researcher: "What do lumins mean to you? Do you care about getting lumins?"

Student 1: "I compete with friends and say you know who has more lumins, which Quests they finished and then how many Quests they finished."

Researcher: "Do you have anything more to say about the motivation factor?"

Student 2: "I know like me I am very competitive and so if my friends could do it I needed to do it too."

Competition between some students may have helped motivate them towards the completion of tasks and may have provided the incentive and morale to finish the four missions. For some students, competition provided a means of accomplishing the tasks involved in each mission.

Immersive Context

The QA world takes place in a 3D virtual online environment. The narrative context, perspectives of characters, and storyline all provide for an immersive experience. The virtual world provides a context for online interaction.

3D World

QA's virtual environment provided a playground with a personal digital representation of oneself. The creation of Avatars and being able to help friends, fly, dance, visit different places in the world, and find people provided a safe haven for students to get involved in the activities. Students felt as if they were part of the world:

Researcher: "What are your top three favorite activities in the Math Unit?"

Student 1: "I liked being able to see my friends in their Avatars and be able to talk to them and stuff… And so I liked going into different worlds like there was a Math world and Emissary Island. And like you could go into different places and they had totally different scenes of people and animals and stuff."

Student 2: "I liked doing missions and stuff because then you could run around and help different people while playing a game. And I also liked helping my friends because I could see their Avatars and everything."

Student 3: "I liked how your Avatar could like do flips in the air and how you could change their clothes and stuff."

The 3D world of QA allowed the students to be part of a new virtual environment parallel to the real world. Digital representations of themselves in the form of Avatars helped them interact with characters and perform tasks in this alternate reality.

Storyline

Most students appeared to be absorbed in the storyline as it contained many characters with whom they interacted. These interactions made some students feel as if real characters were involved and the character's personalities made it all the more lifelike and believable. Here are some quotes from an exchange between the researcher and students:

Researcher: "What do you like about learning the mean, median, mode and range in the Math Unit?"

Student 1: "There was always a story to go with it like the Mayor and Mr. Grant. He was like they were always like competing with each other and it is fun to learn Math that way because it has a story and everything and there was like problems. And you had to talk to a lot of different people."

Student 2: "With the headphone ones… it wasn't like you're doing a Math project. It felt like you were actually talking to actual people to see what their opinion was on the headphones or if they should have a basketball hoop or baseball diamond. It felt like it was like you are actually doing something for your environment like yeah at times it didn't really feel like it was a game like it was actual like these are actual peoples' opinions."

The storyline provided a realistic context within which the students could learn statistics. The quests offered a mode of communication between the students and the characters of Ander City. The students were kept in check by the evolving story, given instructions and also asked about their opinions and recommendations.

Learning

Most students reported that they had a lot of fun while learning in the QA environment. All of the students were adept in technology use and thus appeared to be at home and related directly to the online game. Here are some excerpts between the researcher and students:

> *Researcher: "In what ways is Quest Atlantis different from other things you do on your computer? In the computer lab? In school? At home?"*
>
> *Student 1: "At home you are playing games but like not learning anything but on Quest Atlantis you are learning stuff. And then in class you're learning through writing and stuff but on Quest Atlantis you are learning in a game."*
>
> *Student 2: "Usually you have to search up on the Internet and find the information but in Quest Atlantis you ask the people, they tell you stories and then they give you information at the same time."*
>
> *Student 3: "Like when we are on the computer we usually just do like research or whatever right? Or at home we'll just play games and it doesn't like teach us anything but like in Quest Atlantis it is fun but it teaches you at the same time."*
>
> *Student 4: "For one it is educational rather than home and the schools...And then the computer labs and at school usually all you do is research up the definitions or just surf and find the links to help you learn it but you go on Quest Atlantis it helps you get stuff stuck in your brain."*

From the students' perspectives, they were learning at the same time as having fun in QA, and they were fluent about how a digital game based approach to learning was different than the entertainment games they played at home and different than doing research on the internet at school.

Fun

The majority of students enjoyed learning in QA and described it as fun. Students acknowledged that most of the QA activities were fun to do and the activities allowed them to focus thoroughly while in the experience. Students reported that QA was a place where you

could have fun and enjoy learning at the same time. Below are some selections from the student focus group interviews.

Researcher: "How does the Math Unit motivate you?"

Student 1: "I like thought it was fun and you got to like chat with people and kind of typing more than writing."

Student 2: "Like in Quest Atlantis it was involving me because it was fun to go on all the Quests and figure out how to solve certain like Math equations."

Researcher: "Did it kind of make you feel a desire to do something?"

Student 3: "Yeah it was fun meeting all the different characters and all the different personalities and stuff."

Researcher: "So it helped you focus?"

Student 4: "Because when I know there's something fun I kind of focus more so since that was fun from how you learned the Math it kind of helped me."

Within the digital game based learning environment provided by QA, students had an opportunity to enjoy themselves while learning statistics. They reported that they were able to focus more on the tasks involved as it was a fun way to learn Mathematics.

Meaningful Learning

Students were not just provided with information in QA. Students interacted with game characters and were engaged in learning activities that provided meaningful information that required students to apply new understandings in an authentic and active learning context. All of the information required to solve the statistics problems was contained in the Ander City unit and ideally did not require extra resources, such as looking up information on the Internet by searching with Google. Below are some quotations from the interviews:

Researcher: "What do you like about learning the mean, median, mode and range in the Math Unit?"

Student 1: "I liked it because it wasn't like you had something that just told you straight that you had to go and figure it out yourself and then you had to put it into your response and it was like you know it and you don't really have to use it like because if you didn't put it in your response the kids wouldn't expect it and so I liked it because you had to learn it or else you couldn't do anything really… It kind of forced you to learn it but in a fun way like it wasn't boring sitting their having somebody talk to you about it. You had to figure it out yourself."

Student 2: "It was fun…because you can't give your responses without using the mean, median, mode and range. So like I would say it forces you to learn it but in a fun way. It was different because like you just type it up on the computer and it just gives you the answers…You have to work to get the answer."

Students had to find relevant information in the Ander City unit and then use it to answer the questions posed in the form of recommendations. The student's answers needed to include statistics calculations in the form of the mean, median, mode and range with a rationale for providing an opinion. In addition, the answers had to be insightful and meaningful for the teacher to accept the quest.

Technology

With regard to technology, these students fall into the classification of generation Z students, and given their widespread use of technology at home and at school, they were well versed with technology and computer usage. Most of these students had played commercial games and this was the first time that many of them had had access to an educational online game. The QA environment provided for self-pacing and the student dynamics provided the impetus to finish the quests quickly due to the competition factor. Some interesting quotes are as follows:

Researcher: "What do you like about learning the mean, median, mode and range in the Math Unit?"

Student 1: "It is better than like just sitting in our classrooms listening. Like it is better to…Learn while playing it."

Student 2: "I like that it's involved with a video game so it's fun to learn like you have to figure it out to help somebody like figure out whether they want to play basketball or baseball. So that's a good way to learn it but when you learn it it makes Math easier like finding the middle number, finding out the average, and finding out which number is the one that consistently comes up most."

Student 3: "The fact that…It's fun to learn. Also in that basement in the Math world where it is also like a game because that's what kind of makes it fun because it helped you learn your facts because you actually have to know which one to choose."

In this intervention, the QA digital game provided students with a different way to learn statistics, which clearly appealed to them. QA did not involve any lectures or direct instruction from a teacher and allowed students to set their own pace for learning.

Social Relations

Social relations took place in both the QA environment as well as in the classroom. Students interacted with each other verbally, through the chat tool, and by choosing one of the two options after reading the narrative on the screen when interacting with game characters. The teacher sent email responses to students to check their responses. Students mostly played the game in groups so social interactions were an important aspect of both game play and of motivation. In the next section, two themes are explored, interactions with others and stating opinions.

Interact with Others

Almost all students interacted with each other in person and virtually while playing the online game. Peer interaction and students helping other students was the consistent mode of almost every session. The teacher also interacted with the students and answered their queries by providing hints and involving them in discussions among themselves. The teacher was a constant source of inspiration and was a "go to" person when fellow students could not provide a solution to a problem. Here are some quotes:

Researcher: "How does the Math Unit motivate you?"

Student 1: "Yeah like talking around with the citizens and like seeing other people's perspectives and stuff."

Student 2: "Well, it kind of motivated me because when you are doing the Quests you can have more people with you and it can help you."

Student 3: "The fact that I could see my friends online was really fun because I could talk to them and see what they had done and it just motivated me to do just as good as them."

Interaction between students allowed collaboration to take place, which in turn helped students view different perspectives to the same problem. It was an eventful learning experience to remember as students were able to interact with each other online while learning in class.

Stating Opinions

In the online game, many students were influenced by the game characters opinions about the Ander City unit. Students would talk with other students about their own submissions when they got feedback from the game for this submission. The submissions were a source for discussion and provided a breeding ground for students to express their own opinions and perspectives. Students appeared to be happy to know that there were no right or right answers as the teacher was marking them based on their capabilities. Some interesting excerpts are as follows:

Researcher: "What do you like about learning the mean, median, mode and range in the Math Unit?"

Student 1: "It felt like…You are actually doing something for your environment like yeah at times it didn't really feel like it was a game like it was actual like these are actual peoples' opinions."

Researcher: "What are your top three favorite activities in the Math Unit?"

Student 2: "And I liked how you could give your opinion and it wasn't like this answer was wrong this answer is right it was your opinion."

Students were happy to encounter opinions by the game characters, which they assimilated and in turn discussed with their peers to reach a consensus. Since there were no right or wrong answers students were able to discuss the rationale for stating an opinion and sticking to it.

Computer Technology Survey

A total of 51 students took part in the computer technology survey with 22 students in class A and 29 students in class B. In class A there were 10 males and 12 females and class B consisted of 16 males and 13 females. Every student who took part in the survey reported that the family had a computer and internet access at home. In terms of computer usage, students' responses indicated that 6% used the home computer monthly, 16% weekly, and 78% almost daily. Similarly, in terms of internet access, students' responses indicated that 2% used the internet at home monthly, 14% weekly, and 84% almost daily.

All of the students in school had access to a computer or a computer lab at school. In relation to access of computers in school, students' responses indicated that 49% utilized school technology individually, 37% as a whole class, and 14% in pairs.

In the matter of how often computers were used in an average school year, students' responses indicated that 2% used it monthly, 47% weekly, and 51% almost daily. The percentages for students deciding how often they would use a computer to work on assignments were reported as 2% never, 4% once or twice a year, 4% monthly, 43% weekly, and 47% almost daily. Students were asked how often they would use the computer to complete tasks on a scale of never, once or twice a year, monthly, weekly, and almost daily (see Figure 10).

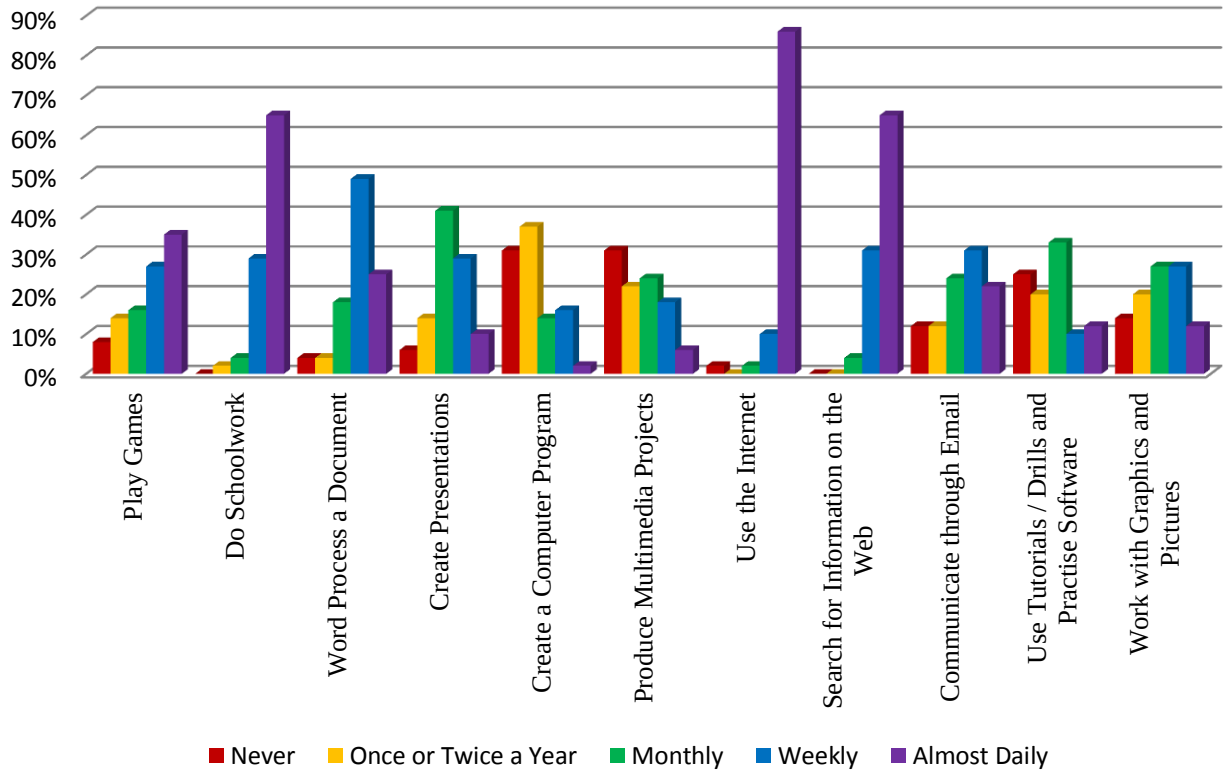


Figure 10. Student Responses to Tasks Completion

It is interesting to note that 65% students report almost daily use of computers to do schoolwork. With regard to completing the task of playing games, 35% students used a computer almost daily and 27% students' reported playing games weekly. To do schoolwork, students' responses indicated that 65% students' completed school tasks daily using a computer. With regard to word processing a document, students' responses indicated that 25% report almost daily use and 49% reported weekly use of word processing to complete school tasks. The computer was utilized to access the Internet by 86% students almost daily. In addition, almost daily 65% students searched for information on the Web through a computer. Seventh grade students reported high levels of independence and skill with computer usage, and demonstrated that they

were well versed with software on their computers in response to questions that assessed levels of help needed (see Figure 11).

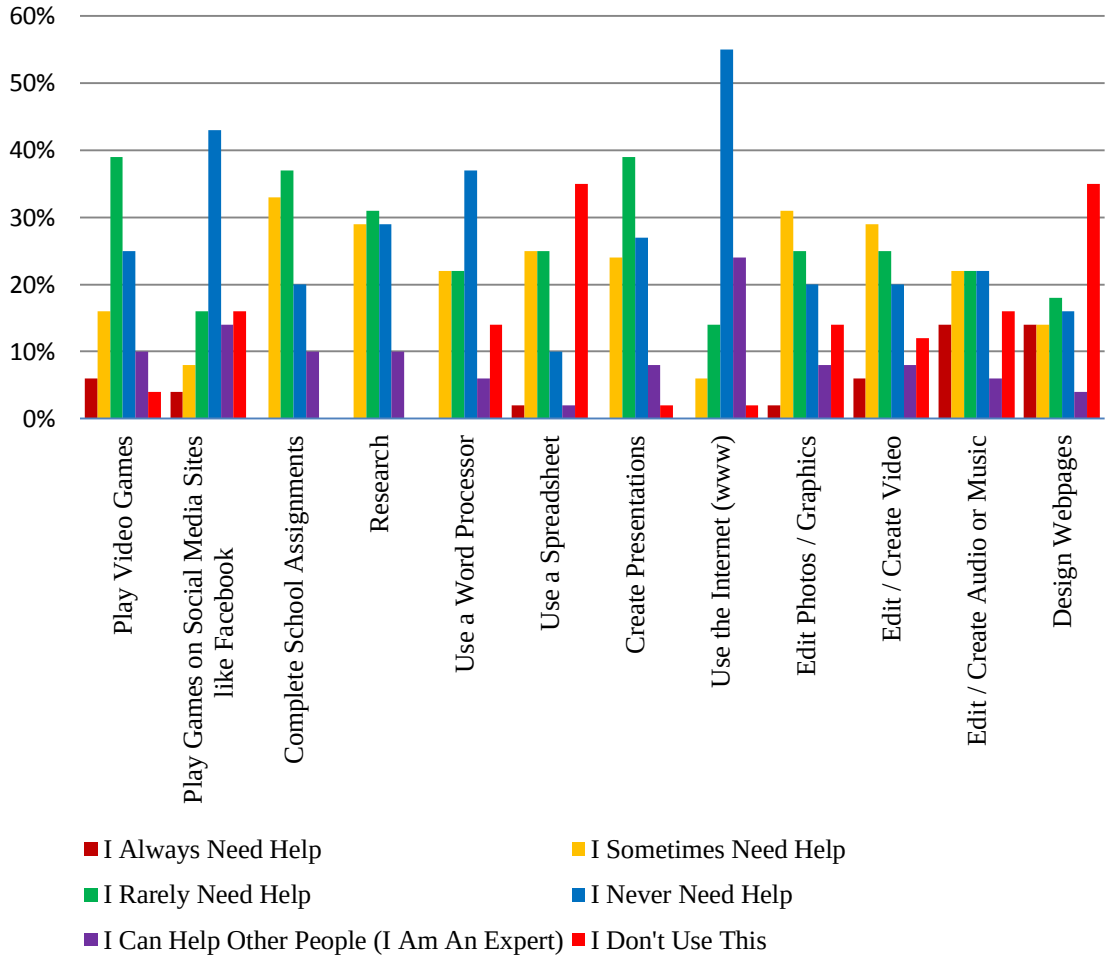


Figure 11. Student Usage of Computer Software

When playing video games 39% students rarely needed help, 25% students never needed help, and 10% students believed they could help others due to their expert status. To complete school assignments, 37% students rarely needed help, 20% students never needed help, and 10% of the students considered themselves experts and could help others. Likewise, 22% students rarely needed help when using a word processor, 37% students never needed help, and 6% believed

they were experts. Also when creating presentations, 39% students rarely needed help, 27% students never needed help, and 8% students considered themselves experts. Furthermore, 14% students rarely needed help when using the Internet, 55% never needed help, and 24% students could help others as experts.

Students were asked to describe their level of agreement with statements related to computer usage (see Figure 12).

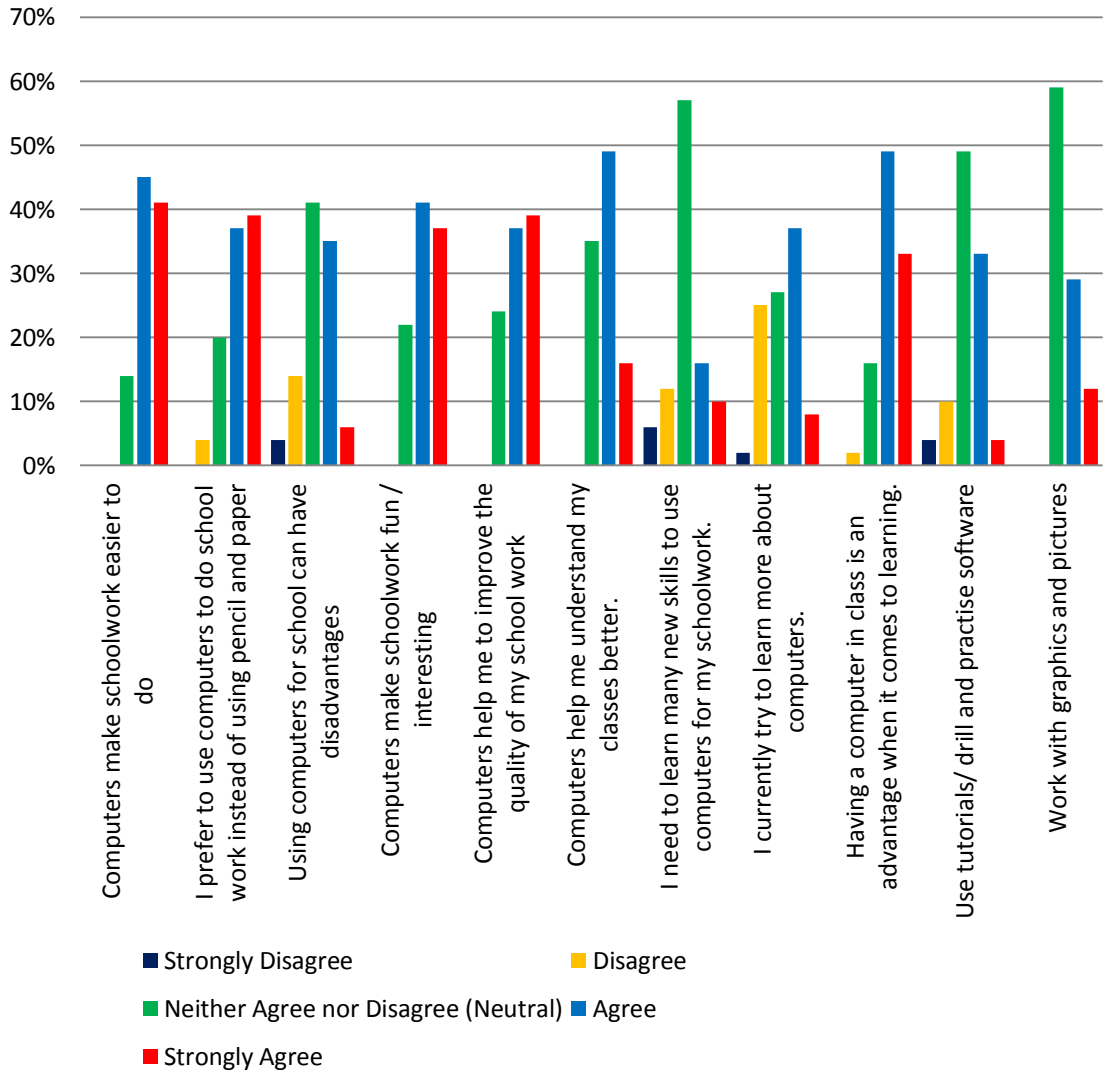


Figure 12. Students Level of Agreement with Computer Related Statements

With regard to the statement, "computers make schoolwork easier to do", 41% of students indicated strongly agree and 45% students indicated agree. Students preferred to use computers to do school work instead of using pencil and paper—39% students strongly agreed and 37% agreed. In relation to computers make school work fun and interesting 37% students strongly agreed and 41% students agreed to the statement. In fact, computers helped to improve the quality of school work as 39% students strongly agreed and 37% agreed to it. Moreover, computers helped students understand their classes better since 16% strongly agreed and 49% agreed. Another significant finding stated that 33% students strongly agreed and 49% students agreed that having a computer in class was an advantage when it came to learning.

