PLAYING AND LEARNING: A CASE STUDY OF CHILDREN'S EXPERIENCES WITH SERIOUS GAMES IN A VIRTUAL WORLD

by

DAISYANE CARNEIRO BARRETO

(Under the Direction of Michael Orey)

ABSTRACT

Educators and researchers have been interested in understanding games and their application for educational purposes for many years. Both have sought to comprehend how these technologies can be used in formal and informal settings to promote learning. Examining how, and if, learning is occurring with games is essential to expand the body of knowledge in the education field. This study addressed children's learning experiences with online educational games during a 10-day research-based game-playing program. Participants in the program were introduced and encouraged to play math games in a virtual world, *Club Penguin*™, covering basic arithmetic and geometric concepts. Cognitive-constructivist theoretical perspectives were used to frame this study. Problem solving was identified as a key construct of game playing and learning. Motivational components of games were also examined to indicate children's engagement (or disengagement) in playing educational games. A qualitative case study approach was designed to investigate children's understanding of and engagement in playing *serious games* as well as to explore strategies used to succeed in play. This study generated data over a two-month period in a private elementary school and at a participant's home using primary participant observation and interview methods. Participants included six- to ten-year-old children. The research led to three conclusions:

(1) engagement was a result of intrinsic and covert academic content in games; (2) cheating strategies in serious games may undermine learning; and (3) high degree of problem solving in serious games fosters creativity. Future research in games shall better understand children's references, needs, limitations and desirable activities before engaging in game design and using games in education.

INDEX WORDS: *Club Penguin*™, Virtual Worlds, Serious Games, Math Games, Children, Engagement, Cognitive-constructivist Theories, Problem solving, Case Study

PLAYING AND LEARNING: A CASE STUDY OF CHILDREN'S EXPERIENCES WITH SERIOUS GAMES IN A VIRTUAL WORLD

by

DAISYANE CARNEIRO BARRETO

BS, Universidade Federal do Ceará, Brazil, 2004

MEd, University of Georgia, 2008

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in Partial

Fulfillment of the Requirements for the Degree

DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2015

PLAYING AND LEARNING: A CASE STUDY OF CHILDREN'S EXPERIENCES WITH SERIOUS GAMES IN A VIRTUAL WORLD

by

DAISYANE CARNEIRO BARRETO

Major Professor: Michael Orey
Committee: Llyod Rieber
Kathryn Roulston

Electronic Version Approved:

Suzanne Barbour
Dean of the Graduate School
The University of Georgia
August 2015

DEDICATION

I dedicate this dissertation to my family and a special friend. First, a special feeling of gratitude to my loving parents, Heli Barreto Filho and Maria José Carneiro Barreto, for their support and unconditional love during my doctoral journey. For my father who expected me to leave my legacy before passing away, I leave this dissertation as my contribution to the field of education in his memory. For my mother who gave me the best gift (education) anyone has ever given me, I share this gift with the world.

I also want to offer thanks to my sister, Natasha Carneiro Barreto, and my brother-in-law, Bobby Sills, for their support and assistance with my dissertation. Likewise, I am very grateful to my friend, Lucas Lima de Vasconcelos, who spent many hours helping me with my dissertation. Finally, I also dedicate this dissertation to my niece, Elizabeth (Ellie) Barreto Sills, who was born in the same year I completed and defended my work.

To Ellie, may you learn by playing!

ACKNOWLEDGEMENTS

Completing this dissertation has been a remarkable challenge. Without the support, patience and guidance of the following people, I could not have completed this work. It is to them that I owe my deepest gratitude. First, I would like to thank my advisor, Dr. Michael Orey, for his understanding, wisdom and encouragement to overcome the challenges of my research. To my committee members, Dr. Lloyd Rieber and Dr. Kathy Roulston, I am extremely grateful for your assistance and suggestions throughout the course of my dissertation work. A special thanks to Dr. Jay Harriman, Dr. Greg Clinton and Dr. Christa Deissler who went out of their way to help me find a research site. I also want to express my sincere gratitude to my colleagues, Dr. Gloria Pobst and Dr. Brandy Walker, for reviewing and providing substantial feedback to my dissertation. Many thanks to Dr. Nic Holt who helped me organize and make sense of my data. I also want to take this opportunity to show my appreciation to administrators and staff of Bright Spirit School (pseudonym) for providing me with all the necessary facilities and technical support to conduct my research. I am also very grateful for all the children who participated in this research project with such enthusiasm as well as their parents for allowing them to participate in this study. To all my friends – especially to Tonia Dousay, Christina Chotiwat, Erkan Er, Jiangmei Yuan, Fernanda Guida, Nastassja Pugliese – and family for their support and encouragement to make me move forward during the stressful moments in this doctoral journey. Most of all, I am grateful to God for giving me the opportunity to fulfill my dream.