All data sources indicated that students were motivated to continue playing QA to learn statistics in the QA online virtual environment. The analysis of student focus group interviews and classroom observations led to the emergence of four categories: 1) accomplishment, 2) immersive context, 3) learning, and 4) social relations. These four categories are similar to the motivation categories brought out in a study titled "Motivating Learners in Educational Computer Games" (Tuzun, 2004). Tuzun's study had thirteen categories: 1) identity presentation, 2) social interaction, 3) playing, 4) learning, 5) ownership and control, 6) fantasy, 7) immersive context, 8) curiosity, 9) creativity, 10) achievement, 11) rewards, 12) uniqueness, and 13) context of support. Therefore this study built on Tuzun's study and had similar findings with almost similar category findings. The computer technology survey showcased students being technologically savvy with all students having a computer and Internet at home. Almost all of the students agreed that computers make school work easier to do. It can therefore be inferred that this group of generation Z students likely prefer to work with technology in tandem with their day to day school work.

Research Question 3: 21st Century Competencies in Quest Atlantis

To describe 21st century competencies, research question three asks: In what ways can the development of 21st century competencies be supported by Quest Atlantis in the classroom? This section presents findings related to 21st century competencies through a teacher's 21st century competencies survey administered online, teacher interview as well as students and teacher observations.

21st Century Competencies Teacher Survey

The researcher administered the 21st century competencies survey to the teacher using an online format. The teacher completed the survey in one day and took just over 16 minutes to complete it. Out of the 35 questions, the teacher answered with a "yes" to 14 questions and "no" to 21 questions along with an evidence of the claim. The 14 statements below display the teacher's evidence of the claim with answers in the affirmative (see Table 7).

Table 7

Teacher Survey 21st Century Competencies (Positive)

	Statement	Example or Evidence of Claim
1.	My students used a directional navigation system for movement in the virtual world.	I saw them moving their avatars and frequently getting stuck in the geometry of the world.
2.	My students used icons, interactions with virtual characters, and active links to process questions and information.	I saw this on several occasions.
3.	My students understand reasons for caution in online environments.	From individual discussions I would say that many of the students understand the reasons for caution in online environments.
4.	My students understand how to sort information according to validity and truthfulness.	Many of the quest responses given in the statistics unit were about finding information and figuring out how that information could support a recommendation or an argument. Many of the students showed that they could find statistical information and use it to make a valid argument. I am not certain that they would all be able to go

	backwards, read a particular argument and see if the statistics were truthful.
5. I observed my students practicing problem solving techniques.	Again, since I didn't observe them directly very frequently, since I needed to mark and respond to quest submissions in real time so that they could continue in the story line, I can only say that I saw some students using problem solving techniques.
6. I observed my students openly discussing solutions to problems.	On several occasions I overheard students discussing problems. Most often they were low level thinking issues (where is the Mayor's office). Every once in a while it would be about how to complete a calculation.
7. My students helped each other understand how to complete problems related to statistics in Quest Atlantis.	Some of the students helped each other complete the projects. Others did it independently.
8. My students understand that collaborating leads to problem solving.	Some students do. Others were much more competitive and worked to keep their solutions secret.
9. I observed my students helping each other in the Ander City unit.	On several occasions students helped each other.
10. My students understand they are accountable for their behavior in Quest Atlantis.	Again, this is about the majority. The majority of them understand that they are accountable for their behaviour. Some students are struggling to be accountable for their behaviour in the real world, those students also struggled with being accountable in the virtual world.
11. I observed written responses on a variety of topics such as math, science, character education, art, and ecology among my students.	Through the assigned quests they submitted written responses in math, LA, science and art.
12. My students readily shared and taught each other what they learned in Quest Atlantis.	Hard for me to say. There were some groups that really worked well that way and some individuals that did not.
13. I observed my students working on problems that affect other communities.	The Ander's City unit really only impacted that virtual world. It was not particularly relevant to our community.
14. My students understand how human actions can affect the entire planet.	Although not necessarily because of QA, this concept is part of their core science curriculum.

According to survey statement 1, the teacher saw students moving their avatars and frequently getting stuck in the geometry of the world. This was due to a glitch in the software as

the MAC version was created by a third party, which could not be solved easily. QA was ideally suited for PC computers and ran seamlessly on this platform.

The teacher agrees with survey statement 2 where the students used icons, interactions with virtual characters, and active links to process questions and information. Students QPod console contained accessible icons for performing different functions like accessing emails from the teacher. Some of the icons provided active links to process questions and information. Students were always interacting with virtual game characters as well as their physical peers.

With regard to survey statement 3, the teacher believed from individual discussions that many of the students understand the reasons for caution in online environments. The teachers' belief stems from the point that all students had to go through the IBURST rules before being able to see each other in the virtual environment. The teacher also made announcements in class regarding caution in the QA environment when certain students were reported for using the chat space inappropriately.

In the statement for survey question 4, the teacher is of the opinion that many of the quest responses given in the statistics unit were about finding information and figuring out how that information could support a recommendation or an argument. Many of the students showed that they could find statistical information and use it to make a valid argument. The teacher is not certain if they would all be able to go backwards, read a particular argument and see if the statistics were truthful. The argument forms the backdrop of the response in the activities in QA it would therefore be difficult for a student to read a particular argument and then understand the rationale for reaching that conclusion.

The statement for survey question 5 mentions that the teacher did not observe the students directly very frequently, since the teacher needed to mark and respond to quest

submissions in real time so that they could continue in the story line, the teacher can only say that some students used problem solving techniques. The researcher actually observed problem solving techniques by students who used multiple approaches to solve a problem and multiple resources to reach a solution.

With regard to statement number 6, the teacher on several occasions overheard students discussing problems. Most often they were low level thinking issues (where is the Mayor's office). Every once in a while it would be about how to complete a calculation. The researcher has observed students openly discussing high-level solutions to problems where students work as a group to problem solve and check off tasks mentioned in the mission list and use multiple approaches to solve a problem.

In statement 7, the teacher believes some of the students helped each other complete the projects. Others did it independently. The observations by the researcher also echo the same opinion as the majority of students worked in groups and a couple of students worked independently during the QA sessions.

In the answer to statement 8, the teacher is of the opinion that some students do. Others were much more competitive and worked to keep their solutions secret. The observations by the researcher reflect a degree of comradeship among students when collaborating for a solution to a common problem. Problem-solving was part of the discussion and was a by-product of collaboration.

The answer to survey statement 9 mentions that on several occasions students helped each other. The observation notes of the researcher also mention that in all the sessions the researcher did not come across a single student being turned away when help was being asked.

For the answer to statement 10 dealing with accountability, the teacher believed again, this is about the majority. The majority of them understand that they are accountable for their behaviour. Some students are struggling to be accountable for their behaviour in the real world; those students also struggled with being accountable in the virtual world. The observation notes of the researcher also mentioned that some students did not use the chat space properly by using language that was not appropriate.

With regard to statement 11, the teacher believed through the assigned quests they submitted written responses in Math, Language Arts (LA), Science, and Art. The responses to the activities in all the four missions as well as researcher's observation notes submitted responses in Math, LA, Science, and art.

In the answer to statement 12, the teacher mentioned that it was hard for the teacher to say. There were some groups that really worked well that way and some individuals who did not. This depended on the group dynamics and seriousness of the individuals involved in the task. Sometimes if the group was distracted then it would take some time before they got back into the task. Mostly, however, groups performed well on the tasks together as they would help each other. Some individuals, on the other hand, did not perform well without collaboration.

The teacher's answer to statement 13 was the Ander's City unit really only impacted that virtual world. It was not particularly relevant to our community. This was the case as the students could not access any other unit and the outside community too.

With regard to the answer to statement 14, the teacher mentioned although not necessarily because of QA, this concept is part of their core Science curriculum. The social commitments in QA depict to some extent how human actions can save the whole planet.

The 21 statements below display the teacher's evidence of the claim with answers in the negative (see Table 8).

Table 8

Teacher Survey 21st Century Competencies (Negative)

Statement	**Example or Evidence of Claim**
1. I observed my students using computer menus to select working activities.	For the majority of the unit I was off to the side madly responding to their quest responses. I had very little actual observation of their work in the QA space.
2. My students managed a virtual Qpak of items and artifacts collected during missions.	ibid
3. I observed my students considering ethical dilemmas.	ibid
4. I observed my students gathering information from interviews and making ethical decisions.	ibid
5. I observed my students dealing with ethical situations concerning the environment.	ibid
6. I observed my students interpreting language or word differences to understand a situation.	ibid
7. I observed students using knowledge from Quest Atlantis to solve new problems.	As of this time, no, I have not seen the students applying the knowledge outside of QA. On the other hand, since the start of the project until the finish, I have only seen them working in the QA environment, they have not been doing any other work or assignments for me.
8. I observed problem solving skills transfer from Quest Atlantis to other uses in the classroom by my students.	ibid
9. I observed an increase in collaboration skills among my students while working in the Ander City unit.	The students in my two classes generally collaborate most of the time when given the opportunity. Those students who did not collaborate in QA don't normally choose to collaborate in the classroom. I would not say that there was an increase.
10. I observed leadership skills as a result of collaboration among my students.	Not particularly or at least, not different from what I would normally see in the classroom.
11. I observed my students using the chat feature to ask questions and socialize with other	I didn't really have time to monitor the chat area, as I was responding to quests.

students and teachers in Quest Atlantis.	
12. I observed increased effort on reading related to accomplishing goals of the missions among my students.	I have no direct observation of that. Indirectly, they seemed to submit more thoughtful answers when the in game evaluation asked them to read the goals more carefully.
13. I observed my students expressing ideas of compassion and understanding in their writing.	I am not sure exactly what is meant by this question. I know that they will have completed quests in QA that were about this topic, but the submitted quests in Ander's city were not particularly good evidence of compassion.
14. I observed artistic expression by my students working in missions.	No, there was not a lot of artistic expression in the missions that I evaluated.
15. My students manipulated dimensions and placement of 3D structures.	Most students found Q-ville didn't work in the Mac environment, so they didn't get to use this aspect.
16. I observed my students creativity in written responses to missions.	The missions in Math World don't really allow for a lot of creativity. There were stylistic differences, but for the most part they looked at the data and then wrote about what they found.
17. I observed my students' responses to art forms, colors or concepts.	Again, not a particular focus of the mission. They may have while they were playing, but I didn't get a lot of direct observation time.
18. I observed the creative use or interpretation of language by my students (to learn mathematics).	I am not sure exactly what is meant by this.
19. I observed examples of my students' understanding of another location in the Quest Atlantis world (by interacting with other students).	There were only a few interactions with students that were with people from other schools, so I don't really know what they encountered in this area.
20. I observed my students write or discuss how students from other cultures are different in many ways, but also the same in many ways.	Not directly.
21. My students understand that Quest Atlantis has students from all over the world who may or may not speak English.	They have been told this, but I don't know that they encountered anyone. There were no other classes in Math World with us, so there was not a lot of opportunity for interaction.

The responses to survey statements 1 to 6 state that for the majority of the unit the teacher was off to the side madly responding to students' quest responses. The teacher had very little

actual observation of their work in the QA space. In addition the response to survey statement 11 expresses that the teacher did not really have time to monitor the chat area, as the teacher was responding to quests. The researcher observed the teacher responding fervently to the student's responses seated in the middle of the library. The teacher had to send feedback to students working on different missions as well as students redoing earlier attempted missions at the same time. The teacher was therefore kept occupied and did not have much time to observe students display of 21st century competencies.

In statement 7 and 8, the teacher responded "As of this time, no, I have not seen the students applying the knowledge outside of QA. On the other hand, since the start of the project until the finish, I have only seen them working in the QA environment, they have not been doing any other work or assignments for me." The researcher agreed with the teacher's comments.

In the response to survey statement 9, the teacher believes that the students in the two classes generally collaborate most of the time when given the opportunity. Those students who did not collaborate in QA don't normally choose to collaborate in the classroom. The teacher would not say that there was an increase. The researcher observed collaboration between students in both class A and B. The collaborations were mostly verbal in both classes and the chat tool in QA was used for chatting in the virtual world. Students helped each other when in doubt and depending on the group dynamics students were always prodding and checking on each other to view the activities of the student sitting beside them. Questions and comments were generally casually spoken in tandem with playing the game. Sometimes it would lead to further discussion of the question, comment, or topic and sometimes it would just fizzle out if the comment was not particularly interesting. Collaboration took on a different role when students ahead in a mission would take time to bring another student up to par with them. Some students

preferred to work together as one unit throughout all four missions egging and constantly exchanging ideas at a ceaseless rate and planning out the next logical move. When fellow students could not provide answers to questions the students approached the teacher for help. The teacher would explain the concept of the mean, median, mode, or range and provide a hint to solve the task. Students were happy with this approach as the completion of the task still rested in their hands.

In statement 10, the teacher remarked with regard to leadership skills as a result of collaboration among students was not particularly or at least, not different from what the teacher would normally see in the classroom. The researcher saw that at most tables there was one student to whom most queries were addressed. This student seemed to have leadership skills and other students seemed to look up to that student for reconfirmation of their intentions and answers to their questions. Sometimes students from other tables would get up and walk to these students and get their questions addressed.

The answer to survey statement 12, says the teacher had no direct observation of increased effort on reading related to accomplishing goals of the missions among students. Indirectly, the students seemed to submit more thoughtful answers when the in game evaluation asked them to read the goals more carefully. The researcher observed students asked to resubmit their answers reading the in screen text carefully to understand what they had missed out in their earlier attempt. The students were observed to scrutinize the text involving statistics content for help in writing effective answers that would be accepted by QA characters.

In the answer to survey statement 13 the teacher was not exactly sure what was meant by this question. The teacher knew that the students would have completed quests in QA that were about this topic, but the submitted quests in Ander's city were not particularly good evidence of

compassion. The observations by the researcher also did not also see evidence of compassion in the students' responses in the unit. The responses consisted of Mathematical expressions mean, median, mode and range and siding with different political in game characters and their perspectives.

In statement 14, the teacher responds no, there was not a lot of artistic expression in the teacher-evaluated missions. The researcher observed that student responses did not contain much of artistic expressions. The responses contained components of statistics related to the mean, median, mode, and range.

The teacher's answer to statement 15 was that most students found Q-ville didn't work in the Mac environment so they did not get to use this aspect. The researcher found that the school only had MAC computers so even though the ideal platform was the PC platform it could not be realized in the circumstances.

In response to statement 16, the teacher felt the missions in Math World did not really allow for a lot of creativity. There were stylistic differences, but for the most part students looked at the data and then wrote about what they found. The researcher was of the same opinion and besides linking the statistics material in the unit and making informed decisions they were not able to build or create structures in the Quest Atlantis environment.

In statement 17 the teacher was of the opinion that again, students' responses to art forms, colors, or concepts were not a particular focus of the mission. They may have while they were playing, but the teacher did not get a lot of direct observation time. The researcher agreed with the teacher but leaving the student responses aside did hear students commenting positively about the colors, buildings, and characters in QA.

With regard to statement 19 the teacher responded that there were only a few interactions with students that were with people from other schools, so the teacher did not really know what the students encountered in this area. During the focus group interviews the researcher got to know that there was another school in the hub but these students did not reply to chat requests written by students who undertook this research study.

Statement number 20 said "I observed my students write or discuss how students from other cultures are different in many ways, but also the same in many ways." The teacher's response to the statement was "not directly." The observations and interviews by the researcher do not showcase QA being instrumental in teaching these cultural traits.

In statement 21 the teacher explains that students have been told QA had students from all over the world who may or may not speak English, but the teacher does not know whether they encountered any other student. There were no other classes in Math World with them, so there was not a lot of opportunity for interaction. The observations by the researcher also reiterate the teacher's response. There were no other classes in the Ander City unit and the co-questing feature in QA had not been selected to allow two or more classes across the globe or nationally to take part in the same unit together.

Teacher Interview and Classroom Observations

Nvivo version 10 software was used for open coding of the teacher interview data and teacher and students classroom observations. The teacher interview data in the form of a word document and classroom observations in word documents were imported into the software for analysis. Nodes that represented open codes and categories were created in the Nvivo software. Data from the teacher interviews and classroom observations were dragged and dropped in to the Nodes and categories to mark traits. Open coding of all the data sources for a period of 4 days

resulted in 10 open codes from the teacher interview and 39 codes from the teacher and student observations (Appendix O). During the axial coding stage recurrent coding took place between the categories and codes. These codes were placed into six categories or 21st century competencies as stated in an earlier study by Smith (2011). These categories were collaboration, communication, creativity, critical thinking, global awareness, and problem solving. In selective coding, these categories were part of the seven 21st century competencies in a QA study conducted by Smith (2011).

After the data analysis, six categories emerged as the 21st century elements to play QA. These categories are collaboration, communication, creativity, critical thinking, global awareness, and problem solving. These categories also contained sub-categories. The 21st century elements categories and sub-categories along with their number of references are displayed in the table below (see Table 9).

Table 9

Six Categories and Sub-categories as 21st Century Elements

Category	Sub-category	No. of References Sub-category	No. of References Category
Collaboration	Flexible in Compromising Towards a Common Goal	10	48
	Works Effectively with Others Towards a Common Goal	38	
Communication	Articulates Ideas Clearly Through Speaking and Writing	10	14
	Listens Effectively to Understand Meaning Towards Common Goal	4	
Creativity	Develops and Communicates New Ideas to Others	3	6
	Makes Connections Among Ideas	3	
Critical Thinking	Synthesis Information to Conclude a Solution	7	10

	Communicates effectively with others to solve a complex problem	3	
Global Awareness	Mutual Respect and Open Dialogue in Work and Community Contexts	3	3
Problem Solving	Multiple Approaches to Solve a Problem	13	26
	Multiple Resources to Reach a Solution	13	

In the sections that follow, each of these categories will be explored further in relation to the observation data.

Collaboration

Students participated in the Ander City unit of QA to learn the mean, median, mode, and range in statistics and displayed 21st century competencies. During the course of play students showed flexibility and were willing to compromise towards a common goal. Students also showed promise to work effectively with peers towards a common goal.

Flexible in Compromising Towards a Common Goal

Students helped each other out towards the attainment of a common goal. Some students were flexible enough to stop what they were doing in order to help a fellow quester reach the exact same point in the game. Students who were absent at the onset of the project were led by their peers to log in and navigate the environment. In fact, some students worked in pairs to prod each other towards the realization of the goal.

Works Effectively with Others Towards a Common Goal

Students in the QA environment were observed to quietly collaborate whereby students worked together as a group to get through parts of the story. Here is an excerpt from the teacher:

Researcher: "Did you find your students learning 21st century competencies in the Quest Atlantis environment? Could you cite the most prominent instances (instances that stood out)?"

Teacher: "Definitely there was a lot more quiet collaboration than I thought in terms of thinking about working together as a group to try and pass through…pieces of the story."

Students asked the teacher for guidance when stuck in the online game and peers could not provide a solution. The teacher would only provide hints and had meaningful conversations with the students. In addition, some students were verbal throughout the sessions and provided running commentary of their exploits. Other students would visually display their whereabouts and how to get there.

Communication

Students displayed well-developed communication skills while interacting with each other in the virtual world. Speaking and writing were in the forefront when exchanging ideas and deciding on a plan of action to complete a mission. Some discussions between students were effective in the sense that one student would patiently wait for the other to finish before the exchange of roles.

Articulates Ideas Clearly Through Speaking and Writing

Students explained clearly why a particular way of performing an action was effective or not effective. This was particularly in cases where students who were ahead in the game were providing feedback to other students and informing them the best way to complete a task.

Listens Effectively to Understand Meaning Towards Common Goal

Students knew that time was limited time so they constantly communicated with each other to reach their common goal. The communication between students and the teacher was dynamic in nature as well as ongoing throughout most of the sessions. The tasks in the Ander

City unit pertaining to a mission were linear, which made students follow a particular path to complete the mission. Since the tasks were similar they were easy for students to explain to each other with the goal in mind.

Creativity

Students need to be creative when playing an online virtual game like QA. The presence of statistics material in the Ander City unit makes it interesting for the student to perceive the material for synthesis to a problem. Ideas do crop up and it is imperative for the student to connect the dots and make informed decisions not only for oneself but for fellow students too.

Develops and Communicates New Ideas to Others

Students were constantly developing new ideas while playing the Ander City unit. These ideas helped in navigation of the environment as well as completing missions. For example, a student explained to another student the concept of navigation in the QA environment with an explanation on how to pin point a location by using the basic analogy of North, South, East and West in our day to day lives and applying it in the game.

Makes Connections Among Ideas

Students tried to find patterns and made connections among ideas in the QA environment. Some students looked at the mission screen to view all the tasks required to complete a mission and the location of a character instrumental for task completion. Sometimes the student had already met the character and therefore knew the location of the character.

Critical Thinking

Students were constantly thinking while playing the game as this immersive experience appeared to bring thinking behavior out in students. The notions of having to read the narrative, constantly navigate the environment through the Avatar, interact with characters, check the Qpod

for latest feeds and complete tasks and activities involved critical thinking in the background with or without the student consciously knowing it.

Synthesis Information to Conclude a Solution

Students enjoyed working on the challenges in the Ander City unit. Students had to provide opinions, statistics and rationale in their answers to the activities, without which their responses were not accepted. In hindsight it actually took some students a little while to understand the trick in writing including the important piece of personal opinion to get going. After grasping this concept, students had an easier time getting their responses accepted and moving on to the next mission. Cognitively students were moving up in their learning as explained by the teacher:

> *Researcher: "How would you like to tweak Quest Atlantis to make it more effective for future students in terms of engagement, motivation, and learning 21st century competencies?"*
>
> *Teacher: "When we move from the realm of acquiring the knowledge to the realm of applying the knowledge we've moved up in terms of our thinking."*
>
> *Researcher: "Did you find the activities in the Ander City Unit to be cognitively challenging for the students? Can you cite some instances?"*
>
> *Teacher: "Cognitively it was pretty challenging for some of them to see that you can actually use the information that you have to provide an example of why your opinion is correct."*
>
> *Teacher: "I thought the tool sorter where it was broken and you had to figure out which of the tools was coming out when you put in a certain set of numbers."*

Students' critical thinking skills appeared to be developed and brought out by the QA online virtual environment. The environment was instrumental in creating a scenario that brought out students' higher order cognitive skills to answer questions in the missions.

Communicates Effectively with Others to Solve a Complex Problem

Students were most of the time constantly engaged in active dialogues to solve problems when playing QA. The assignments in QA where students had to make recommendations based on their interactions with game characters and the knowledge gained helped to write out solutions to complex problems. For example, when a student's recommendation was not accepted by the teacher and had to be resubmitted then most of the time the student would first ask a fellow student for suggestions to solve the problem before asking the teacher. The student that asked for help would verbally explain the situation to a peer in the context of the game scenario and get answers. The answers or sometimes different perspectives of different students were scrutinized by the student that led to deep thinking. Through reflection the student was able to reason out an optimum answer as a response to a question.

Global Awareness

Students were aware of the consequences of using inappropriate language in the chat tool as they had been forewarned by the teacher as well as reminded when going through the IBURST rules. Students were also aware that QA was an online game that could be played by students from different parts of the world at the same time. In addition, students were also told about the likelihood of bumping into students of another country while playing the game.

Students need to know how to behave and communicate with one another in an online environment. This attitude is not only useful in an online environment but also translates to the real world where behavior and attitude play a major role in our communities and workplaces.

Mutual Respect and Open Dialogue in Work and Community Contexts

Almost all students demonstrated respectful behaviors when interacting with their peers in the virtual environment. Most students appeared to understand the concept of being a digital citizen and followed the IBURST rules. Here are some excerpts with the teacher:

Researcher: "Did you find your students learning 21st century competencies in the Quest Atlantis environment? Could you cite the most prominent instances (instances that stood out)?"

Teacher: "I think the general citizenship ideas that were occurring the vast majority of them followed the rules so they understood what it meant to be a digital citizen. They weren't particularly giving out their names they knew we worked really hard to keep their identities a secret so they were looking after that."

QA administration sent an email reporting inappropriate language use by three students in the chat room for not displaying good citizenship behavior. The email also included the excerpts between the usernames of the students in the chat room preventing any scope for error. After receiving the email, the teacher placed the main student who caused the trouble in isolation where the student could neither make comments nor be visible to others. The two other students were debriefed by the teacher in a separate room and asked not to repeat the mistake.

Problem Solving

Students constantly displayed prowess in problem solving. The QA environment was made in such a manner that constant problem solving was the crux on which it was built. There may be a relationship between generation Z students ability to adapt to technological savvy environments given their exposure to technology at home and at school, and their experience with commercial video games, hand-held devices and other technology. The students' relationship and experience with technology may have contributed to the students' bond with the QA educational experience.

Multiple Approaches to Solve a Problem

Students interacted with each other and developed multiple approaches to solve a problem. Most students also interacted with all the characters involved in the mission list to gather the information required to complete the problems. When students talked about their

mission exploits, the other students sitting in close proximity often quipped in with information that turned out to be vital for solving the activity even though they were not involved in the initial conversation. This peer interaction and support phenomenon showcased that the induced environment provided a playground for the students to participate in a common platform for problem solving that was understood by the seventh graders.

Multiple Resources to Reach a Solution

Students were absorbed in the online virtual game to such an extent that they were willing to rapidly go through all sources available to them to solve a problem. The information resources to support problem solving consisted of non-playing characters, fellow students, the teacher, the researcher, and the Internet. Some students waited for the Avatar of the student sitting next to them to reach the same location and level in the game so they could work together from that point onwards or to observe what the student would do individually and then adopt the new strategies. The teacher, when approached by students, would seldom provide a direct answer to a question. Instead, the teacher provided guidance and hints that were different for each student given that the teacher knew the capabilities of each student in the classroom. In this manner, the teacher seemed to be able to provide just the right stimulus required to nudge the student towards better understanding and to complete the task.

In summary, the teacher answered "yes" to 14 questions and "no" to 21 questions, and provided evidence of the claim, in response to the 21st century competencies teacher survey. Inferences throughout this section were made based on the survey evidence, interviews, and observations of teacher and student interaction with Anders City in QA.

QA appeared to provide an environment for the development of 21st century skills. Collaboration between students proved to be the most exhibited 21st century competency and this

is believed to be directly linked to QA's engaging and motivating learning environment. The data showcases 48 references in the Collaboration category with 38 references pointing to the sub-category "works effectively with others towards a common goal". The six 21st century competencies categories were: 1) collaboration, 2) communication, 3) creativity, 4) critical thinking, 5) global awareness, and 6) problem solving. These six competencies were demonstrated while playing QA. Out of these competencies the top three 21st century competencies displayed in QA were: 1) collaboration, 2) problem solving, and 3) communication.

Relationship Between Engagement, Motivation, and 21st Century Competencies

After completing the Introductory mission in Quest Atlantis, feeling comfortable with their Avatars, and understanding navigation concepts related to movement and interaction with game characters students were raring to get into the Math world and learn Statistics. In the first mission "Finding the Safest Bike" in the Ander City unit, students were deeply affected by the novelty of the 3D online virtual game and were not only engaged but motivated and learned and displayed 21st century competencies. Students met game characters such as Tukey, Nancy, and Mai and understood that children in Ander City needed the help of students in the form of statistics consultants. Students as statistical consultants would help to decide whether the safest brand of bike to offer for rental in the park were either Mayor Enoch's preference (Speedy Spokes) or Mr. Grant's selection (Rollin' Steady). The choice of the safest bike to rent was done by analyzing data from bike trials that measured the braking distance and in turn made the candidacy choice easier to make.

During the start of the mission students were in a competitive mode as each student wanted to outdo the other. The competition factor provided in the game not only engaged

students but made them want to complete the mission in the fastest manner possible. Students sitting next to each other were monitoring each others progress and constantly talking to one another to explain how to complete a task. For example, students after meeting Rollin; Reba were asked to complete bike trails by climbing up a platform and clicking a sign to begin braking distance trials. Four bike trials had been done earlier and the rest of six trials had to be done by the students. Some students would click the sign only once and thought that the six bike trials would be done automatically. It was only through 21st century competencies of collaboration and communication, and problem solving were they able to find out amongst their peers that each trial had to be done separately. One student was so excited and overjoyed about playing the digital game that while conducting the braking distance trials he exclaimed loudly and provided a running commentary of each of his six braking distance trials. Students sitting in close proximity and especially those sitting at his table did not have any problems completing the braking distance trials due to the motivation portrayed by the student while playing the game. Students were also motivated by the autonomous learning provided in the game due to the fact that learning was not routed through the teacher. The student could follow any pace as long as the missions were completed in the time frame provided by the teacher. Students were motivated by the common storyline, task list feature (where they could see the tasks that needed to be completed for each mission), 3D environment, rich graphics and game characters they interacted with. Most students faltered when making recommendations at the City Hall Computer Terminal near the end of the mission as their initial attempts were not accepted by the teacher. Students did not know that the teacher read the recommendations and based on the response would accept or ask the students to revise it. The teacher would also sign off the feedback as Tukey or Nancy that made the students even more engrossed with the storyline and digital game. Students whose

recommendations did not get accepted would go to peers whose recommendations were accepted to find out how their responses needed to be tweaked or made more comprehensive for acceptance. Students were happy to share their recommendations and even spent time explaining the reason why the range, mode, and mean may be required to analyse the braking distance and lead to a bike choice. Sometime students would carry their laptops to the teacher or ask the teacher to come to their table and explain why their recommendation was not accepted. The teacher would read their response and give them just the right amount of information required to nudge them into a more detailed answer for acceptance. For example the teacher would ask the student to calculate the mode and range and see if it would help to analyze the bike with the better braking distance. The teacher never made it obvious to the students that he was accepting their recommendations or asking them to revise it. In this manner students felt more comfortable discussing their thoughts, reasoning, and arguments thinking that the teacher was not part of the digital game but knew the content anyway. The display of 21st century competencies likes problem solving, critical thinking, collaboration, and communication were evident during discussions between students and teacher and students.

Prior Ander City Research Studies

A descriptive and exploratory approach was conducted in a study by Karimi and Lim (2010) with primary school students (n=21) between the ages of 8 to 12 in Malaysia. The aim of this study was to gauge students' engagement and enjoyment in a 3D digital narrative environment—Quest Atlantis's Ander City unit. Data sources in the study included questionnaires, interviews, observations, and time records. Both Quantitative and Qualitative approaches were used to analyze the data. The results of the study showed that students underwent a high level of enjoyment and engagement when they played the 3D digital online

game. The study also contributed to the existing body of digital narrative design knowledge for children.

An article by Gresalfi and Barab (2011) discussed the means through which tasks were designed to engage students in the Ander City unit via technology. Students were immersed in the role of a statistician who was placed in situations where Mathematical tools were used in conjunction to analyze different data sets and reflect on the process to get their results. Through the design of the curricula four types of engagement were displayed: 1) procedural, 2) conceptual, 3) consequential, and 4) critical. The article highlights the importance of immersive and interactive narratives to engage students with content in school.

The Ander City unit was part of a comparison study by Barab, Gresalfi, Arici, Pettyjohn, and Ingram-Goble (2010c) that involved two grade seven classes between 12 to 14 years and taught by the same teacher. The curricular units were similar and affected the same key areas and included situations that engaged students. But the units differed in terms of details in the situations where the length of the storylines were different, arrangement of the unit where activities were paper based vs. online video game, and where the teacher was held accountable vs. characters in the 3D virtual online game. One class had a lower performance than the other and was allowed to play the Ander City unit to learn statistics whereas the higher performance class used the other curriculum. The results of the comparison showed that the Ander City class improved more than the other class as the repeated measures ANOVA revealed a significant effect for the Quest Atlantis class.

This researcher's study is similar to the research done by Barab et al. (2010c) as this study also had two grade 7 classes with students between the ages of 12-13 years and the same teacher. But students were not segregated in terms of curricula and not compared due to the

absence of a control group in the study. This research also adds to the literature in terms of 21st century competencies brought out during digital game play involved in the Ander City unit as well as highly motivated students in the multi user 3D online virtual environment.

Chapter Summary

This chapter described in detail an analysis of data collected in this study from multiple data sources that included the teacher and student classroom observations, student focus group interviews, teacher interview, student computer technology survey, student engagement survey, students pre and post-test survey, and teacher 21st century competencies survey. In chapter five, discussion, conclusions, and recommendations, will be described.

CHAPTER 5 DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Building upon on previous studies by Tuzun (2004) and Smith (2011), this descriptive case study examined the use of an online educational 3D virtual game "Quest Atlantis" as a technology to support learning in Mathematics and to contribute new understandings to the current literature on digital game based learning. Participants were recruited from two grade 7 classes of an urban school district in Alberta, Canada. The descriptive study was designed to examine whether QA provided a meaningful learning environment to engage, motivate, and develop students' 21st century skills in the classroom.

This chapter is organized as follows: 1) a discussion based on the findings in relation to each of the research question is presented, 2) a discussion of key findings and the study conclusions of the study are provided, and 3) several recommendations based on the study as well as future recommendations are provided.

Discussion

This discussion section is divided into three sub-sections on engagement, motivation, and 21st century skills. In each section, the discussion addresses one of the research questions.

Engagement

The first research question of this descriptive case study was, "In what ways can student engagement in learning be supported by playing Quest Atlantis in the classroom?" Several data sources were gathered to develop an answer to this question.

Students completed the engagement survey (Appendix D) after the teacher's stipulated timeline for completing all the missions in the Ander City unit. The results of the student survey on engagement showed a high level of engagement. According to the students' responses, the top three engagement statements from highest to lowest were: 1) I was involved in learning in

the Ander City unit, 2) I was satisfied with how I was doing in the Ander City unit, and 3) I felt in control while learning in the Ander City unit. In other words, the majority of students appeared to be immersed in the game while learning Mathematics with their peers or while they worked alone. Classroom observations documented that students were overjoyed when their responses got accepted and they were satisfied with their performance. Also students were happy to take control of their learning, and demonstrated an ability to be self-directed in their learning where collaboration played a major role by providing the resources necessary to accomplish tasks.

The results of the Independent samples t tests on the pre and post-tests did not show significant statistical differences for gender. Even though the pre and post-test questions were different, the overall results were positive. The gain in scores in the post-test scores of boys and girls in both classes is positive, which is a very promising finding; however, this gain in scores cannot only be attributed to QA as there was no control group in this study. The teacher and students observations also showed evidence of overall student engagement regardless of gender when learners interacted with QA.

Motivation

The second research question of this descriptive case study was, "Do students feel more motivated about their learning and about Mathematics when learning is supported by Quest Atlantis?" Several data sources were gathered to develop an answer to this question.

The adapted constant comparison method used by Tuzun (2004) was conducted with the focus group interviews and observation notes data. The analysis of the data sources led to the emergence of four main categories related to motivation: 1) accomplishment, 2) immersive context, 3) learning, and 4) social relations. Tuzun's (2004) study had thirteen categories: 1)

identity presentation, 2) social interaction, 3) playing, 4) learning, 5) ownership and control, 6) fantasy, 7) immersive context, 8) curiosity, 9) creativity, 10) achievement, 11) rewards, 12) uniqueness, and 13) context of support. The four categories related to motivation that were found in this study were not as extensive as those in Tuzun's study but were comparable to some of the categories brought forth in his study. These four categories of motivation could also be called motivational elements as a result of students' interactions in the QA environment. This study appears to have replicated some of Tuzun's findings, and thus has contributed useful insights on motivation. With future research, more insights about motivation while learning with digital games can be sought.

The results of the computer technology survey showed that students' are well versed with technology. The 10 major findings were that: 1) all students' families had a computer and internet access at home, 2) 78% students on a daily basis used the home computer, 3) 84% students daily used the Internet, 4) 100% students had access to a computer or computer lab in school, 5) 49% students made use of school technology individually, 5) 51% students responded that computers were almost daily used in an average school year, 6) 65% students reported almost daily use of computers to do schoolwork, 7) 39% students rarely need help when playing video games while 25% students never need help plus 10% consider themselves experts, 8) 22% students rarely needed help when using a word processor while 37% students never needed help plus 6% believed they were experts, 9) 41% of students indicated strongly agreed and 45% students indicated agreed to the statement "computers make schoolwork easier to do", and 10) 37% students strongly agreed and 41% students agreed to the statement "computers make school work fun and interesting". These results show that students are knowledgeable and comfortable in the use of technology including video games and prefer to learn through an interesting and fun

computer medium. Generation Z students irrespective of gender appear motivated in the collaborative DGBL virtual environment that stimulated situations for social interaction, collaboration, and competition. These situations also foster autonomous learning by giving control to the students and the teacher takes the role of a facilitator. As a facilitator the teacher provides guidance and support and only purposely intervenes when students go off task (which was rare). Students were also constantly reminded of a unit test administration at the end of intervention which would count towards their Mathematics grade. Students were therefore intrinsically motivated by QA and extrinsically motivated by the grade for assignment by the teacher.

21st Century Competencies

The third research question of this descriptive case study was, "In what ways can the development of 21st century competencies be supported by Quest Atlantis in the classroom?" Several data sources were gathered to develop an answer to this question.

The results of the 21st century competencies survey disclosed the teacher supported evidence to the claim of technology skills, critical thinking, problem solving, collaboration, communication, and global awareness. According to the teacher interview and classroom observations, QA appeared to be conducive to supporting a technology enabled learning environment for the development of 21st century skills. The six 21st century competencies categories were: 1) collaboration, 2) communication, 3) creativity, 4) critical thinking, 5) global awareness, and 6) problem solving. The 21st century competency of collaboration proved to be the most exhibited 21st century competency by the students in this study, and this is believed to be directly linked to QA's engaging and motivating learning environment. Collaboration was not only present between peers but also between the students and their teacher. Students also

seemed to approach the teacher as a last resort and would first ask their peers to answer questions or reach a solution through active collaboration during game play. When students could not get answers from their peers and asked the teacher for help, the teacher's instructional strategy was to only provide clues or to engage in meaningful conversations about the Math or statistics concepts with students which would not directly provide the answer but offer enough context and guidance for the student to reach a solution to the activity. This instructional style was responsive and supportive of student learning. Sometimes, when other students noticed this interaction between teacher and student, they would first approach the student for the solution to the same activity. Therefore, the teacher would sometimes notice the spread of information from one student to a whole group of students. Occasionally the dispersion of this information occurred from one group of students to another group of students seated in a different area of the library. The role of a teacher was therefore more of a facilitator and guide than a direct medium of instruction such as in the traditional context of teaching. The second most displayed 21st century competency was problem solving. Students displayed attributes to problem solve in the QA environment due to the situational context of the QA curriculum. Students were placed in situations where they had to solve problems to move forward in the game world and complete tasks. Students enjoyed problem solving and seemed happy to collaborate with one another or with the teacher to find a solution to a question. The 21st century competency of communication came third where students either spoke to each other or wrote in the chat tool provided in the game to each other. On the whole, students preferred to communicate with one another by speaking rather than writing through the chat tool as it was quicker to speak and get a response right away.

These three sub-sections presented key findings related to the research questions. In the next section, discussions and conclusions, recommendations, limitations and final reflections are presented.

Discussion and Conclusions

The purpose of this study was to investigate whether digital game play results in positive learning benefits, greater motivation, increased engagement, and the assimilation of 21st century competencies by students. The key themes and ideas generated from the literature review on engagement, motivation, and 21st century competencies as well as the analysis of the qualitative and quantitative data collected and analyzed in this study, lead to the following conclusions:

1. Quest Atlantis can support student engagement when learning in the classroom.
2. Students appear to feel more motivated about their learning and about mathematics when learning is supported by Quest Atlantis
3. Quest Atlantis can support the development of 21st century competencies when learning in the classroom.

These three conclusions are explained in detail in the sub-sections that follow.

Quest Atlantis Supports Student Engagement

Data analyzed from the student engagement survey (Appendix D), pre and post-test survey (Appendix E), and teacher and students observations points to QA supporting student engagement when learning Mathematics.