TABLE OF CONTENTS

Page

APPENDICES

LIST OF TABLES

Page

LIST OF FIGURES

Page

CHAPTER 1

INTRODUCTION

People often use technologies on a daily basis for communication, work and entertainment. Interestingly, these technologies are not only a part of the adult world, for children are growing up in this digital sphere, too. Young people are being exposed to multiple modes of technology, and as a consequence, they start using these devices on a daily basis as well. A common use of technology by this cohort, in addition to communication purposes, is to play games.

Indeed, the game industry is growing, and digital games are becoming a popular use of technology among young people. For example, a recent report from Entertainment Software Association has shown that approximately 159 million digital games were sold in 2013. In addition, players have spent more than 21 billion American dollars on the game industry (Entertainment Software Association, 2014). Moreover, 60% of children and adolescents in the United States play video games at least once a day (Rideout, Foehr, & Roberts, 2010). In the past, non-digital games were limited by physical space. However, with technological innovations, the majority of game-playing contexts have shifted from physical places to dynamic, virtual, and portable environments. This mobility and apparent flexibility of games has provided easy access to play anywhere, with anyone, and at any time. Online free or subscription-based games allow the user to connect to the game wherever he or she goes. Users can play through an Internet-connected computer, smartphone, or other mobile device. In recent years, these electronic games have gained popularity among young people. Digital games are becoming part of children's daily routines.

Given that playing digital games is turning into a prominent activity among children, many educators (e.g., Squire, 2003; Shaffer, Squire, Halverson & Gee, 2005; Gee, 2007) have begun to explore the potential benefits of gaming technologies for education. Some of these include the application of digital games for motivational purposes (de Freitas, 2006; Ke, 2008a, 2008b) and for improving cognitive processes such as problem solving and decision-making (López & Cáceres, 2010; Moline, 2010; Gee, 2004), as well as player's cognitive abilities such as speed processing (Anderson & Bavelier, 2011). Overall, educators and researchers have been interested in understanding game technologies to support learning, including games' motivational features. Specifically, both parties have focused on games designed for learning, examining how academic content and gaming features can be integrated to expand learning in formal and informal settings.

Games and Learning

Using digital games for educational purposes is not a new approach. This genre of games, also called educational games, has been present since the early 1970s, and it was a result of experimentation involving computer technologies and educational content (Egenfeldt-Nielsen, 2007). Interestingly, the need for educational games did not come from the actual consumers, children, but from parents and teachers, who were the ones with the power to acquire and invest in these technologies (Ito, 2008). Although children value toys for entertainment purposes, parents and teachers appreciate toys based on their educational merits. This dichotomy between toys for play and toys for learning drove the creation of educational games. While some game designers directed their focus to the entertainment features, others concentrated on the educational content.

A subset of educational games, also know as "edutainment," has been criticized by many scholars because of their repetitive drill-and-practice features and lack of meaningful activities grounded in constructivist learning theories (Papert, 1998; Bruckman, 1999; Okan, 2003; Egenfeldt-Nielsen, 2007). Edutainment games were designed to combine the "good" characteristics of entertainment and education. Sadly, the product of edutainment was a mixture of the undesirable characteristics of the aforementioned areas. The educational value of these games was often derived from completing "schoolish exercises," while the entertainment was playing a "fun" mini-game as a reward for completing the exercises correctly (Papert, 1998). These categories of educational games have gradually faded out and given rise to a new genre of educational games known as *serious games*.

The term serious games has been used to redefine the design of game technologies to be used beyond recreational contexts. The technology emerged from both computer games and educational simulations (Aldrich, 2009) and can be defined as "any type of digital game and game-like application" designed for learning or training purposes (Loh, 2011). The aim of the serious games movement is to assess learning (Michael & Chen, 2005), by providing evidence of what is being learned and when it is happening within the context of the game.