There are some 21st century learning environments that allow students to engage in inquiry based tasks (Jacobsen et al., 2010). QA has demonstrated its capability to be one of these 21st century learning environments in this case study. Some students seemed to be totally engrossed with the learning involved in the game that could be attributed to being in a state of

flow (Csíkszentmihályi, 1990). More research is needed to explore this potential for flow while using QA. However, observations of student behavior while they were immersed in QA suggest the potential for flow experiences. Prensky (2001b) was of the opinion that since 'digital natives' minds were wired differently engagement could be supported by digital games, which appeared to hold true in the QA environment in this study. Student engagement was observed and reported by learners who used the QA environment to learn Mathematics. QA being a virtual online game appeared to be a novelty for the students interacting with the digital game medium. Inquiry based learning activities in QA prompted student engagement and natural curiosity to make sense of the virtual world. The QA collaborative learning environment appears conducive for intellectual engagement. For learning to take place intellectual engagement needs the support of a collaborative environment. In addition, knowledge building processes (Jacobsen & Friesen, 2011) were observed in the QA environment as through inquiry-based learning and collaboration students display knowledge building traits in their interactions that are necessary skills to build in school before they join the 21st century work force. The experience of higher order critical thinking skills (Jacobsen, 2010) were displayed in the QA environment brought about the realization that students evaluate information by game play, going through the immersive content in the unit and completion of activities. The real world environment (OECD, 2007) in QA provides students with the ability to relate to a virtual real world that simulates real life experiences that engages and stimulates the students to learn.

Furthermore, the Quest Atlantis environment allows students to interact socially while learning that increases learning abilities by allowing students to reinforce and reflect on their learning that leads to deep thinking, which relates to the literature by Schank (2011) on cognitive processes. For example, students involved in the QA gameplay collaborate with students sitting

next to them or in other parts of the library to discuss the solution to an activity. Students discussed various means and individual perceptions to provide solutions to an activity and in that process of deliberations reinforced and reflected on the content that lead to increased cognition. Knowledge accumulated by the combination of deep thinking and emotional commitment to a task sets the stage for intellectual engagement (Jacobsen, 2010). For example, students help Tukey and his friends who are game characters analyze data to decide whether the present Mayor Enoch or opponent Mr. Grant arguments make more sense. Students relate and form an emotional attachment to Tukey and his friends as one of their own and are emotionally attached since Tukey asks each student for help. The activities and recommendations in the QA environment enable deep thinking where the teacher corrects the submissions and signs off as a QA character like Tukey or Nina. The sign off with QA characters personalizes learning for each student, which again makes an emotional attachment and facilitates deep thinking through social and virtual interactions. Situated cognition (Gee, 2003) and immersive environments (Barab et al., 2008b) allow students to be part of a virtual world that allows them to experience the world from within and engage them through the situational contexts and storyline. For example, students in the first mission had to find out the safest bike between two bike brands—Speedy Spokes and Rollin' Steady. The context and scenario provides a breeding ground for situated cognition where students interact with game characters and conduct bike trials to come up with the breaking distance through 10 bike trials. The scenario immerses students in the activity and makes them find answers by calculating the mean, median, mode, and range. The students write recommendations in the form of a letter that explains to the children of Ander City which brand of bike is safer and why and then submit the recommendation online. Students show signs of excitement, eagerness, and immersions to get answers to their online submissions

while playing another mission that displays high immersion not only in the present activity but earlier activities too.

According to Knighton et al. (2010) 15 year old males outperform females by 12 score points in Mathematics. But the use of QA as a tool for learning exhibited that the results of the Independent samples t test between the males and females scores on the pre and post-tests did not show significant statistical differences for gender. While this is a preliminary result based on a small sample in a case study, this analysis does appear to show that QA appeals to both males and females and is broadly useful for learning that is independent of gender. The classroom observation also indicated student engagement in the QA environment was not differentiated by gender. For example, both boys and girls seem to show an equal liking for learning during game play in QA. Both genders also appear to be evenly immersed in the activities of the QA curriculum and did not show any loss of interest during game play.

Students Feel Motivated About their Learning and Mathematics

Data analyzed from the focus group interviews (Appendix B), computer technology survey (Appendix A), and teacher and students observations indicated that students felt motivated when learning Mathematics in the QA environment.

This descriptive case study built on the multiple motivations framework proposed by Tüzün (2006). The motivational elements that emerged from the analysis of the student focus group interviews were: 1) accomplishment, 2) immersive context, 3) learning and 4) social relations. These motivational elements were similar to the motivational elements found in a seminal study leading to the multiple motivations framework by Tuzun (2004) and highlight the link between learner motivation and digital game play. Earlier studies in middle and primary

school also found positive motivational effects of educational digital games in Mathematics (Klawe, 1999; Rosas et al., 2003).

The computer technology survey results showed grade 7 students knowledgeable with technology with all students having a computer and Internet access at home. Most of the students were of the opinion that school work was made easier with computer usage. It could therefore be concluded that nowadays students prefer to work with technology in their school environment to accomplish tasks. The classroom observations showcased students motivated in the QA environment with their excited chatter and shrieks of delight when playing the game. Besides finding the virtual online game fun they were motivated to finish the game by completing all the four missions as quickly as possible.

Quest Atlantis Supports the Development of 21st Century Competencies

Data analyzed from the teacher's 21st century survey (Appendix C), teacher interview survey (Appendix C), and teacher and students observations support students development of 21st century skills when learning Mathematics in QA.

The QA environment provided an environment for the development of 21st century skills. According to Voogt and Roblin (2010) and P21Framework (2012) the seven 21st century competencies were: 1) technology skills 2) collaboration, 3) communication, 4) creativity, 5) critical thinking, 6) global awareness, and 7) problem solving. In this case study collaboration between students was confirmed to be the most exhibited 21st century skill, which can be attributed to QA's engaging and motivating environment. The collaborative environment provided by QA brought about a new mode of collaboration not just between students but between students and the teacher too. Students felt that the characters in the game were providing feedback to their responses even though it was actually the teacher providing feedback

to their responses and signed off with the name of one of the characters in Ander City. It is inferred that because the students did not associated the teacher with this feedback system in QA, that students felt free with the teacher and asked technical questions as well as questions related to the activities in Ander City.

The next most prevalent 21st century competency displayed in QA was problem solving. The Ander City curriculum was designed in such a manner that students had to solve problems to advance in the digital game environment. These tasks were solved individually or in collaboration with other students that made the attainment of educational objectives more meaningful and thought provoking. The third 21st century competency by rank order was communication. Students spoke or wrote in the chat tool in the online virtual game environment when they communicated to each other. The teacher and students classroom observations also revealed the development of 21st century competencies in the use of QA. Students were always constantly chatting with students sitting next to them or with students from other groups in the library. Communication was a means of problem solving which led to collaboration so it appears that these competencies were interdependent on each other.

Recommendations

A reflection on experiences gained from carrying out the research design and data collection methods in this case study yields suggestions for future research of this kind. Several suggestions are presented in the following sections on methodology, ethics approval and the use of QA in the classroom.

Methodology

While working on the analysis chapter, the researcher reflected on the strengths and weaknesses of the research methods. Several realizations emerged about modifications that can

be made to gather superior data in future studies of this kind. The student focus group interview questions (Appendix B) should be modified to include only questions related to motivation. In the present study, only the first four student focus group questions were related to motivation. The probing of student responses using more motivation based questions during the focus group interviews may have resulted in the development of more than four categories in the multiple motivations framework (Tüzün, 2006).

With regard to the teacher data, the question "I observed the creative use or interpretation of language by my students (to learn Mathematics)" could have been better written for clarity in the teacher 21st century competency survey (Appendix C). A better written question, such as "I observed the creative use of my students to learn Mathematics" may have resulted in a clearer answer by the teacher.

In the pre and post-tests (Appendix E), question 5 in the post-test had to be deleted from the analysis of results because the answer provided in the QA lesson plan was incorrect (i.e., the most rational answer was another answer—option d). Second, answers to question 7a and 7b in the pre-test could be answered by students without using statistics (e.g. the questions referred to one single watermelon of a particular weight and the question dealt with weight). On the other hand, questions 7a and 7b in the post-test needed statistics to answer the question (e.g., tomatoes were mentioned in a plural form and on this occasion the question dealt with time. While marking the pre and post-tests, question 5 as well as question 7 had to be taken out of contention and removed from the results since they were not equal comparisons on the whole. It would be best to discuss the questions in the pre and post-test and get an approval by the teacher before implementing the tests as part of the research study.

The class observation protocol (Appendix M) may have been more useful had the researcher included the use of an observation instrument in a study by Kardynal (2009). The study by Kardynal (2009) made use of a rubric and had a five point scoring scale that yielded data that was more quantifiable. One drawback of the Kardynal (2009) instrument is that it does not provide a rubric to cover 21st century competencies related to technology skills, communication, creativity, and global awareness. In a future study, the combination of class observation methods from the present study and Kardynal's (2009) rubrics may strengthen this form of data collection.

Ethics Approval

Researchers who aim to pursue school-based research on the use of digital games with children need to consider and plan for the time it may take to receive ethics approval to conduct this research with children. In this study, ethics approval needed to be sought from the University and also from the school jurisdiction. The research ethics board at the University of Calgary reviewed the application and granted approval to conduct the study within two and a half weeks. The school jurisdiction, on the other hand, took six weeks to review the application and to provide ethics approval to conduct this case study, which was from the time the original application for ethics approval and the University Ethics Approval Certificate were submitted to the time actual approval was granted by the school jurisdiction. Part of the reason for the lengthy review period for this particular study was the connection between the research team at another university in the United States, and the proposed research to be carried out with Canadian students in an Alberta school. The whole ethics application process is described in detail in the methodology chapter. The recommendation for future research that emerges here is that it would benefit researchers to plan well ahead if they are applying for ethical approval to conduct a

school-based study with children using proprietary digital game software that belongs to a research team located in a different University in a different country.

Another logistical challenge to do with ethical research methods in this particular study had to do with the process of gaining informed consent. Students were asked to take home two consent forms to be read and signed by their parents and themselves— one from the University of Calgary and one from ASU. Besides these two major consent forms, the researcher was required to ask students to sign an assent form in the classroom as well. After getting the signed ASU consent forms, the researcher was required to scan and send these forms to the assigned buoy in ASU. The logistical complexity in communicating the intent of the study, inviting participants to give their informed consent, and then asking students for assent, resulted in several layers of permissions that needed to be tracked on a spreadsheet. There were students who provided ASU consent to play the game, and did not provide University of Calgary consent to participate in the research; therefore, while all of the students played QA, there were several students who were not part of the researcher's study. It was vital to only include participants in the study who had given all three levels of consent (i.e., ASU, University of Calgary and assent). The researcher had to carefully examine the University of Calgary consent form as well as the student assent form when making decisions to collect student data for analysis. For example, if the parent and student gave consent for taking part in the pre and post-test survey in the University of Calgary consent form, but the student did not given consent for same in the student assent form, then any data from the pre and post-test survey for that student could not be used in this case study, and was removed from analysis. This description of the many layered consent process required for human participants in this particular study does not necessary yield a useful

recommendation for improvement for future studies, but perhaps serves as a cautionary tale for researchers and the advice to include this knowledge in planning the research design.

Installation of Quest Atlantis Software

As demonstrated in this case study, QA can a useful, engaging and motivating technology enabled learning environment that offers clear benefits for learners in the classroom. Researchers and educators who plan to use QA should keep in mind that there may be some technological challenges that will need to be dealt with in order to use this technological resource in the classroom. For instance, the installation process for the present study turned out to be cumbersome and time consuming. QA is meant to run on PC computers and it turned out to be difficult to install QA on MAC computers. Many schools have Mac computers for use, and this is a consideration for teachers who are planning to adopt QA for learning. Many considerations had to be taken to task when installing QA on Mac computers: 1) network bandwidth issues, which involved 20 computers connected to the school's LAN and the remaining computers gaining access via the wireless network, 2) the school's technical analyst only came in once a week to school (Thursday) to address technical issues, 3) an xwindows / quartz issue, which led the technical analyst to have to build a customized installation package so that the QA application could write the cache to a place that had permission to also save, 4) special permissions needed to be given to student accounts so that the cache could be saved locally, and 5) two test user accounts were set up in QA to check if the customized installation package worked as intended.

Classroom Practice

Teachers interested to use QA as a tool for learning may want to run a trial version with students in an after school activity to view firsthand the pros and cons of using QA. The setup

would help to understand the network load and classroom feasibility issues that may crop in a large full classroom setting. QA works best with PC computers and it would be best to make arrangements for PC computers if a school uses MAC computers. Since students prefer to sit with their friends it may be a good idea for fixed seating arrangements to foster social interactions between students with inhibitions to one another. Students can still walk-up to one another in the settings and collaborate with each other but it does give a chance for students that do not usually choose to sit together to interact and exchange views with one another based on the common contextual game play environment. In the same regard weaker students could be placed next to stronger students for enhancement of 21st century skills. Weaker students may observe and replicate the actions of stronger students and get the scaffolding required in the early stages of the game. The teacher could be positioned next to weaker students for scaffolding purposes as well as explain navigation issues that may arise in the beginning of the game to find characters and locations. Student trial accounts should be created to ascertain permission issues and time constraints that may plaque students from accessing the QA environment if not configured properly. A timeline for completion should be stated early in the activity so that students do not rush into completing their missions without reading the subject matter contents embedded in the game play. Students may just want to submit their recommendations without the application of principles, methods, and understandings associated with the discipline at hand.

Teacher experience with technology and their tolerance for technology and network issues may be a factor in the use of QA in the classroom. In this particular case study, the teacher was technology savvy and helped in setting up the computers to run QA. In the teacher's prior experience with QA on PC computers, he did not encounter these complex installation

issues and cache related problems. However, given this prior experience, the technology and network issues were an inconvenience but did not stop the innovation from going forward.

Research Study Limitations

There were several study limitations that may have impacted the quality and extent of the findings. The first limitation of this study may be the Hawthorne Effect (HE), which is the term applied to an experiment where factory workers production increased with an increase in benefits such as lighting and wages and increased further even when the benefits were removed as the workers felt they were being observed (Raywid, 1979). In the present study, students may have felt the novelty effect with the introduction of a 3D online virtual digital game for learning during which they had field trips to the library for the sessions. This novelty effect in tandem with the researcher's presence may be linked to the students' demonstrated behaviour of being excited, engaged, and motivated. The students may have ignored the researcher over time, having become used to his presence, but may have demonstrated gains in productivity through the new medium of learning with DGBL because of the HE. So even though students may have not found the technology to be particularly exciting, given their experience with and exposure to technology at home and at school, the innovative nature of the digital game, the new setting, and the research purpose may be linked with the students industrious behaviour because of the HE.

The second limitation may be the convenience sample where the findings may have been different if the study was carried out in two different grade seven classrooms at a different school. The convenience sample in this study was taken from two grade seven classes that belonged to the same school and had the same Mathematics teacher. The quantitative data analysis did not show a significant statistical difference between the genders on the post test but there may be a significant statistical difference in gender if the classes were from two different

schools. Further research with different sample types may add credibility to the findings of the study.

The third limitation of the study may be the recruitment of an experienced QA teacher where the findings may have been different if the study was carried out with a teacher who was less experienced with the use of Quest Atlantis. The teacher in his study was well acquainted with the QA software which may have made students feel comfortable with the learning through the DGBL environment. The teacher's experience with the software resulted in quick solutions for technological issues as well as meaningful responses to students' online assignment submissions that in turn triggered students' cognition and kept them engaged. On the other hand a less experienced teacher or a teacher that uses QA for the first time in a live classroom setting may encounter technological issues with the software as described earlier in chapter three. The inexperienced teacher may also take more time to get acquainted with the software and respond to students' online assignment submissions. Therefore, findings related to the study may have been different depending on the teacher's experience with QA.

The final limitation of the study deals with the instruments used to collect data. Surveys and interviews tend to gather participant perspectives, which are subject to some bias. However, to counter this limitation, the study design included several data collection methods, such as classroom observations and pre- and post-tests, that enabled the researcher to observe classroom events first hand and to gather information on student knowledge of statistics. The triangulation of several data sources was deliberately designed into this research to strengthen the reliability and validity of knowledge claims that emerged from the case study.

Research Study Delimitations

There were four delimitations that provide a context for the study's findings. First, the teacher recruited for the study had a deep interest from an early age to play digital games and had used QA three times prior to this study. The teacher had also taught Mathematics in grade 6 for 15 plus years and had been a learning leader in school technology for four years. Second, the convenience sample of participants were recruited from the experienced QA teacher's two grade seven classes of an urban school district in Alberta, Canada. Third, the case study employed both quantitative and qualitative data collection methods, making it a mixed-methods case study, and triangulated several data sources to make knowledge claims about student engagement, motivation and the development of 21st century competencies through the use of QA. Last but not least, there were many online educational digital games available in the market but for this study QA was chosen as the DGBL tool.

Final Thoughts

Based on the findings summarized in this case study, it can be argued that the use of QA as a tool for DGBL can motivate and engage middle school grade seven students to socially and virtually interact with one other and their teacher, and to increase the understanding of Mathematics concepts related to statistics. In this study, suggestions on using QA as a tool for learning have been generated to inform future teachers, researchers, and educators.

The DGBL tool QA is found to benefit students who appear to fit the category of generation Z students who seem to be wired for interacting in a technological savvy environment brought about by the use of QA. The online virtual game environment appear to meet the students demands for DGBL environment for learning Mathematics as opposed to the traditional rote learning style where the teacher is the focus for learning.

Findings from this study can inform teachers and educators of the benefits of DGBL as a tool to foster engagement, motivation and the development of 21st century competencies. Students seemed to be motivated and enjoyed learning through this interactive game based medium. In fact learning in this environment was in some ways autonomous due to the simple fact that the motivation element was the online virtual game. The self-directed and interactive learning style propagated in QA puts the reigns to learn in the students' hand where the teacher's role is to facilitate, guide, and help students when required. All in all students were thrilled and found it fun to learn through a game based medium where control to a certain extent is in their hands. The apparent display of 21st century competencies through the game play by students in the QA environment seems to support the observation that QA leads to the development of 21st century skills and makes students more ready for the workplace environment down the years.

This case study expands the current knowledge base on the use of QA with students by providing insights on engagement, motivation, and 21st century competencies. QA appears to promote knowledge building, deep thinking, and situated cognition vital for student engagement. This study generates the potential of encouraging teachers and educators to think about the use of QA as a tool for learning in school especially for the generation Z students born in an environment surrounded by technology and digital games. Still more research is required to explore and develop the use of DGBL to engage students to collaboratively improve their learning in school.

REFERENCES

Aldrich, C. (2004). *Simulations and the future of learning: An innovative (and perhaps revolutionary) approach to e-learning.* San Francisco: Pfeiffer.

Aldrich, C. (2005). *Learning by doing: A comprehensive guide to simulations, computer games, and pedagogy in e-learning and other educational experiences.* San Francisco: Pfeiffer.

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). Bloomington, IN: Indiana University.

Atlantis Remixed. (n.d.). Retrieved from http://atlantisremixed.org/#44

Barab, S. A., Arici, A., & Jackson, C. (2005a). 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://sashabarab.com/research/onlinemanu/papers/eat%20your%20veggies23.pdf

Barab, S. A., Sadler, T., Heiselt, C., Hickey, D., & Zuiker, S. (2007a). Relating Narrative, Inquiry, and Inscriptions: Supporting Consequential Play. *Journal of Science Education & Technology, 16* (1), 59-82. doi: 10.1007/s10956-006-9033-3

Barab, S. A., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005b). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development, 53*(1), 86-107.

Barab, S. A., Warren, S., & Ingram-Goble, A. (2008a). Conceptual play spaces. In R. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education* (pp. 1 - 20). Hershey, PA: IGI Global Publications. Retrieved from http://www.sashabarab.com/research/onlinemanu/papers/acad_play.pdf

Barab, S. A., Dodge, T., & Ingram-Goble, A. (2008b). Reflexive play spaces: A 21st century pedagogy. *Games, learning, and society: Learning and meaning in the digital age. Cambridge, MA: Cambridge University Press. Volume in preparation*.

Barab, S. A., Dodge, T., Thomas, M. K., Jackson, C., & Tuzun, H. (2007b). Our Designs and the Social Agendas They Carry. *Journal of the Learning Sciences, 16*(2), 263-305. doi: 10.1080/10508400701193713

Barab, S. A., Gresalfi, M., & Arici, A. (2009). Why educators should care about games. *Educational Leadership, 67*(1), 76-80.