Interestingly, most serious games have been embedded in virtual worlds, which can be defined as a "synchronous, persistent network of people, represented as avatars, facilitated by networked computers" (Bell, 2008, p.2). Choosing these technologies to host serious games can be related to the affordance of the tools. That is, these tools not only allow individuals to play games but they also provide spaces for individuals to engage in other activities that are not game-based such as avatar customization and chat conversations. Furthermore, because virtual worlds permit both gaming and non-gaming features, several labels and terms have been used to identify these online worlds. For this reason, the literature review in this study focuses on defining and distinguishing this technology from others commonly associated with it such as Massive Multiplayer Online Games (MMOG).

Given the popularity of virtual worlds with children, recent research has been conducted to examine the potential learning outcomes supported by these technologies. In general, positive experiences have been reported regarding the use of virtual worlds and gaming technologies for learning (e.g., Barab, Arici, & Jackson, 2005; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Barab, Zuiker, Warren, & Hickey, 2007; Ke 2008a, 2008b; Kafai, 2010; Habgood & Ainsworth, 2011; Chang, Wu, Weng and Sung, 2012; Pareto, Haake, Lindström, Sjödén, & Gulz, 2012). These studies indicate that children are usually engaged in and motivated to use these technologies. In terms of the learning content implicit to the game, studies (e.g., Ke 2008a, 2008b; Pareto et al., 2012) have indicated that children improve their attitude toward a subject area, in this particular case mathematics, as result of game playing. Despite these findings supporting the use of these technologies for educational purposes, there are still controversies about their effectiveness in terms of learning (Gredler, 1996; O'Neil, Wainess, & Baker, 2005; Egenfeldt-Nielsen, 2007). For example, some authors (e.g., Gredler, 1996; Egenfeldt-Nielsen, 2007) have attributed these controversies to the quality of previous studies in the area, pointing out that these studies have been biased and flawed. In contrast, Prensky (2005) has attributed the lack of effectiveness to the quality of educational games, emphasizing that most games for learning have not been well designed.

Indeed, even though games include characteristics and attributes that can contribute to instruction and learning, these tools need to be examined with caution. For example, a key game characteristic that can motivate individuals is fantasy; at the same time, fantasy is an element that distorts the reality represented in the game. This distortion of reality can affect the learning content presented in the game, and consequently, affect students' learning outcomes. For example, Ke (2008a, 2008b) indicated that when the fantasy element was not intrinsic to the game, i.e., exogenous fantasy (Rieber, 1996), students' math test performances were affected as the activities presented in the game play were not congruent with the learning goals. Moreover, Habgood and colleagues (2011) found that children would retain academic information longer if the learning content was intrinsic to game play, i.e., endogenous fantasy (Rieber, 1996). As children play using these technologies, it is important to examine how the design of the learning content in the game can influence or contribute to children's learning experiences.

Games, Problem Solving, and Cognitive-Constructivist Perspectives

Defining games can be a complicated task given that there is no agreement on a single definition among researchers. Nevertheless, a characteristic that most games share and most researchers and game designers (e.g., Salen & Zimmerman, 2004; Koster, 2005; Gee, 2007; Schell, 2008) seem to agree on is problem solving. Certainly, most games encompass problem-solving characteristics such as players starting out at an initial stage in the game, i.e., first level, and leveling up as they achieve the goals and sub-goals of the game. Moreover, players employ a set of operation*s* or strategies to overcome the constraints or challenges posed by the game. Problem solving involves identifying possible strategies that can lead an individual to a problem solution. To reach a solution, individuals may have to explore, manipulate, and test the factors that might influence the problem. In contrast, others might use analogies from previous experiences or problems faced in the past to generate a solution. Nevertheless, it is through an interaction with a problem or new situation that an individual develops his/her understanding and how to solve it. Thus, constructing knowledge out of the interactions between an individual and a new situation/problem can be aligned with Piaget's views of learning.

Piaget (1983), whose work has been associated with constructivism, held that the construction of knowledge depended on the action of an individual toward an object as well as the learning of the individual on how to perform the actions on the object itself. Moreover, Piaget (1962) considered the act of play as an important element in children's cognitive development. As children play, they not only exercise their motor skills (e.g., throwing a ball) but they also exercise their cognitive skills (e.g., thinking of the fastest and best way to throw a ball so an opponent cannot catch it). In addition, as children interact with play objects, they develop an understanding of how these objects can be used in other contexts outside of play.

Based on this perspective, learning by playing games occurs as part of the interactions between the player and the game. Players assimilate information from the game, connecting this information with existing their prior knowledge, while, at other times, they may have to accommodate to and change the previous information about games to fit the content presented by a particular game. This process of constantly adjusting and balancing information through interaction can be considered an equilibrium process. During play, individuals seek to reach this stage of equilibrium and completeness; however, this seems difficult when playing a game. Players are constantly faced with cognitive conflicts (e.g., manipulating objects to assist a virtual character to escape a cave) leading them to problem solving. Thus, a problem-solving conceptual framework was used to investigate learning with games in this study (Figure 1.1).

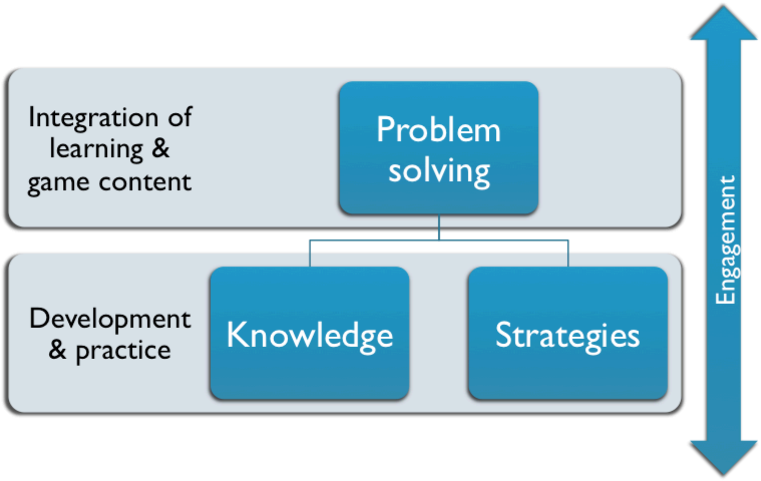


Figure 1.1 Conceptual framework for problem solving in games for learning.

In this framework, problem solving is the process that players undertake to complete tasks within a game. Problem solving allows for a better integration of the learning content and gaming elements in serious games. Players can develop gaming and academic skills in the process of carrying out problem solving tasks in the game. In that instance, players employ strategies to be successful in a game such as trial-and-error or association based on previous games or levels in the game. In addition to strategies, knowledge domain is also important in problem solving. Examining players' understanding of the content in serious games might provide insights into how players make sense of and solve the problems posed in the games.

Consequently, this study was framed based on cognitive-constructivist theoretical perspectives. Given these viewpoints, problem solving in game play was examined as an aspect of learning. Children's actions executed within the game, as well as their perceptions of the game playing, were investigated through observations and interviews. Additionally, children's knowledge of the content in the game was assessed prior to and after a 10-day game-playing program to verify whether there were improvements in terms of learning outcomes.

Thus, two serious games (i.e., *Bits and Bolts* and *Pufflescape*) part of a virtual world called Club Penguin™ were investigated in the context of a 10-day game-playing program. Both games were selected because their learning content was intrinsic to the game play and math content being taught. Children's conceptual and strategic understanding of the math content, as well as their gaming skills for succeeding in the games, was explored. Moreover, children's perceptions and learning outcomes regarding engagement in and math understanding of these two games were explored.

Research Questions

The purpose of this study was to determine how children understand, develop strategies for, and engage with two serious games in a 10-day game-playing program. Four cases were identified in this program to support problem solving as an aspect of learning and a key cognitive process in game playing. Specifically, this case study addressed the questions presented in the table (Table 1.1) below using the following methods:

Table 1.1

Research Questions and Methods

Research Question	Data Type	Data Source	Analysis Procedure
1. How do children understand academic and game content in serious games?	Qualitative	Interview	Interactional Analysis
2. How do children employ strategies to succeed in playing serious games?		Observation	
3. How do children engage in or disengage in playing serious games?		Observation	

Significance of the Study

There is no doubt that virtual worlds and online games are emerging technologies. For example, the current number of children playing online games in U.S. has grown, with 91% of boys and 93% of girls now playing in these online spaces (M2 Research, 2010). Indeed, as these technologies become available to children, it is important to understand whether and how these tools can be used for educational purposes. In addition, before advocating and integrating digital games into school contexts, it is fundamental to investigate which games are more important to learning, and what it is about them that make them effective before assuming that all learning games work.