Barab, S. A., Gresalfi, M., Arici, A., Pettyjohn, P., & Ingram-Goble, A. (2010c). Transformative play: games as 21st century curriculum. In *Proceedings of the 9th International Conference of the Learning Sciences-Volume 2* (pp. 93-100): International Society of the Learning Sciences. Retrieved from http://dl.acm.org.ezproxy.lib.ucalgary.ca/citation.cfm?id=1854548

Barab, S. A., Gresalfi, M., Dodge, T., & Ingram-Goble, A. (2010a). Narratizing disciplines and disciplinizing narratives: Games as 21st century curriculum. *International Journal for Gaming and Computer Mediated Simulations, 2*(1), 17–30. Retrieved from http://sashabarab.com/research/onlinemanu/papers/ijgcmsbarab.pdf

Barab, S. A., Gresalfi, M., & Ingram-Goble, A. (2010b). Transformational Play: Using Games to Position Person, Content, and Context. *Educational Researcher, 39*(7), 525-536. doi: 10.3102/0013189x10386593

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report, 13*(4), 544-559. Retrieved from http://www.nova.edu/ssss/QR/QR513-544/baxter.pdf

Can, G., & Cagiltay, K. (2006). Turkish prospective teachers' perceptions regarding the use of computer games with educational features. *Journal of Educational Technology and Society, 9*(1), 308-321.

CAST. (2011). *Universal design for learning guidelines version 2.0*. Wakefield, MA: Author.

Consortium, T. N. M. (2005). *A global imperative: The report of the 21st century literacy summit*. Retrieved from the New Media Consortium website: http://www.nmc.org/pdf/Global_Imperative.pdf

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

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

De Aguilera, M., & Mendiz, A. (2003). Video games and education:(Education in the Face of a "Parallel School"). *Computers in Entertainment (CIE), 1*(1), 1. doi: 10.1145/950566.950583

Dondlinger, M. J. (2007). Educational video game design: A review of the literature. *Journal of Applied Educational Technology, 4*(1), 21-31. Retrieved from http://www.eduquery.com/jaet/JAET24-21_Dondlinger.pdf

Elizabeth, S. S. (2005). Evolution in the Classroom: What teachers need to know about the video game generation. *TechTrends, 49*(5), 17-22. doi: 10.1007/bf02763685

Entertainment Software Association of Canada. (2012). *Essential Facts 2012*. Retrieved from http://www.theesa.ca/wp-content/uploads/2012/10/ESAC_ESSENTIAL_FACTS_2012_EN.pdf

Fennema, E. (2002). *Gender equity for mathematics and science*. Retrieved from http://www.woodrow.org/teachers/math/gender/02fennema.html

Fiore, C. (1999). Awakening the tech bug in girls. *Learning and Leading with Technology, 26*(5), 10-17.

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry, 12*(2), 219-245. doi: 10.1177/1077800405284363

Friedman, T. L. (2007). *The world is flat: A brief history of the twenty-first century.* New York: Farrar, Straus and Giroux.

Gates Foundation Funds QA. (2010). Retrieved from http://atlantisremixed.org/site/view/Sponsors#22

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

Greene, J. C., Caracelli, V. J., & Graham, W. F. (1989). Toward a conceptual framework for mixed-method evaluation designs. *Educational evaluation and policy analysis, 11*(3), 255-274. doi: 10.3102/0162373701100325

Gresalfi, M., & Barab, S. A. (2011). Learning for a Reason: Supporting Forms of Engagement by Designing Tasks and Orchestrating Environments. *Theory Into Practice, 50*(4), 300-310. doi: 10.1080/00405841.2011.607391

HAWTHORNE EFFECT. (2007). In *Encyclopedia of Special Education: A Reference for the Education of Children, Adolescents, and Adults with Disabilities and Other Exceptional Individuals.* Retrieved from http://www.credoreference.com.ezproxy.lib.ucalgary.ca/entry/wileyse/hawthorne_effect

Jacobsen, M. (2010). Teaching in a Participatory Digital World. *Education Canada, 50*(3), 13-17. Retrieved from http://www.cea-ace.ca/education-canada/article/teaching-participatory-digital-world

Jacobsen, M., & Friesen, S. (2011). Web Exclusive: Hands On vs. Hands Up: Technology-Enabled Knowledge Building in High School. *Canada Education, 51*(2). Retrieved from http://www.cea-ace.ca/education-canada/article/web-exclusive-hands-vs-hands-technology-enabled-knowledge-building-high-sch

Jacobsen, M., Friesen, S., Daniels, J., & Varnhagen, S. (2012). *A Two-Year Case Study of High School Student Engagement and Learning with Technology.* Paper presented at the American Educational Research Association (AERA) 2012 Annual Meeting, Vancouver, B.C., Apr 13 - 17.

Jacobsen, M., Friesen, S., & Saar, C. (2010). *Teaching and learning in a one to one mobile computing environment.* (A research report on the personalized learning initiative At Calgary Science School). Report delivered to the Board of the Calgary Science School, March 2010.

Johnson, L., Adams, S., & Cummins, M. (2012). *The NMC horizon report: 2012 K-12 edition*. Austin, Texas: The New Media Consortium. Retrieved from the New Media Consortium: http://www.nmc.org/pdf/2012-horizon-report-K12.pdf

Johnson, L., Adams, S., Cummins, M., Estrada, V., Freeman, A., & Ludgate, H. (2013). *The NMC Horizon Report: 2013 Higher Education Edition*. Austin, Texas: The New Media Consortium. Retrieved from New Media Consortium website: http://www.nmc.org/pdf/2013-horizon-report-HE.pdf

Johnson, L., Smith, R., Levine, A., & Haywood, K. (2010). *Horizon Report: K12 Edition.* Austin, Texas: The New Media Consortium. Retrieved from New Media Consortium website: http://www.nmc.org/pdf/2010-Horizon-Report-K12.pdf

Johnson, L., Smith, R., Willis, H., Levine, A., & Haywood, K. (2011). *The 2011 Horizon Report.* Austin, Texas: The New Media Consortium. Retrieved from New Media Consortium website: http://www.nmc.org/pdf/2011-Horizon-Report.pdf

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher, 33*(7), 14-26. doi: 10.3102/0013189X033007014

Kafai, Y. B., Franke, M. L., Ching, C. C., & Shih, J. C. (1998). Game Design as an Interactive Learning Environment for Fostering Students' and Teachers' Mathematical Inquiry. *International Journal of Computers for Mathematical Learning, 3*(2), 149-184. doi: 10.1023/a:1009777905226

Kardynal, J. P. (2009). *The Potential of Serious Games for Teaching High School Construction Technologies: A Case Study* (Master's thesis). University of Saskatchewan.

Karimi, A., & Lim, Y. P. (2010). Children, engagement and enjoyment in digital narrative. In C.H. Steel, M.J. Keppell, P.Gerbic & S. Housego (Eds.), *Curriculum, technology & transformation for an unknown future. Proceedings ascilite Sydney 2010* (pp. 475-483).

Kaufman, D., Sauvé, L., & Renaud, L. (2011). Enhancing Learning Through an Online Secondary School Educational Game. *Journal of Educational Computing Research, 44*(4), 409-428. doi: 10.2190/EC.44.4.c

Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay? *Computers & Education, 51*(4), 1609-1620. doi: 10.1016/j.compedu.2008.03.003

Kirriemuir, J., & Mcfarlane, A. (2004). *Literature review in games and learning: A report for NESTA futurelab (Research Report No.8).* Retrieved from http://www.coulthard.com/library/Files/kirriemuir-futurelabs_2004_gamesreview.pdf

Klawe, M. M. (1999). Computer games, education and interfaces: The E-GEMS project. *In Proceedings of the Graphics Interface Conference* (pp. 36-39). Ontario, Canada. Retrieved from http://echo.iat.sfu.ca/library/klawe_01_games_education_interfaces.pdf

Knighton, T., *Council of Ministers of Education, C., Canada, S., Brochu, P., & Gluszynski, T. (2010). Measuring up: Canadian results of the OECD PISA study: the performance of Canada's youth in reading, mathematics and science 2009: first results for Canadians aged 15*. Toronto, ON: CMEC. Retrieved from http://www.cmec.ca/Publications/Lists/Publications/Attachments/254/PISA2009-can-report.pdf

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*: Englewood Cliffs, NJ: Prentice-Hall.

Li, Q. (2010). Digital game building: learning in a participatory culture. *Educational Research, 52*(4), 427-443. doi: 10.1080/00131881.2010.524752

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry* (Vol. 75): SAGE Publications, Incorporated.

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

Ma, X. (1999). Dropping out of advanced mathematics: The effects of parental involvement. *The Teachers College Record, 101*(1), 60-81.

Malone, T. W. (1980, September). What makes things fun to learn? Heuristics for designing instructional computer games. In *Proceedings of the 3rd ACM SIGSMALL symposium and the first SIGPC symposium on Small systems* (pp. 162-169): ACM.

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitude learning and instruction, 3*(3), 223-253.

Mcfarlane, A., Sparrowhawk, A., & Heald, Y. (2002). Report on the educational use of games: An exploration by TEEM of the contribution which games can make to the education process. Cambridge, UK: Futurelab. Retrieved from http://educationarcade.org/files/videos/conf2005/Angela%20MacFarlane-2.pdf

McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world.* New York: Penguin Press.

McLester, S. (1998). Girls and technology: what's the story? *Technology & Learning, 19*(3), 18-26.

Means, B., Toyama, Y., Murphy, R., Bakia, M., & Jones, J. (2009). *Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies*. Washington, D.C: U.S. Dept. of Education, Office of Planning, Evaluation and Policy Development, Policy and Program Studies Service. Retrieved from http://www.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. CA: Jossey-Bass.

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of the literature*. London: Learning and Skills Development Agency. Retrieved from http://dera.ioe.ac.uk/5270/1/041529.pdf

Niederhauser, D. S., & Stoddart, T. (2001). Teachers' instructional perspectives and use of educational software. *Teaching and Teacher Education, 17*(1), 15-31. doi: http://dx.doi.org/10.1016/S0742-051X(00)00036-6

Oblinger, D. G. (2004). The Next Generation of Educational Engagement. *Journal of Interactive Media in Education 2004*(1), 1-18. Retrieved from http://dynamichistory.com/oblinger-2004-8.pdf

OECD. (2002). *Understanding the brain: Towards a new learning science*. Paris: Organisation for Economic Co-operation and Development.

OECD. (2007). *Understanding the brain: The birth of a learning science*: OECD Publishing.

OECD. (2010). *PISA 2009 Results: What Students Know and Can Do Student Performance in Reading, Mathematics and Science (Volume I).* OECD Publishing.

Orkwis, R., & McLane, K. (1998). *A Curriculum Every Student Can Use: Design Principles for Student Access. ERIC/OSEP Topical Brief* (No.ED423654). Reston, VA: U.S. Department of Education, Office of Special Education Projects. Retrieved from http://eric.ed.gov/?q=+A+Curriculum+Every+Student+Can+Use%3a+Design+Principles+for+Student+Access.&id=ED423654

Papastergiou, M. (2009). Digital Game-Based Learning in high school Computer Science education: Impact on educational effectiveness and student motivation. *Computers & Education, 52*(1), 1-12. doi: http://dx.doi.org/10.1016/j.compedu.2008.06.004

PARTNERSHIP FOR 21ST CENTURY SKILLS . (2012). P21 Framework Definitions. Retrieved from http://www.p21.org/storage/documents/P21_Framework_Definitions.pdf

Pastore, R. S., & Falvo, D. A. (2010). Video games in the classroom: Pre-and in-service teachers' perceptions of games in the K-12 classroom. *Instructional Technology and Distance Learning, 7*(12), 49-61.

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health services research, 34*(5 Pt 2), 1189-1208. Retrieved from http://www-ncbi-nlm-nih-gov.ezproxy.lib.ucalgary.ca/pmc/articles/PMC1089059/pdf/hsresearch1000022-1080112.pdf

Plante, J., & Canada, S. (2004). *Connectivity and ICT integration in canadian elementary and secondary schools: First results from the information and communications technologies in schools survey, 2003-2004*. Ottawa, ON: Statistics Canada. Retrieved from http://publications.gc.ca/Collection/Statcan/81-595-MIE/81-595-MIE2004017.pdf

Prensky. (2001b). Digital natives, digital immigrants Part 1. *On the Horizon, 9*(5), 1-6. doi: 10.1108/10748120110424816

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

Prensky, M. (2003). Digital game-based learning. *Computers in Entertainment, 1*(1), 1-4. doi: 10.1145/950566.950596

Prensky, M. (2006). *Don't bother me, mom, I'm learning!: How computer and video games are preparing your kids for 21st century success and how you can help!* St. Paul: Paragon House

Prensky, M. (2010). *Teaching digital natives: Partnering for real learning*. Los Angeles, California: Corwin Press.

Raywid, M. A. (1979). In Praise of the Hawthorne Effect. *Journal of Teacher Education, 30*(3), 64. doi: 10.1177/002248717903000325

Ritzhaupt, A., Higgins, H., & Allred, B. (2010). Teacher experiences on the integration of modern educational games in the middle school mathematics classroom. *Journal of Computers in Mathematics and Science Teaching, 29*(2), 189-216.

Rosas, R., Nussbaum, M., Cumsille, P., Marianov, V., Correa, M., Flores, P., . . . Salinas, M. (2003). Beyond Nintendo: design and assessment of educational video games for first and second grade students. *Computers & Education, 40*(1), 71-94. doi: http://dx.doi.org/10.1016/S0360-1315(02)00099-4

Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field Methods, 15*(1), 85-109. doi: 10.1177/1525822X02239569

Sasha A. Barab. (n.d.). Retrieved from http://lsi.asu.edu/people/sasha-barab-phd

Schank, R. (2011). *Teaching minds: How cognitive science can save our schools*. New York: Teachers College Press.

Simpson, E. S. (2009). Video Games as Learning Environments for Students with Learning Disabilities. *Children, Youth and Environments, 19*(1), 306-319. doi: 10.7721/chilyoutenvi.19.1.0306

Smith, T. K. (2011). *Cultivating 21st century competencies in a virtual worlds learning environment* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses.

Squire, K. (2005). Changing the game: What happens when video games enter the classroom. *Innovate: Journal of Online Education, 1*(6), 25-49. Retrieved from http://www.innovateonline.info/pdf/vol21_issue26/Changing_the_Game-__What_Happens_When_Video_Games_Enter_the_Classroom_.pdf

Tuzun, H. (2004). *Motivating learners in educational computer games* (Doctoral dissertation). Retrieved from ProQuest Dissertations and Theses.

Tüzün, H. (2006). Multiple Motivations Framework. In M. Pivec (Ed.), *Affective and Emotional Aspects of Human-Computer Interaction* (pp. 59-92). Amsterdam: IOS Press. Retrieved from http://bib.convdocs.org/docs/8/7388/conv_1/file1.pdf#page=74

Tüzün, H., Yılmaz-Soylu, M., Karakuş, T., İnal, Y., & Kızılkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education, 52*(1), 68-77. doi: http://dx.doi.org/10.1016/j.compedu.2008.06.008

Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE review, 41*(2), 1-16. Retrieved from http://edergbl.pbworks.com/w/file/fetch/47991237/digital%47991220game%47991220based%47991220learning%47202006.pdf

Virvou, M., Katsionis, G., & Manos, K. (2005). Combining software games with education: Evaluation of its educational effectiveness. *Educational Technology & Society, 8*(2), 54-65. Retrieved from http://ifets.info/journals/8_2/ets_8_2.pdf#page=59

Voogt, & Roblin. (2010). *21st CENTURY SKILLS.* Retrieved from http://www.encorewiki.org/download/attachments/5374189/Voogt+Robin+21CS+2010.pdf

Voogt, J. (2008). IT and Curriculum Processes: Dilemmas and Challenges. In J. Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (Vol. 20, pp. 117-132): Springer US. doi: 10.1007/978-0-387-73315-9_7

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

Weiner, B. (1990). History of motivational research in education. *Journal of educational Psychology, 82*(4), 616-622. doi: 10.1037/0022-0663.82.4.616

Willms, D., Friesen, S., & Milton, P. (2009). *What did you do in school today? Transforming classrooms through social, academic, and intellectual engagement* (First National Report May 2009). Retrieved from Canadian Education Association website: http://www.cea-ace.ca/sites/cea-ace.ca/files/cea-2009-wdydist.pdf

Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5): Sage publications, INC.

APPENDIX A COMPUTER TECHNOLOGY SURVEY

1. Does your family have a computer at home? Yes / No

2. If your family has a computer, how often do you use it?

Never	Once or twice a year	Monthly	Weekly	Almost daily

3. Does your family have internet access at home? Yes / No

4. If your family does have internet access at home, how often do you use it?

Never	Once or twice a year	Monthly	Weekly	Almost daily

5. Do you have access to a computer / a computer lab at school? Yes/ No

6. How do you access computers at school?

Individually	As a whole class	In small groups	In pairs

7. In an average school year, how often do you use computers at school?

Never	Once or twice a year	Monthly	Weekly	Almost daily

8. How often do you decide when you want to use a computer to work on assignments

Never	Once or twice a year	Monthly	Weekly	Almost daily

9. How often do you use a computer to complete the following tasks?

	Never	**Once or twice a year**	**Monthly**	**Weekly**	**Almost Daily**
a) Play Games					
b) Do school work					
c) Word process a document					
d) Create presentations					
e) Create a computer program					
e) Produce multimedia projects					
f) Use the internet					
g) Search for information on the web					

h) Communicate through email					
i) Use tutorials/ drill and practise software					
j) Work with graphics and pictures					

10. Check the statement that most accurately describes "how much help you need" when using software on your computer. Choose "I don't use this" if you do not use that type of software yet.

	I always need help	**I sometimes need help**	**I rarely need help**	**I never need help**	**I can help other people. I am an expert**	**I don't use this**
a) Play video games						
b) Play Games on Social Media Sites like Facebook (i.e. Farmville, Gardens of Time)						
c) Complete school assignments						
d) Research						
e) Use a word processor						
f) Use a spreadsheet						
g) Create presentations						
h) Use the Internet (www)						
i) Edit photos/graphics						
j) Edit/create video						
k) Edit/create audio or music						
l) Design webpages						

11. Choose the response that most accurately describes your level of agreement with the following statements:

	Strongly Agree	Disagree	Neither Agree nor Disagree (Neutral)	Agree	Strongly Agree
a) Computers make schoolwork easier to do					
b) I prefer to use computers to do school work instead of using pencil and paper					
c) Using computers for school can have disadvantages					
d) Computers make schoolwork fun / interesting					
e) Computers help me to improve the quality of my school work					
f) Computers help me understand my classes better.					
g) I need to learn many new skills to use computers for my schoolwork.					
h) I currently try to learn more about computers.					
i) Having a computer in class is an advantage when it comes to learning.					
j) Use tutorials/ drill and practise software					
k) Work with graphics and pictures					

APPENDIX B STUDENT FOCUS GROUP INTERVIEW QUESTIONS

1. How does the Math Unit motivate you? Please cite instances or examples. (prompt: suggest that motivation is about both enjoyment and commitment – a desire to do something.)
2. What do lumins mean to you? Do you care about getting lumins?
3. What do you like about learning the mean, median, mode and range in the Math Unit?
4. What are your top three favorite activities in the Math Unit? (prompt them about avatars, collaboration, chats, telegram, cooperation, interacting with non-playing characters)
5. How did the Math Unit engage you? Please provide examples. (prompt: did the challenge in the game make you concentrate on the tasks, activities, responses)
6. In what ways has the Math Unit changed the way you learn? (prompt: how is it different from the way you normally learn)
7. In what ways is Quest Atlantis different from other things you do on your computer? In the computer lab? In school? At home?
8. In the Math Unit, did the feedback to your responses help you consider relevant information to conclude (come to) a solution? Please cite some examples.
9. How did the non-playing characters help you learn statistics in the Math Unit?
10. Did you find it easy to solve problems related to statistics in the Math unit? How?
11. Did you find it fun collaborating with your friends to find answers to statistics problems? Please provide examples.
12. Did you communicate what you learned in the Math unit with your friends? How?
13. Did the assignments in the Math unit provide you with an opportunity for creative (persuasive) writing in your responses? How? Please provide examples.
14. Did the IBURST rules make you aware of a common online community in the virtual environment? How? (prompt: the fact that these guidelines are common to all communities irrespective of race, country and religion: global awareness: sense of equality)

APPENDIX C 21ST CENTURY COMPETENCIES SURVEY

Statement	Yes	No	Example or Evidence of Claim
Technology Skills 1-4 (What technological skills were displayed / demonstrated by students when they were working in Quest Atlantis?)			
1. I observed my students using computer menus to select working activities.			
2. My students used a directional navigation system for movement in the virtual world.			
3. My students managed a virtual Qpak of items and artifacts collected during missions.			
4. My students used icons, interactions with virtual characters, and active links to process questions and information.			
Critical Thinking 5-10 (What critical thinking skills were displayed / demonstrated by students when they were working in Quest Atlantis?)			
5. I observed my students considering ethical dilemmas.			
6. I observed my students gathering information from interviews and making ethical decisions.			
7. I observed my students dealing with ethical situations concerning the environment.			
8. I observed my students interpreting language or word differences to understand a situation.			
9. My students understand reasons for caution in online environments.			
10. My students understand how to sort information according to validity and truthfulness.			
Problem Solving 11-14 (What problem solving skills were demonstrated / displayed by students when they were working in Quest Atlantis?)			
11. I observed my students practicing			

problem solving techniques.			
12. I observed students using knowledge from Quest Atlantis to solve new problems.			
13. I observed my students openly discussing solutions to problems.			
14. I observed problem solving skills transfer from Quest Atlantis to other uses in the classroom by my students.			
Collaboration 15-20 (What collaboration skills were demonstrated / displayed by students when they were working in Quest Atlantis?)			
15. My students helped each other understand how to complete problems related to statistics in Quest Atlantis.			
16. My students understand that collaborating leads to problem solving.			
17. I observed my students helping each other in the Ander City unit.			
18. My students understand they are accountable for their behavior in Quest Atlantis.			
19. I observed an increase in collaboration skills among my students while working in the Ander City unit.			
20. I observed leadership skills as a result of collaboration among my students.			
Communication 21-25 (What communication skills were demonstrated / displayed by students when they were working in Quest Atlantis?)			
21. I observed my students using the chat feature to ask questions and socialize with other students and teachers in Quest Atlantis.			
22. I observed written responses on a variety of topics such as math, science, character education, art, and ecology among my students.			
23. My students readily shared and taught each other what they learned in Quest Atlantis.			