Furthermore, because games involve fictional worlds in which children can make inferences from the situations in the games they are playing, games might be perceived differently through the eyes of a child. For instance, what an adult considers a lack of strategic planning, a child might see a mistake made during play as a “trap” that the game has set for her. Thus, it is essential to explore children’s perceptions regarding their understanding of these technologies. In addition to an understanding of games, children’s engagement with these technologies should also be investigated. The idea of using games for educational purposes comes from the apparent motivation that children have for playing games. Therefore, as this study investigated two serious games, it is appropriate to check whether both games can promote engagement among children.

Using games to support and promote learning is one step to exposing, encouraging, and stimulating children to learn about topics they may not enjoy such as mathematics. Indeed, mathematics is one of the core subjects in schools, but it is also one of the academic areas that children usually dislike or have difficulty grasping. Thus, implementing serious games to stimulate children's understanding of mathematics might contribute to their motivations toward that topic.

Overview of the Dissertation

This dissertation is divided into five chapters and an appendix section. The first chapter provides an introduction about educational games and how they have evolved. It also includes the purpose and significance of this study. The second chapter presents a review of the literature, including relevant definitions related to games and virtual worlds. The review of the literature also includes the current research conducted on virtual worlds and math games, as well as motivational factors in games. The review of the literature concludes with the theoretical perspectives framing this study. The third chapter describes the research methods utilized to conduct this case study, covering the research questions and study design as well as data quality practices. The fourth chapter presents the cases of participants in a 10-day game-playing program. The last chapter includes conclusions of the study, discussing limitations and future research related to serious games. All references used in this dissertation are included. The appendix section contains copies of the documents submitted and approved by the UGA Internal Review Board and other relevant documents.

CHAPTER 2

REVIEW OF THE LITERATURE

Playing games in the past would imply having a limited group of people getting together at the same time and in the same physical space. With technological advances, games have shifted the experience of play from physical to virtual spaces, from tabletop games to online games. The current number of children playing online games in U.S. has grown, with 91% of boys and 93% of girls now playing online (M2 Research, 2010). Online games have been associated with many labels: Multi-User Virtual Environments (MUVEs), Massively Multiplayer Online Role-Playing Games (MMORPG), Massively Multiplayer Online Games (MMOG), and even broader categories such as virtual worlds or synthetic worlds (Castronova, 2005) have been used to accommodate environments that afford both gaming and non-gaming features. Due to the number of online worlds, it has been difficult to identify and organize appropriate research in the area of online games, particularly studies that would discuss the use of these technologies to support children's learning.

Independent of the labels used to classify online games, the broader term *virtual world* has been used to identify and specify research in online environments such as or similar to Club Penguin™. The reason for using this nomenclature is based on the following criteria: (a) the inclusiveness of the term, i.e., it can include not only environments that have stronger gaming narratives (e.g., World of Warcraft) but also playground environments, thereby mixing play- and game-based activities in an online context (e.g., Club Penguin) and (b) the popularity of the term in research with children, as most studies referred to these environments as "virtual worlds" (e.g., Barab, Thomas, Dodge, Carteaux, & Tuzun, 2005; Kafai, 2010; Meyer, 2009; Marsh, 2010, 2011).

In spite of their non-gaming characteristics, games are still a vital part of these environments. Most players who choose to enter virtual worlds decide to do so because of the gaming experience they afford. Moreover, even if a virtual world lacks a strong gaming narrative, the environment is designed to provide a resemblance to digital gaming spaces through its graphic style and user-machine interaction. As Castronova (2005) noted, the electronic tools (i.e., computer, handheld devices, or game consoles) are just means to engage in play, and consequently, experience the game world. Thus, given that games are key features of most virtual worlds, this literature review examines research on digital games as well. Specifically, this section will discuss math games. The reason to focus on this area is based on the academic content in the Club Penguin™'s games (i.e., *Bits and Bolts* and *Pufflescape*) that explore math content.