24. I observed increased effort on reading related to accomplishing goals of the missions among my students.			
25. I observed my students expressing ideas of compassion and understanding in their writing.			
Creativity 26-30 (What creativity skills were demonstrated / displayed by students when they were working in Quest Atlantis?)			
26. I observed artistic expression by my students working in missions.			
27. My students manipulated dimensions and placement of 3D structures.			
28. I observed my students creativity in written responses to missions.			
29. I observed my students' responses to art forms, colors, or concepts.			
30. I observed the creative use or interpretation of language by my students (to learn mathematics).			
Global Awareness 31-35 (What global awareness skills were demonstrated / displayed by students when they were working in Quest Atlantis?)			
31. I observed examples of my students' understanding of another location in the Quest Atlantis world (by interacting with other students).			
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.			
33. I observed my students working on problems that affect other communities.			
34. My students understand that Quest Atlantis has students from all over the world who may or may not speak English.			
35. My students understand how human actions can affect the entire planet.			

Open ended Interview Questions for the teacher.

1. What did you observe or discover about students working in Quest Atlantis that you would like to share with this study?
2. What do you think were the high points of using Quest Atlantis compared to other methods of teaching and learning?
3. Did you find your students engaged in Quest Atlantis? Were they more engaged than in other activities in the classroom environment? Can you cite instances of their engagement in the virtual world?
4. Did you find your students motivated in Quest Atlantis? Were they more motivated than in in other activities in the classroom environment? Can you cite instances of their engagement in the Ander City virtual world?
5. Did you find your students learning 21st century competencies in the Quest Atlantis environment? Could you cite the most prominent instances (instances that stood out)?
6. Were students eager to complete the activities in Quest Atlantis? Can you cite some instances?
7. Did students complete activities due to a sense of competition between them? Did it have to do with being in a virtual world and having the opportunity to personally analyze and find a solution to a problem?
8. Did you find the activities in the Ander City unit to be cognitively challenging for the students? Can you cite some instances?
9. According to your observation of students in the Quest Atlantis virtual world—what are the stand out benefits of learning in this virtual environment?
10. How would you like to tweak Quest Atlantis to make it more effective for future students in terms of engagement, motivation, and learning 21st century competencies?
11. What are the affordances and constraints of using DGBL in your classroom? Please elaborate.
12. How was the experience with Quest Atlantis this time compared to your last implementation with students? What would you attribute the differences to?

APPENDIX D STUDENT ENGAGEMENT SURVEY

Statement	Strongly Agree	Agree	Neither Agree or Disagree	Disagree	Strongly Disagree
1. I was involved in learning in the Ander City Unit.					
2. I was concentrating during the Ander City Unit.					
3. I felt in control while learning in the Ander City Unit.					
4. The Ander City Unit was challenging.					
5. I was skillful when learning in the Ander City Unit.					
6. The Ander City Unit was important to me.					
7. I was succeeding in what I was doing in the Ander City Unit.					
8. I was satisfied with how I was doing in the Ander City Unit.					
9. I felt as if I were inside the gaming environment in the Ander City Unit.					
10. I felt as if the gaming environment was real.					
11. I felt as if the characters in the Ander City Unit were real.					
12. I felt as if I and the characters in the Ander City Unit were together in the same place.					
13. I felt as if I could associate myself with the game characters.					
14. I felt as if I were participating in the Ander City Unit events.					
15. I felt as if the events were really happening in the Ander City Unit.					

APPENDIX E STATISTICS PRE AND POST TESTS

1. What is the definition of the **mean**?

   a. the sum of all values
   b. the average of a set of values
   c. the sum of all values divided by 2
   d. the average of half the numbers in a set

2. What is the definition of the **mode**?

   a. the middle value
   b. the average of all values
   c. the value that occurs most often
   d. the average of the highest and lowest values

3. Calculate the median of the following set of numbers: 80 80 80 0

   a. 80
   b. 0
   c. 40
   d. 60

4. Why can the median be a useful tool when interpreting data?

   a. the median is the true average of all values
   b. the median shows all the data points
   c. the median shows the most important data
   d. the median isn't affected by extreme scores

5. Your class did very poorly on the last science test. Your teacher decided to make a grading scale so that the average student receives a C. She decided to use the mode to determine the grade of C (A is the highest and F is the lowest with C in the middle). You complain that this is unfair because:

   a. using the average grade would allow close to the same number of students to receive an A, B, C, D or F
   b. using the median grade would distribute the grade evenly
   c. using the mean would have half the students higher than a C and half the students lower than a C
   d. using the mode could allow the whole class to get all the answers correct and everyone would receive a C

6. You have been hired to find the longest lasting batteries on the market. You decide to test different brands of batteries by putting them in a flashlight and turning the flashlight on, and then measuring how long it takes before the flashlight runs out of batteries. Each brand gets three trials (you do this test three times for each brand of batteries).

Battery brand	**Trial 1**	**Trial 2**	**Trial 3**	**Mean**	**Median**	**Mode**
Long and steady	10 hrs	11 hrs	18 hrs	13	11	10, 11, 18
Reliables	15 hrs	15 hrs	15 hrs			
Allready	12 hrs	20 hrs	20 hrs			

a. Determine the mean, median, and mode of the battery life for Reliables and Allready. Show or explain your work.

Reliables

Mean:

Median:

Mode:

Allready

Mean:

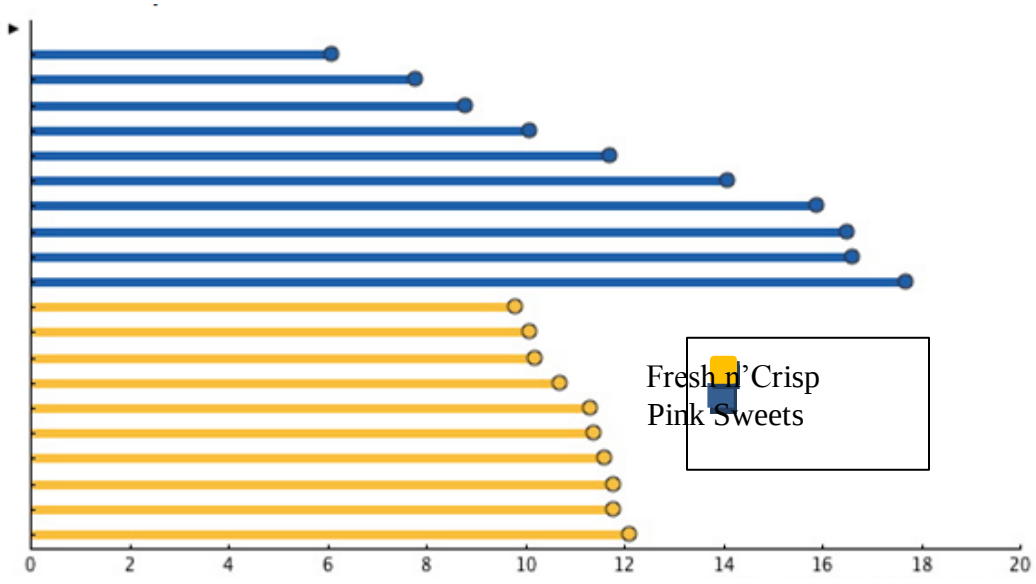
Median:

Mode:

b. Which brand of batteries would you recommend, and why? Please be specific about the evidence you are using to support your opinion.

7. A new restaurant recently opened up that specializes in making all kinds of fresh juices. One of the most popular things on their menu is the watermelon juice. The manager of the

restaurant realized that he should make sure he is getting the best, juiciest watermelons that he can, so he can make the maximum profit. He is considering watermelons from two companies—both of which charge $2.99 per watermelon. Because heavier watermelons produce more juice, the manager decided to compare the weight of the watermelons from the two companies. To do so, the restaurant manager decided to randomly choose ten watermelons from each company and then record the weight of each watermelon. The data is shown below:



Weight of watermelons in pounds

a. According to this graph, which brand of watermelon has the HEAVIEST weight?

b. Which brand of watermelon has the LIGHTEST weight?

c. Would you choose Fresh n'Crisp or Pink Sweets to make the most juice for your money? Please explain why you think so.

1. Calculate the **mean** of the following set of numbers: 8 8 8 0

a. 8
b. 0
c. 4
d. 6

2. What is the definition of the **median**?

   a. the average of all values
   b. the average of the highest and lowest values
   c. the sum of all values divided by 2
   d. the value that divides a set into two equal subsets

3. Calculate the **mode** of the following set of numbers: 80 80 80 0 60 60

   a. 80
   b. 0
   c. 40
   d. 60

4. Why is the mean not always a useful tool in mathematics?

   a. the average of all numbers is not used very often
   b. extreme scores can make the average change a lot
   c. the mean is too hard to calculate
   d. the mean is another word for the average

5. Your class went on a hiking trip in the woods. Mosquitoes bit everyone. The teacher only has a small amount of cream to stop the itching. She decides to use the mode to determine which students get the cream, so the most people with the same number of bites get the cream. You complain that this is unfair because

   a. using the average number would allow close to the same number of students to receive itch cream
   b. using the median number would distribute the itch cream evenly
   c. using the mean would have the most kids be able to get the itch cream
   d. using the mode might mean that people who don't need itch cream as badly to get it

6. Ms. York gave a math quiz to each of her two classes. The quiz scores of each class are shown below.

	Morning Class Quiz Scores	After noon Class Quiz Scores
Quiz Scores	91, 80, 75, 80, 60, 87, 80, 88, 90, 87, 92, 98	80, 87, 90, 70, 93, 80, 85, 90, 95, 80
Mean	84	?
Median	87	?
Mode	80	?

a. Determine the mean, median, and mode of the quiz scores for the afternoon class. Show or explain your work.

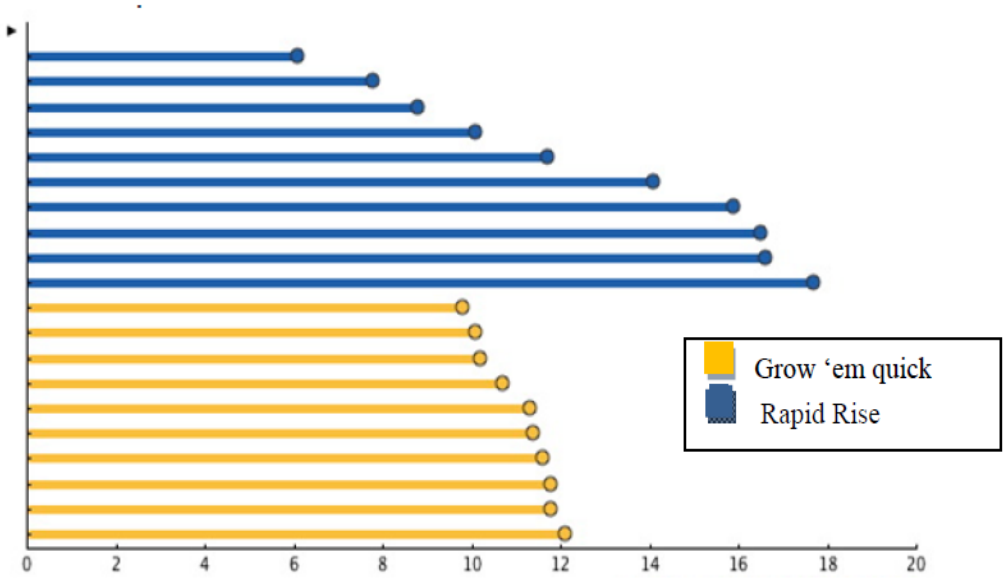
Mean:

Median:

Mode:

b. If you had to randomly choose a person from one class to take a quiz for you (assume you want to do the best possible), would you choose a student from the morning or afternoon class? What would you look at to decide, and why?

7. Normal Village is trying to make sure that they have enough food for people in their community who are homeless. They have decided to start a community garden to grow fresh fruits and vegetables for their homeless shelter, but they're pressed for time— they can't wait forever for plants to produce edibles! They have decided to use fertilizers on their tomato plants to help them to grow faster, and they want to be sure that they choose the one that works the best. They are looking for the fertilizer that will help the plants to produce tomatoes fastest. They have data from the two fertilizer companies from tests they did with earlier tomato plants. The plants were tested in the EXACT SAME WAY—twenty plants were planted (from seeds) in the same sunny patch, and given the same amount of water. Half of the plants were treated with "Grow 'em Quick" fertilizer, and the other half were treated with "Rapid Rise" fertilizer. The results are shown below—every bar represents how long it took (in weeks) for ONE plant to produce tomatoes.



a) According to this graph, which brand of fertilizer took the MOST amount of time to produce tomatoes? Explain.

b) Which brand of fertilizer took the LEAST amount of time to produce tomatoes? Explain.

c) Would you choose Grow 'em Quick or Rapid Rise? Please explain why you think so and how the way you looked at the data supports your ideas

APPENDIX F TEACHER CONSENT FORM (UNIVERSITY OF CALGARY)

UNIVERSITY OF CALGARY

INFORMED CONSENT LETTER FOR TEACHER

Name of Researcher, Faculty, Department, Telephone & Email:

Robert Louis, Master of Arts Student, Graduate Programs in Educational Research,

Phone: 403-719-1762 email: rlouis@ucalgary.ca

Supervisor: Dr. Michele Jacobsen, Associate Professor, Educational Technology

Title of Project:

A Descriptive Case Study of Students Meaningful Learning Experiences in Quest Atlantis

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Dear Teacher,

You are formally invited to participate in a study using a 3D multi-user virtual environment and digital game called Quest Atlantis. Please read this letter for the details of the study and what will be involved.

Purpose of the Study:

The purpose of this study is to investigate whether digital game play results in positive learning benefits, greater motivation, increased engagement and the assimilation of 21st century competencies by students. This study also aims to determine if inquiry-based learning leverages students' natural curiosity to make sense of the virtual world environment by using narratives and storylines as well as display 21st century competencies to accomplish the desired goal. The main use of collected data will be to inform a Master's Degree thesis project.

What Will I Be Asked To Do?

Over 8 - 12 classes you and your students will be will be going through a series of inquiry-based activities in QA that are grounded in real-world issues within an immersive context, requiring the application of principles, methods, and understandings associated with core disciplines. During this time, the researcher will observe student work, observe discussions between the students' and teacher about the activities, and conduct surveys and interviews with the teacher and students'. Interactions between you and your students may be observed during the project and noted in field notes. As well, there will be a pre and post statistics test directly related to curriculum objectives that all students will be invited to complete –

only data from consenting students will be used in the research.

What Type of Personal Information Will Be Collected?

Should you agree to participate, you will be anonymous in the final report. No personal information about you, or that could identify you to others will be reported. Absolute confidentiality cannot be guaranteed due to the nature of recruitment and data collection, and it is probable that your participation in the study will be widely recognized by your students and colleagues.

Other data collected could include:

- One audio taped interview
- One online survey after the learning experience
- Observation data of you and the students working together
- Notes based on classroom discussions between you and the researcher

All identifying information that is associated with anything collected in this project will be removed by the researcher, prior to the data being analyzed. In the study you will only be referred to as “the teacher.”

There are several options for you to consider if you decide to take part in this research. You can choose all, some or none of them. Please put a check mark on the corresponding line(s) that grants the researcher your permission:

I grant permission to be audio taped. Yes: ___ No: ___

I grant permission to complete the online survey. Yes: ___ No: ___

I grant permission to be observed in the classroom while working on this project. Yes:___ No: ___

I grant permission to allow conversations between the researcher and myself to be captured in field notes. Yes: ___ No: ___

Disclosure: Arizona State University Research

Your students and you will be using Quest Atlantis in the classroom. Quest Atlantis is 3D learning and teaching program that uses a 3D multi-user gaming environment to immerse children in educational tasks.

As part of the preparation for this research project, I completed training with the research team at Arizona State University. Dr. Sasha Barab and his research team, collects "in-world" data on all participants in QA, which is all data collected by the educational game. This is a large-scale, multi-university project that you and your students will be a part of. Interview and survey data from my study will NOT be shared with the Arizona State University Research team; however, in-world data will be collected by the Arizona Research Team from students as they play the game. Only me and my supervisor will have access to the classroom data that I will collect, which consists of students' online work submissions, unit progress, game interactions, online survey data, observations, audio recordings, and teacher work and feedback. Finally, chat and telegram content from classes during my research will be made available by Arizona

State University (Quest Atlantis team). I will not have access to the large data sets that are gathered by the Arizona State University Research team that comprises of all game data. All students will be required to complete a consent form that informs them that online data will be collected by the Arizona State University Research team, and gain access to Quest Atlantis and participate in the learning activities.

Also note the following points:

1. The Arizona State University (ASU) Team will have access to the signed letters of consent for the ASU project,
2. Personal data will be stored on a server in the United States and subject to their laws.
3. While there is no intent in the ASU research protocol to link anonymous online data with the identities of students from the consent forms, absolute confidentiality cannot be guaranteed, and personal information may be disclosed if required by the laws of the United States.

Are there Risks or Benefits if I Participate?

There are no teaching, learning or social risks anticipated during this project.

You will gain knowledge and experience with an innovative, online 3D multi-user virtual world that has been studied and has been found to result in valued learning outcomes for students with the support of the researcher.

What Happens to the Information I Provide?

Participation is completely voluntary. Every attempt will be made to ensure your anonymity in the final document however, absolute confidentiality cannot be guaranteed due to the nature of recruitment and data collection, and it is probable that your participation in the study will be widely recognized by your students and colleagues.

If you request to withdraw from the study, the researcher commits to completing the classroom project (at your discretion) and you will be thanked and debriefed. Data collected up to the point of withdrawal will be used in the analysis.

Interview, Classroom Observations

- The survey data will be collected electronically and temporally stored on a private server in Canada. The company hosting the survey complies with Canadian and Alberta privacy standards. Once the survey is completed, the data will be removed from the server and stored electronically. The survey is anonymous.
- Both physical and electronic means will be used to securely store records and data that result from this study. Only the researcher and his supervisor will have access to physical and electronic records that may contain confidential information.
- All electronic raw data will be kept on the researcher's computer in a password protected directory and backed up onto a password secured USB key. All text based raw data will be kept in a locked filing cabinet in Robert Louis' home. The data will be kept indefinitely.
- All physical transcripts and artifacts will be kept in a locked filing cabinet in the researcher's home office.
- The written key connecting the groups with the names of the individual students will be kept in a separate secured location at the University of Calgary. This written key will be destroyed in June

2013.

- Only the researcher and his supervisor will have access to this data.

You and the school administration will be given a summary of the research, in the form of the defended thesis, when it is completed.

Signatures (written consent)

Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate as a research subject.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) _____

Participant's Signature _____ Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____ Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Robert Louis

Master of Arts student, Faculty of Education

403.719.1762

rlouis@ucalgary.ca

and

Dr. Michele Jacobsen

403.220.4123

dmjacobs@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact the Senior Ethics Resource Officer, Research Services Office, University of Calgary at (403) 220-3782; email rburrows@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

APPENDIX G STUDENT AND PARENT CONSENT FORM (UNIVERSITY OF CALGARY)

INFORMED CONSENT LETTER FOR PARENTS

Name of Researcher, Faculty, Department, Telephone & Email:

Robert Louis, Master of Arts Student, Graduate Programs in Educational Research.

Phone: 403-719-1762 email: rlouis@ucalgary.ca

Supervisor: Dr. Michele Jacobsen, Associate Professor, Educational Technology

Title of Project:

A Descriptive Case Study of Students Meaningful Learning Experiences in Quest Atlantis

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

Dear Parents,

Your child is invited to participate in a study using a 3D multi-user virtual environment and digital game called Quest Atlantis. Please read this letter for the details of the study and what will be involved.

Purpose of the Study:

The purpose of this study is to investigate whether digital game play results in positive learning benefits, greater motivation, increased engagement and the assimilation of 21st century competencies by students. This study also aims to determine if inquiry-based learning leverages students' natural curiosity to make sense of the virtual world environment by using narratives and story lines as well as display 21st century competencies to accomplish the desired goal. The main use of collected data will be to inform a Master's Degree thesis project.

What Will I Be Asked To Do?

Over 8 - 12 classes your child will be will be going through a series of inquiry-based activities in QA that are grounded in real-world issues within an immersive context, requiring the application of principles, methods, and understandings associated with core disciplines. During this time, the researcher will

observe student work, observe discussions between the students' and teacher about the activities, and conduct surveys and interviews with the teacher and students'. Interactions between the classroom teacher and the students may be observed during the project and noted in field notes. As well, there will be a pre and post statistics test directly related to curriculum objectives that all students will be invited to complete – only data from consenting students will be used in the research.

What Type of Personal Information Will Be Collected?

Two levels of consent and permission are being sought for this study.

1. Arizona State University Research on Quest Atlantis

Your child will be using Quest Atlantis in the classroom. Quest Atlantis is 3D learning and teaching program that uses a 3D multi-user gaming environment to immerse children in educational tasks.

As part of the preparation for this research project, I completed training with the research team at Arizona State University. Dr. Sasha Barab and his research team, collects "in-world" data on all participants in QA, which is all data collected by the educational game. This is a large-scale, multi-university project that you and your students will be a part of. Interview and survey data from my study will NOT be shared with the Arizona State University Research team; however, in-world data will be collected by the Arizona Research Team from students as they play the game. Only me and my supervisor will have access to the classroom data that I will collect, which consists of students' online work submissions, unit progress, game interactions, online survey data, observations, audio recordings, and teacher work and feedback. Finally, chat and telegram content from classes during my research will be made available by Arizona State University (Quest Atlantis team). I will not have access to the large data sets that are gathered by the Arizona State University Research team that comprises of all game data. All students will be required to complete a consent form that informs them that online data will be collected by the Arizona State University Research team, and gain access to Quest Atlantis and participate in the learning activities.

If you agree to participate, your child will be one of up to 150,000 participants worldwide who will be involved in this research.

You can learn more about Quest Atlantis project by visiting:
http://questatlantis.org

For questions about the Arizona State University Research or a research-related injury, contact the researcher Dr. Sasha Barab at 480 727 5674

Use of the Quest Atlantis application requires interaction with American-based online software platforms. As such, collected data is subject to U.S. Laws, including the USA Patriot Act. The risks associated with participation are minimal, however, and similar to those associated with many e-mail programs such as Hotmail(c) and social utilities spaces, such as Facebook(c) and MySpace(c).

2. University of Calgary Master's Thesis Research

Should you agree to allow your child to participate in my masters research, your child will be asked to provide his/her gender and age. Other data collected could include:

- An audio taped focus group interview with other students
- Online surveys asking questions about use of technology for learning, school work and home activities
- A copy of the student's statistics test before and after the project.
- The researcher's notes and observations from the classroom, made during the project.

All identifying information that is associated with anything collected in this project will be removed by the researcher, prior to the data being analyzed.

There are several options for you to consider if you decide to allow your child to take part in this research. You can choose all, some or none of them. Please put a check mark on the corresponding line(s) that grants the researcher your permission:

I grant permission for my child to be audio taped during a focus group interview: Yes: ___ No: ___

I grant permission for the researcher to collect my child's statistics pre and post-test from this project. Yes: ___ No: ___

I grant permission for my child to be observed in the classroom while working on this project. Yes: ___ No: ___

I grant permission for analyzing and using my child's data after participating in the pre/post surveys about using technology and learning. Yes: ___ No: ___

Are there Risks or Benefits if I Participate?

The students, with the mentorship of an experienced technology educator and their classroom teacher, will learn how to use an online, 3D multi-user virtual environment and digital game called Quest Atlantis, and they may continue to use the virtual world and their newly developed expertise to explore both personal and academic projects in the future.

There are no learning or social risks anticipated during this project.

What Happens to the Information I Provide?

Participation is completely voluntary and confidential. An alternate provision will be provided to students who do not participate in the research in the classroom and no research data will be collected by the researcher from this child. Note, by virtue of participation in Quest Atlantis, the Arizona State University Research team intends to collect online data from all participants that comprises of all game data. Parents or students are free to discontinue participation at any time during the study by informing / contacting the researcher, Robert Louis. If there is a request to withdraw from the study, the students will be thanked and debriefed. Data collected from these participants, up to the point of withdrawal will be used in the analysis.

During the interview process, students will be in a focus group, so anonymity cannot be guaranteed. However, each team of students will be asked to keep comments shared during interviews confidential.

Interview, Classroom Observations and Survey Data

- The survey data will be collected electronically and temporally stored on a private server in Canada.

The company hosting the survey complies with Canadian and Alberta privacy standards. Once the survey is completed, the data will be removed from the server and stored electronically. The survey is anonymous.

- Both physical and electronic means will be used to securely store records and data that result from this study. Only the researcher and his supervisor will have access to physical and electronic records that may contain confidential information.
- All electronic raw data will be kept on the researcher's computer in a password protected directory and backed up onto a password secured USB key. All text based raw data will be kept in a locked filing cabinet in Robert Louis' home. The data will be kept indefinitely.
- All physical transcripts and artifacts will be kept in a locked filing cabinet in the researcher's home office.
- The written key connecting the groups with the names of the individual students will be kept in a separate secured location at the University of Calgary. This written key will be destroyed in June 2013.
- Only the researcher and his supervisor will have access to the data generated outside of the game at the school.

Student Program Files and Reflections

- The researcher will keep a copy of these digital artifacts in the same manner than is described for interview and survey data. Student names will be removed from the artifacts prior to them being used for analysis. Only the researcher and his supervisor will have access to this data.
- The students will keep a copy of their programs and their reflections, and the teacher may choose to use these for student evaluation. Ownership of any collected student work or artifacts resides with the student and the school and that the researcher is enjoying limited use of these materials for the purposes of research only.

In the final thesis, participant anonymity will be ensured via the reporting of only aggregated results and by using only generic identifiers such as 'student #' to describe the students in this project. The teacher and the school administration will be given a summary of the research, in the form of the defended thesis, when it is completed. Captain Nichola Goddard School will be named in this document, but not the classroom number or the teacher's name.

Also note the following points:

1. The Arizona State University (ASU) Team will have access to the signed letters of consent for the ASU project,
2. Personal data will be stored on a server in the United States and subject to their laws.
3. While there is no intent in the ASU research protocol to link anonymous online data with the identities of students from the consent forms, absolute confidentiality cannot be guaranteed, and personal information may be disclosed if required by the laws of the United States.

Signatures (written consent)

Your signature on this form indicates that you 1) understand to your satisfaction the information provided to you about your participation in this research project, and 2) agree to participate as a research subject.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Student's Name: (please print) _____

Parent/Guardian Name: (please print) _____

Parent's Signature _____ Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Robert Louis

Master of Arts student, Faculty of Education

403.719.1762

rlouis@ucalgary.ca

and

Dr. Michele Jacobsen

403.220.4123

dmjacobs@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact the Senior Ethics Resource Officer, Research Services Office, University of Calgary at (403) 220-3782; email rburrows@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

APPENDIX H STUDENT AND PARENT CONSENT FORM

(ADAPTED FROM QA RESOURCES)

ASU Learning Sciences Institute
Arizona State University

Dear parents and guardians,

We are pleased to invite your child to participate in the Atlantis Remixed Project. The Atlantis Remixed Project is an innovative computer program sponsored by Arizona State University and approved for use in your child's school. The Atlantis Remixed Project strives to use technology to involve children in meaningful learning experiences—experiences where they might solve educational computer game challenges, called Quests. Completing Quests requires that your child participate in real-world, socially and academically meaningful activities, such as conducting environmental studies, researching other cultures, calculating frequency distributions, analyzing newspaper articles, interviewing community members, and developing action plans. Our hope is that through these experiences children will not only learn to use technology, but develop academic and important 21st century literacy and communication skills as well.

In the Atlantis Remixed Project program, your child will not only be using commercially available educational software packages, but he or she will also build web pages that will be placed online. As a result, your child will spend time online (using the internet) participating in the Atlantis Remixed Project. All teachers using the Atlantis Remixed Project are provided with guidelines and structures that will help them promote online safety for your child. Additionally, our virtual environment is password protected and monitored to ensure that it is safe and secure.

As a part of our project development, we may observe your child interacting at the school and in the Atlantis Remixed Project space. If we observe your child's class, a member of our team will be taking notes on how children use the technology, and possibly interviewing them about their experiences in the program. Some of these observations and interviews may be videotaped so that we can better understand and improve the program. However, participating in the Atlantis remixed project is completely voluntary. Your child does not have to participate in the Atlantis Remixed Project, he or she is free to withdraw from the program at any time without penalty. However, we hope that you will choose to participate in this most exciting project.

We are looking forward to working with you and your child through the Atlantis Remixed Project program. We are confident that participating in the Atlantis Remixed Project will provide your child with valuable experience using technology to participate in meaningful learning activities. At the same time, your child's participation will help us understand how children learn with technology and how to design meaningful and engaging learning experiences.

Please read and sign the enclosed consent form. This signed form must be returned in order for your child to participate. If you have any questions about any aspects of this program, please don't hesitate to call me, Dr. Sasha Barab, the project director, at (480) 727-5674.

Sincerely,

Sasha A. Barab, Professor
Pinnacle West Chair of Education & Senior Scientist of Learning Sciences
Arizona State University
108D Payne Hall ph: (480) 727-567
1000 S. Forest Mall, fax: (480) 965-3237
Tempe, AZ 85287 mail: sasbarab@gmail.com
homepage: http://lacunagames.org/barab

ARIZONA STATE UNIVERSITY
INFORMED CONSENT STATEMENT

Atlantis Remixed
Your child is invited to participate in a research study of learning and teaching project that uses an online, computer-based environment to engage children in educational tasks. Your child was selected as a possible participant because your child's teacher or a member of your school or center's administration requested to use the program. We ask that you read this form and ask any questions you may have before agreeing to be in the study.
Dr. Sasha Barab, a professor of Education at Arizona State University, is conducting the study. This work has been funded by the John D. and Catherine T. MacArthur Foundation, the Bill and Melinda Gates Foundation, the National Science Foundation, NASA, the National Parks Service and other sponsors.

Study Purpose:
The purpose of this study is to learn about the program's effectiveness for supporting academic learning and understanding how engaging children in a narratively-rich game-based environment can affect a child's enjoyment of and participation in the learning process.

Number of People Taking Part in the Study:
If you agree to participate, your child will be one of up to 150,000 participants worldwide who will be involved in this research.

Procedures for the Study:
If you agree to be in the study, your child will be using the Atlantis Remixed Project program. The Atlantis Remixed Project strives to use technology to involve children in meaningful learning experiences – experiences where they solve educational challenges called Quests. Completing Quests requires that your child participate in real-world, socially and academically meaningful activities, such as conducting environmental studies, researching other cultures, calculating frequency distributions, analyzing newspaper articles, interviewing community members, and developing action plans. Our experience is that through these activities, children will not only learn to use technology, but will also develop academic and 21st century new media literacy and communication skills as well.

As a part of our project development, we will be observing children interacting at their school or in an after-school program and in the online Atlantis Remixed Project space. All interactions in the online space are recorded by the computer and saved as part of our database. Our team may also be taking notes on how children use the technology, and possibly interviewing students or teachers about their experiences in the program. Interviews will last from 15 to 30 minutes. Information from these observations and interviews, as well as the computerized records of their participation in the online space will be entered into a password- protected database. Observations and interviews may be audio or video taped so that researchers can analyze data more closely. We also may make copies of materials that your child produces in the Atlantis Remixed Project space.

Your child is free to participate in this study as much or as little as he or she chooses. He or she may withdraw at any time without any penalty. Typically, your child might spend 40 minutes a session interacting with the program, with the number of sessions being determined by your child's teacher or staff member. Your child may participate in this study for one year or for several years, depending on your willingness to participate. Participation in this program is strictly voluntary. If you or your child chooses not to participate or to withdraw from this study, he or she will not be audio or video taped, and his/her data will not be analyzed.

Risks of Taking Part in the Study:
Although we do not anticipate any risks associated with your child taking part of the study, it is possible that, because of the interactive nature of the game which allows students to chat with other children also using the program, children may witness or be the recipient of teasing, mean-spirited exchanges or inappropriate language. In addition, despite our best efforts, there is a risk of losing confidentiality.
To reduce these risks, we take a variety of precautions to prevent the loss of confidentiality. All records are kept either in a password-protected database or in locked drawers (see the Confidentiality section below for more details). Further, we hold students to a strict code of conduct which instructs students not to share personal information.

All interactions in the game are captured and diligently monitored by our staff to document and act upon any potentially problematic situations. Children and teachers can also easily report any problems they encounter within the game. A team member will share problematic exchanges with a child's teacher, and children who repeatedly violate our code of conduct can and will be denied access to the game.

Benefits of Taking Part in the Study:
The benefits to participation that are reasonable to expect are:

- Children will have an opportunity to learn disciplinary content in an engaging and personally meaningful context;
- Children may learn 21st century new media literacy skills as they interact with children from around the globe;
- Children will have the opportunity to interact with others worldwide in a protected virtual environment;
- Children may come to appreciate the value of school and education for solving real-world problems;

- Children will gain experiences applying content and skills associated with multiple disciplines;
- children may develop a new sense of purpose as individuals, as members of their community, and as knowledgeable citizens of the world; and/or
- Children will come to see themselves as having important ideas to contribute to the well-being of the world.

Alternatives to Taking Part in the Study:
If your child chooses not to be a part of the study, his or her classroom teacher can accommodate their learning in a variety of ways. Teachers and staff members around the globe can create different kinds of experiences to serve as alternatives to participation in this project. Each of these is determined at the local level and therefore, up to staff and teachers in the setting in which your child participates. Additionally, parents may request a modified form of consent from teachers which allows children to participate fully but not have audio or videotaped data collected about their participation.

Confidentiality:
Protecting your child's confidentiality is extremely important to us. The online space is password protected so that only registered users with a password are in the online space. Every effort will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published. In any reports of this research, there will be no mention of your child by name or the name of his or her school or after-school program. All computerized records of their work, emails, or chat will be sanitized so that in the reporting of the data your child will not be identifiable. Confidentiality will be maintained in all reports of this study. Further, all data will be kept in a locked place. All identifying marks will be removed from the data and pseudonyms will be used in any and all reporting of the data. Any tapes or materials will be destroyed at the end of the project, or within three years, whichever comes first.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the ASU Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections.

Costs:
Taking part in this study should not lead to added costs to you. Some participants have computers at home or use library computers for additional access, but this is not a required element of the program. Occasionally, additional project associated resources might be made available for download or purchase by your child's school, but this is strictly voluntary and not a required element of participation.

Payment:
Neither you nor your child will receive payment for taking part in this study.

Contacts for Questions or Problems:
For questions about the study or a research-related injury, contact the researcher Dr. Sasha Barab at 480-727-5674.

If you have any questions about your rights as a subject/ participant in this research or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU office of Research Integrity and Assurance at (480) 965-6788.

Voluntary Nature of Study:
Taking part in this study is voluntary. Your child may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with the investigator(s).

Participant's Consent:
In consideration of all of the above, I give my consent for my child to participate in this research study.
I may request a copy of this informed consent document to keep for my records. I agree to take part in this study.

Printed Name of Parent: _____
Signature of
Parent:_____Date:_____

Printed Name of Child: _____
Signature of
Child:_____Date:_____

Printed Name of Person Obtaining
Consent:_____
Signature of Person Obtaining Consent:_____Date: _____

School/Office Use Only:
Name of Current Teacher: _____
School: _____ State/Country: _____

School/Office Use Only
Name of Current Teacher: _____
School: _____ State/Country: _____

APPENDIX I TEACHER CONSENT FORM (ADAPTED FROM QA RESOURCES)

ARIZONA STATE UNIVERSITY
INFORMED CONSENT STATEMENT

Atlantis Remixed
You are invited to participate in a research study of learning and teaching project that uses an online, computer-based environment to engage children in educational tasks. You were selected as a possible subject because you have requested use of the program or a member of your school or center's administration suggested that you use the program. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by Dr. Sasha Barab, a professor of Education at Arizona State University. This work has been funded by the John D. and Catherine T. MacArthur Foundation, the Bill and Melinda Gates Foundation, the National Science Foundation, NASA, the National Parks Service and other sponsors.

Study Purpose:
The purpose of this study is to learn about the program's effectiveness for supporting academic learning and understanding how engaging children and adults in a narratively-rich game-based environment can affect their enjoyment of and participation in the learning process.

Number of People Taking Part in the Study:
If you agree to participate, you will be one of up to 150,000 participants worldwide who will be involved in this research.

Procedures for the Study:
If you agree to be in the study, you will be trained to use the Atlantis Remixed Project program. Atlantis Remixed project strives to use technology to involve children and adults in meaningful learning experiences – experiences where they solve educational challenges called Quests. Completing Quests requires that you and your students participate in real-world, socially and academically meaningful activities, such as conducting environmental studies, researching other cultures, calculating frequency distributions, analyzing newspaper articles, interviewing community members, and developing action plans. Our experience is that through these activities, children will not only learn to use technology, but will also develop academic and 21st century new media literacy and communication skills as well.

As a part of our project development, we will be observing children interacting at their school or in an after-school program and in the online Atlantis Remixed Project space. All interactions in the online space are recorded by the computer and saved as part of our database. Our team may also be taking notes on how children use the technology, and possibly interviewing students or teachers about their experiences in the program. Interviews will last from 15 to 30 minutes. Information from these observations and interviews, as well as the computerized records of their participation in the online space will be entered into a password- protected database. Observations and interviews may be audio or video taped so that researchers can analyze data

more closely. We also may make copies of materials that you or your students produce in the Atlantis Remixed Project space.

You are free to participate in this study as much or as little as you choose. You may withdraw at any time without any penalty. Typically, you might spend 40 minutes a session interacting with the program, with the number of sessions being determined by you, the teacher or staff member. You may participate in this study for one year or for several years, depending on your willingness to participate. If you choose to participate, we will need your consent for observing and videotaping your activities. Participation in this program is strictly voluntary. If you choose not to participate or withdraw from this study, you will not be audio or video taped, and your data will not be analyzed.

Risks of Taking Part in the Study:
Although we do not anticipate any risks associated with your participation in the study, it is possible that, despite our best efforts, confidentiality might be lost. In addition, some of your students may be exposed to inappropriate language which may result in additional intervention time with parents or students. In addition, there may be other side effects we cannot predict.

To reduce these risks, we take a variety of precautions to prevent the loss of confidentiality. All records are kept either in a password-protected database or in locked drawers. (see the Confidentiality section below for more details).

All interactions in the game are captured and diligently monitored by our staff to document and act upon any potentially problematic situations. Children and teachers can also easily report any problems they encounter within the game. Students are also provided with a series of guidelines about appropriate behavior in the game which may reduce the number of inappropriate exchanges you might need to mediate.

Benefits of Taking Part in the Study:
We expect you will benefit by participating in this study by being given an innovative curriculum which couples disciplinary learning with real-world applications, thus creating a project-based learning context for you and your students to explore. Both your use of this curriculum, and the support we provide to you and your students while using it, are subsidized by grant funding. In addition, you will be invited to join a community of teachers who are using Atlantis Remixed Project in their own classrooms, thus creating a novel source of professional development and support, should you choose to use it.

Alternatives to Taking Part in the Study:
You have the option to evaluate the program and determine if you wish to participate. You are not obligated to participate in Atlantis Remixed and you can withdraw your participation at any time. Interested students or parents may request a separate version of the consent form which does not allow audio or video taping but does allow us to analyze data gained through the study. If you have students with this modified consent in your classroom, we will not be audio or video taping those students during any research implementation.

Confidentiality:
Protecting your confidentiality is extremely important to us. The online space is password protected so that only registered users with a password are in the online space. Every effort will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published. In any reports of this research, there will be no mention of your name or the name the school or after-school program. All computerized records of their work, emails, or chat will be sanitized so that in the reporting of the data you will not be identifiable. Confidentiality will be maintained in all reports of this study. Further, all data will be kept in a locked place. All identifying marks will be removed from the data and pseudonyms will be used in any and all reporting of the data. Any tapes or materials will be destroyed at the end of the project, or within three years, whichever comes first.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the ASU Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections.

Costs:
Taking part in this study should not lead to added costs to you. Some participants have computers at home or use library computers for additional access, but this is not a required element of the program. Occasionally, additional project associated resources might be made available for download or purchase but this is strictly voluntary and is not a required element of participation.

Payment:
You will not receive payment for taking part in this study. We reserve the right to award an honorarium if participation exceeds our expectations.

Contacts for Questions or Problems:
For questions about the study or a research-related injury, contact the researcher Dr. Sasha Barab at 480-727-5674.

If you have any questions about your rights as a subject/ participant in this research or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU office of Research Integrity and Assurance at (480) 965-6788.

Voluntary Nature of Study:
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with the investigator(s).

Participant's Consent:
In consideration of all of the above, I give my consent to participate in this research study.

Printed Name of Participant: _____
Signature of
Participant:_____Date:_____

Printed Name of Person Obtaining
Consent:_____
Signature of Person Obtaining
Consent:_____Date:_____

APPENDIX J PRINCIPAL CONSENT FORM (ADAPTED FROM QA RESOURCES)

ARIZONA STATE UNIVERSITY
INFORMED CONSENT STATEMENT

Atlantis Remixed
Your teachers and students are invited to participate in a research study of learning and teaching project that uses an online, computer-based environment to engage children in educational tasks. Your teachers were selected as a possible subject because you have requested use of the program or a member of your school or center's administration suggested that you use the program. We ask that you read this form and ask any questions you may have before agreeing to allow your teachers and students to be in the study.

Dr. Sasha Barab, a professor of Education at Arizona State University is conducting this study. This work has been funded by the John D. and Catherine T. MacArthur Foundation, the Bill and Melinda Gates Foundation, the National Science Foundation, NASA, the National Parks Service and other sponsors.

Study Purpose:
The purpose of this study is to learn about the program's effectiveness for supporting academic learning and understanding how engaging children in a narratively-rich game-based environment can affect a child's enjoyment of and participation in the learning process.

Number of People Taking Part in the Study:
If you agree to allow your teachers and students to participate, you will be one of up to 150,000 participants worldwide who will be involved in this research.

Procedures for the Study:
If you agree to allow your teachers and students to be in the study, you will be trained to use the Atlantis Remixed Project program. The Atlantis Remixed Project strives to use technology to involve children in meaningful learning experiences – experiences where they solve educational challenges called Quests. Completing Quests requires that you and your students participate in real-world, socially and academically meaningful activities, such as conducting environmental studies, researching other cultures, calculating frequency distributions, analyzing newspaper articles, interviewing community members, and developing action plans. Our experience is that through these activities, children will not only learn to use technology, but will also develop academic and 21st century new media literacy and communication skills as well.

As a part of our project development, we will be observing children interacting at their school or in an after-school program and in the online Atlantis Remixed Project space. All interactions in the online space are recorded by the computer and saved as part of our database. Our team may also be taking notes on how children and adults use the technology, and possibly interviewing students or teachers about their experiences in the program. Interviews will last from 15 to 30 minutes. Information from these observations and interviews, as well as the computerized records of their participation in the online space will be entered into a password- protected

database. Observations and interviews may be audio or video taped so that researchers can analyze data more closely. We also may make copies of materials that your teachers or students produce in the Atlantis Remixed Project space.

You, your teachers and students are free to participate in this study as much or as little as you choose. You may withdraw this consent at any time without any penalty. Typically, your students might spend 40 minutes a session interacting with the program, with the number of sessions being determined by you, the teacher or staff member. Your school may participate in this study for one year or for several years, depending on your willingness to participate. If you choose to allow your teachers to participate, we will need your consent for observing and videotaping their activities. Participation in this program is strictly voluntary. If you choose not to participate or to withdraw from this study, your teachers and students will not be audio or video taped, and your data will not be analyzed.

Risks of Taking Part in the Study:
Although we do not anticipate any risks associated with your participation in the study, it is possible that, despite our best efforts, confidentiality might be lost. In addition, since children may chat with other students using the program, some of your students may be exposed to inappropriate language which may result in additional intervention time with parents or students. In addition, there may be other side effects we cannot predict.

To reduce these risks, we take a variety of precautions to prevent the loss of confidentiality. All records are kept either in a password-protected database or in locked drawers. (see the Confidentiality section below for more details).

All interactions in the game are captured and diligently monitored by our staff to document and act upon any potentially problematic situations. Children and teachers can also easily report any problems they encounter easily within the game. Students are also provided with a series of guidelines about appropriate behaviour in the game which may reduce the number of inappropriate exchanges teachers might need to mediate.

Benefits of Taking Part in the Study:
We expect that your teachers will benefit by participating in this study by being given an innovative curriculum which couples disciplinary learning with real-world applications, thus creating a project-based learning context for your teachers and students to explore. Both your use of this curriculum, and the support we provide to your teachers and students while using it, are subsidized by grant funding. In addition, educators will be invited to join a community of teachers who are using Atlantis Remixed Project in their own classrooms, thus creating a novel source of professional development and support, should they choose to use it.

Alternatives to Taking Part in the Study:
You have the option to evaluate the program and determine if you wish to participate. You are not obligated to participate in Atlantis Remixed and you can withdraw your participation at any time. Interested teachers, students or parents may request a separate version of the consent form which does not allow audio or video taping but does allow us to analyze data gained through the

study. If your teachers have students with this modified consent in your classroom, we will not be audio or video taping those students during any research implementation.

Confidentiality:
Protecting your confidentiality is extremely important to us. The online space is password protected so that only registered users with a password are in the online space. Every effort will be made to keep your personal information confidential. We cannot guarantee absolute confidentiality. Your personal information may be disclosed if required by law. Your identity will be held in confidence in reports in which the study may be published. In any reports of this research, there will be no mention of your name or the name the school or after-school program. All computerized records of your work, emails, or chat will be sanitized so that in the reporting of the data you will not be identifiable. Confidentiality will be maintained in all reports of this study. Further, all data will be kept in a locked place. All identifying marks will be removed from the data and pseudonyms will be used in any and all reporting of the data. Any tapes or materials will be destroyed at the end of the project, or within three years, whichever comes first.

Organizations that may inspect and/or copy your research records for quality assurance and data analysis include groups such as the study investigator and his/her research associates, the ASU Institutional Review Board or its designees, and (as allowed by law) state or federal agencies, specifically the Office for Human Research Protections.

Costs:
Taking part in this study should not lead to added costs to you. Some participants have computers at home or use library computers for additional access, but this is not a required element of the program. Occasionally, additional project associated resources might be made available for download or purchase but this is strictly voluntary and not a required element of participation.

Payment:
Neither you nor your teachers will receive payment for taking part in this study. We reserve the right to award an honorarium if participation exceeds our expectations.

Contacts for Questions or Problems:
For questions about the study or a research-related injury, contact the researcher Dr. Sasha Barab at 480-727-5674.

If you have any questions about your rights as a subject/ participant in this research or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU office of Research Integrity and Assurance at (480) 965-6788.

Voluntary Nature of Study:
Taking part in this study is voluntary. You may choose not to take part or may leave the study at any time. Leaving the study will not result in any penalty or loss of benefits to which you are entitled. Your decision whether or not to participate in this study will not affect your current or future relations with the investigator(s).

Participant's Consent:
In consideration of all of the above, I give my consent to teachers and their students at my school to participate in this research study.

Printed Name of Participant: _____
Signature of
Participant:_____Date:_____

Name of School: _____
City/State: _____ Country: _____

Printed Name of Person Obtaining
Consent:_____
Signature of Person Obtaining Consent:_____Date: _____

APPENDIX K STUDENT ASSENT FORM

Over the next few weeks I will be conducting a study to determine whether digital game play results in positive learning benefits, greater motivation, increased engagement and helps in the assimilation of 21st century competencies by you. As a university student, I am interested to study whether inquiry-based learning leverages your natural curiosity to make sense of a virtual world environment. This virtual world environment also uses narratives, storylines, and brings out 21st century skills necessary to accomplish the desired goal.

Below is a list of the different kinds of information I would like to collect. For each one, please choose yes or no with a check mark beside your choice. You may choose to allow me to collect all or none of these types of information:

1) You grant permission to be audio taped during a focus group interview
   YES _____ NO____
2) You grant permission to collect your writing material when performing different activities in this project.

   YES _____ NO____
3) You grant permission to be observed in the classroom while working on this project.
   YES _____ NO____
4) You grant permission for analyzing and using data after participating in the pre/post surveys about using technology and learning.

YES _____ NO_____

If you allow me to collect this information, I will not mention your name when I write my report about this project. Your participation is voluntary. You may refuse to participate altogether, may refuse to participate in parts of the study, or may withdraw from the study at any time without penalty or lose. If you decide to withdraw prior to the project natural conclusion, the data collected to the point of withdrawal will be retained and used. If you choose not to allow me to use your information as part of my research, you will still receive my help and expertise in Quest Atlantis to complete the tasks. Saying yes or no to being a part of the research will not excuse you from completing any tasks related to this project that your teacher requires you to do.

If you agree to let me collect the types of information that you selected above, please print your name and signature on the lines below.

Date:_____ Name: _____ Signature or initials:_____

APPENDIX L PRINCIPAL CONSENT FORM (UNIVERSITY OF CALGARY)

UNIVERSITY OF CALGARY

INFORMED CONSENT LETTER FOR PRINCIPAL

Name of Researcher, Faculty, Department, Telephone & Email:

Robert Louis, Master of Arts Student, Graduate Programs in Educational Research,

Phone: 403-719-1762 email: rlouis@ucalgary.ca

Supervisor: Dr. Michele Jacobsen, Associate Professor, Educational Technology

Title of Project:

A Descriptive Case Study of Students Meaningful Learning Experiences in Quest Atlantis

This consent form, a copy of which has been given to you, is only part of the process of informed consent. If you want more details about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

The University of Calgary Conjoint Faculties Research Ethics Board has approved this research study.

The Calgary Board of Education has approved this research study; however, this in no way obligates you to give consent to participate in this study.

Dear Principal,

You are formally invited to participate in a study using a 3D multi-user virtual environment and digital game called Quest Atlantis. Please read this letter for the details of the study and what will be involved.

Purpose of the Study:

The purpose of this study is to investigate whether digital game play results in positive learning benefits, greater motivation, increased engagement and the assimilation of 21st century competencies by students. This study also aims to determine if inquiry-based learning leverages students' natural curiosity to make sense of the virtual world environment by using narratives and storylines as well as display 21st century competencies to accomplish the desired goal. The main use of collected data will be to inform a Master's Degree thesis project.

What Will I Be Asked To Do?

Over 8 - 12 class periods, your teacher and students will be will be going through a series of inquiry-based activities in QA that are grounded in real-world issues within an immersive context, requiring the application of principles, methods, and understandings associated with core disciplines. During this time, the researcher will observe student work, observe discussions between the students' and teacher about the activities, and conduct surveys and interviews with the teacher and students'. Interactions between

your teacher and students may be observed during the project and noted in field notes. As well, there will be a pre and post statistics test directly related to curriculum objectives that all students will be invited to complete – only data from consenting students will be used in the research.

What Type of Personal Information Will Be Collected?

Should you agree to participate, you will be anonymous in the final report. No personal information about you, or that could identify you to others will be reported. Absolute confidentiality cannot be guaranteed due to the nature of recruitment and data collection, and it is probable that your participation in the study will be widely recognized by your students, teachers, and colleagues.

All identifying information that is associated with anything collected in this project will be removed by the researcher, prior to the data being analyzed. In the study you will only be referred to as “the principal.”

Disclosure: Arizona State University Research

Your students and you will be using Quest Atlantis in the classroom. Quest Atlantis is 3D learning and teaching program that uses a 3D multi-user gaming environment to immerse children in educational tasks.

As part of the preparation for this research project, I completed training with the research team at Arizona State University. Dr. Sasha Barab and his research team, collects "in-world" data on all participants in QA, which is all data collected by the educational game. This is a large-scale, multi-university project that you and your students will be a part of. Interview and survey data from my study will NOT be shared with the Arizona State University Research team; however, in-world data will be collected by the Arizona Research Team from students as they play the game. Only me and my supervisor will have access to the classroom data that I will collect, which consists of students' online work submissions, unit progress, game interactions, online survey data, observations, audio recordings, and teacher work and feedback. Finally, chat and telegram content from classes during my research will be made available by Arizona State University (Quest Atlantis team). I will not have access to the large data sets that are gathered by the Arizona State University Research team that comprises of all game data. All students will be required to complete a consent form that informs them that online data will be collected by the Arizona State University Research team, and gain access to Quest Atlantis and participate in the learning activities.

Also note the following points:

1. The Arizona State University (ASU) Team will have access to the signed letters of consent for the ASU project.
2. Personal data will be stored on a server in the United States and subject to their laws.
3. While there is no intent in the ASU research protocol to link anonymous online data with the identities of students from the consent forms, absolute confidentiality cannot be guaranteed, and personal information may be disclosed if required by the laws of the United States.

Are there Risks or Benefits if I Participate?

There are no teaching, learning or social risks anticipated during this project.

You will gain knowledge and experience with an innovative, online 3D multi-user virtual world that has been studied and has been found to result in valued learning outcomes for students with the support of the researcher.

What Happens to the Information I Provide?

Participation is completely voluntary. If you request to withdraw from the study, the researcher commits to completing the classroom project (at your discretion) and you will be thanked. Data collected up to the point of withdrawal will be used in the analysis.

Interview, Classroom Observations

- The survey data will be collected electronically and temporally stored on a private server in Canada. The company hosting the survey complies with Canadian and Alberta privacy standards. Once the survey is completed, the data will be removed from the server and stored electronically. The survey is anonymous.
- Both physical and electronic means will be used to securely store records and data that result from this study. Only the researcher and his supervisor will have access to physical and electronic records that may contain confidential information.
- All electronic raw data will be kept on the researcher's computer in a password protected directory and backed up onto a password secured USB key. All text based raw data will be kept in a locked filing cabinet in Robert Louis' home. The data will be kept indefinitely.
- All physical transcripts and artifacts will be kept in a locked filing cabinet in the researcher's home office.
- The written key connecting the groups with the names of the individual students will be kept in a separate secured location at the University of Calgary. This written key will be destroyed in June 2013.
- Only the researcher and his supervisor will have access to this data.

You and the school administration will be given a summary of the research, in the form of the defended thesis, when it is completed.

Signatures (written consent)

Your signature on this form indicates that you give consent for this research to take place in your school. Separate consent will be sought from each teacher and student at the school to participate in this research study.

In no way does this waive your legal rights nor release the investigators, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from this research project at any time. You should feel free to ask for clarification or new information throughout your participation.

Participant's Name: (please print) _____

Participant's Signature _____ Date: _____

Researcher's Name: (please print) _____

Researcher's Signature: _____Date: _____

Questions/Concerns

If you have any further questions or want clarification regarding this research and/or your participation, please contact:

Robert Louis

Master of Arts student, Faculty of Education

403.719.1762

rlouis@ucalgary.ca

and

Dr. Michele Jacobsen

403.220.4123

dmjacobs@ucalgary.ca

If you have any concerns about the way you've been treated as a participant, please contact the Senior Ethics Resource Officer, Research Services Office, University of Calgary at (403) 220-3782; email rburrows@ucalgary.ca.

A copy of this consent form has been given to you to keep for your records and reference. The investigator has kept a copy of the consent form.

APPENDIX M CLASS OBSERVATION PROTOCOL

Observation Fieldnotes: Use of Quest Atlantis in the classroom
Setting: Classroom: 7a and 7b
Role of Observer: Observing 1) Teacher Activities, 2) Teacher & Students Interaction, 3) Students Activities, 4) Physical Setting, 5) On-Task Behavior, 6) Engagement, 7) Motivation
Time: During school day, 0820hrs and 1310hrs
Date: February 11 onwards
Length of Observation: 110 minutes (approx.)

Categories / Description of Observations	Reflection
Physical Setting (classroom)	
• Arrangement of desks, chairs	
• Seating arrangement	
On-Task Behavior (with relation to)**:**	
• Problem-solving	
✓ Shows multiple approaches to solving a problem	
✓ Uses multiple resources to reach a solution	
• Critical Thinking	
✓ Formulates clear/precise vital questions/ problems	
✓ Gathers/ assesses relevant information to effectively interpret and conclude a solution	
✓ Open-mindedly thinks about alternate systems of thought to reach a practical conclusion	
✓ Communicates effectively with others to solve a complex problem	
• Collaboration	
✓ Works effectively and respectfully with other students towards a common goal	
✓ Exercise flexibility in making necessary compromises to accomplish a common goal	
• Communication	
✓ Articulates thoughts and ideas clearly and effectively through speaking and writing	
✓ Listen effectively to understand meaning, knowledge, values, attitudes towards a common goal	
• Creativity	
✓ Develops, implements and communicates new ideas to others	
✓ Finds patterns / relationships and make connections among ideas.	
• Global Awareness	
✓ Collaboratively working with students from diverse cultures, religions, and lifestyles	
✓ Mutual respect and open dialogue in personal, work and community contexts	
Engagement ✓ Exhibits concentration due to the challenge provided in the game	
Motivation	

✓ Displays enjoyment from controlled learning as the game provides a personalized learning environment	
✓ Commitment and desire to accomplish the goal.	
Teacher Activities	
• Instructions to students (in general, whole class)	
• Discussions between researcher and teacher	
Teacher and Students Interaction	
• Instructions to students (personal or groups)	
• Guidance during game play (i.e., helping one-on-one, working with groups, etc.)	
• Interaction with students	
○ Chatting in the classroom	
○ Chatting in Quest Atlantis	
○ Collaboration between teachers and students	
Students Activities	
• Students interacting with other students	
○ Chatting in the classroom	
○ Chatting in Quest Atlantis	
○ Collaboration between students	
• Seating arrangement (group dynamics)	
○ Boys sitting next to boys, or mixed?	
○ Girls sitting next to girls, or mixed?	
○ Groups, Pairs or individuals?	
• Getting help	
○ From teacher	
○ From peers (boy from boy, girl from girl, boy from girl, girl from boy?)	
○ Online from the game	

APPENDIX N UNIVERSITY OF CALGARY ETHICS APPROVAL

Granted: Certificate on file.

APPENDIX O OPEN CODES MOTIVATION

1. Fun	44. Get More
2. Quest	45. Lumins
3. Learn Math	46. Quests
4. Focus More	47. Avatars
5. Missions	48. Competition Between Students
6. Enjoy	49. Talk with People
7. More Than Any Other Way	50. View Peoples Perspectives
8. Math Equations	51. Judgement
9. Information in One Place	52. See Friends
10. Get Information Yourself	53. See Peers Doing
11. Solve Activities Yourself	54. Walk Anywhere
12. Keep on Trying	55. Help the City
13. Finish the Game	56. Work Together with Friends
14. Maths in Answers	57. Chat with Peers
15. Easy to Solve	58. Peoples Perspectives
16. Eliminate Paper	59. Own Submissions
17. Self-pacing	60. Own Opinions
18. Software	61. Real World
19. Typing	62. No Right No Wrong
20. Liked the Game	63. Houses a Story
21. Computers	64. Characters
22. Automatic Learning	65. Competition
23. Not Boring	66. Problems
24. No Lecture	67. Reading
25. Figure it Out Yourself	68. Write in Quests
26. Better Way of Learning	69. Learning Math
27. Video Game	70. Help People
28. Do My Best	71. Talking to Real People
29. Proof to Myself	72. Personalities
30. Prevent Redoing	73. Avatars
31. Do Not get Bored	74. Different Worlds
32. Keep On Going	75. Different Places in Worlds
33. Finish the Quest	76. Different Scenery
34. Lumins	77. Help Different People In Game
35. Standings	78. Help Friends
36. Race	79. Glitches
37. Good Acts	80. Fly
38. Experience	81. ID Tag
39. Social Responsibility	82. Dance
40. Score	83. Secret Place
41. Accomplish	84. Find People
42. Win	85. Tool Sorter
43. Do It	

APPENDIX P OPEN CODES 21ST CENTURY COMPETENCIES

1. Help Each Other 2. Reach the Same Point 3. Spending Time 4. Work as One Unit 5. Ahead in Quest Atlantis 6. Ask Researcher 7. Ask Teacher 8. Comprehensive Response 9. Find Game Character 10. Quiet Collaboration 11. Reconfirmation 12. Verbal Talks 13. Visual Cues 14. Work Together 15. Formative Feedback 16. Make a Choice 17. Navigation 18. Speaking Skills 19. Writing Skills 20. Between Researcher and Students 21. Between Students 22. Between Teacher and Student 23. Navigation 24. Paper with Calculations 25. Visible Classmates 26. Location 27. Mission Screen 28. Non-playing Character 29. Applying Knowledge 30. Challenge 31. Opinion 32. Write Report 33. Digital Citizen 34. General Citizenship 35. Character to meet in Game 36. Check 37. Objectives in Mission List 38. Probe 39. Randomly Pick On Things	40. Reconfirm 41. Talk to All Characters in Game 42. Activities 43. Hints and Clues 44. Internet 45. Location 46. Paper with Calculations 47. Student asks Researcher 48. Student asks Students 49. Student asks Teacher

APPENDIX Q EDUCATION BOARD APPROVAL

Granted: Certificate on file.

APPENDIX R EDUCATION BOARD CONDITIONAL APPROVAL

Granted: Certificate on file.