Therefore, this literature review (Table 2.1) is organized into the following subsections: (1) virtual worlds and games, (2) research with virtual worlds, (3) research with digital games in mathematics, (4) research on motivational factors of digital games, (5) effectiveness of games for learning, and (6) theoretical perspectives in digital games for learning. In the first subsection, given that this study examines games that are part of a virtual world, defining games and virtual worlds is important to understanding how these terms have been framed in the context of this study. Next, research using virtual worlds for educational and entertainment purposes is examined in order to identify the potential benefits of these tools for education. Moreover, current studies exploring math games in schools are presented in this section as a means to assess what recent research is investigating in this area and how its findings can frame this study.

Additionally, research on motivational factors of digital games is explored in this literature review because it has been an area of interest for game researchers as well as a key reason to introduce games in school settings, i.e., implementing games in schools in order to observe changes in children's motivation towards certain academic content. In addition to motivation, it is important to address the effectiveness of games for learning and discuss the quality of games in general for educational purposes (covered in a later subsection). Finally, this literature review ends with theoretical perspectives in digital games for learning, targeting one aspect of learning, i.e., problem solving, to frame and examine the relationship between games and learning.

Table 2.1

Literature Review Organization

Literature Review	1. Definition of Terms
	2. Empirical Studies with Virtual worlds
	3. Empirical Studies with Math Games
	4. Empirical Studies on Motivational Factors of Digital Games
	5. Effectiveness of Games for Learning
	6. Problem-Solving Theoretical Perspectives

Games and Virtual Worlds

Defining games is a difficult task because of the inconsistency and ambiguity generated by the terms. Given a review of the seminal work in the study of games, Salen and Zimmerman (2004), along with Juul (2005), observed that eminent theorists used the words "play" and "games" interchangeably. Indeed, the boundary between play and games is slender. Games can be a subset of play as well as play can be a subset of games (Salen & Zimmerman, 2004). That is, when considering all possible activities categorized as play, playing games is as much one of them as is playing the piano or playing with a doll. These are all forms of play. When considering games, play is an element of games. The interaction between the player and the game produces the experience of play, which is a way of comprehending the larger phenomenon of games.

In an attempt to define games, Salen and Zimmerman (2004) categorized them as systems "in which players engage in an artificial conflict" (p.80). This artificial conflict could also be categorized as a problem-solving activity (Schell, 2008). That is, the problem is outlined by the rules of the game, and players seek to solve the problem posed by the game. In addition, games have goals that result in outcomes. These outcomes are quantified by a value or numerical score determining whether a player has won or lost the game. In addition to these features, a relationship emerges, and consequently sustains the play, as a player interacts with the game. This relationship can be defined as game play. In Juul's (2005) definition of games, it is the potential outcome of the game that prompts a player to invest time and effort in the game, i.e., how the player perceives the game outcomes leads to his/her attachment to the game. Moreover, Schell (2008) argued that games are designed to promote a "playful attitude," meaning that players are motivated to engage in game play. If players are not enjoying a game, then the game activity becomes an exercise, a chore, or even a work related task. In this context, not only the characteristics of a game should be taken into consideration but also the relationship between the player and the game.

Until now, games have been discussed with an isolated definition and its relationship to the player. Nevertheless, games can also be integrated into much larger experiences such as online worlds. These spaces can not only host the games but also offer opportunities for a player to interact with and engage in other pleasurable activities that do not necessarily include game features (e.g., rule-based activities). Thus, analyzing and distinguishing these online worlds from other tools such as games is important in identifying and delineating the boundaries of this research. Hence, the remaining part of this section includes a definition of virtual worlds beginning with the origins of this new technology.

The concept of virtual worlds came from two sources: the fantasy role-playing game (RPG) *Dungeons and Dragons* and the early computer-based role-playing environment *Multi-User Dungeons* (MUDs). Dungeons and Dragons was invented by Gary Gygax and Dave Arneson in the mid-1970s (Kelly, 2004); it is a game in which players take on and perform roles from fantasy adventure stories in face-to-face game sessions. This idea of taking on roles is the defining characteristic of the RPG genre. Taken as a whole, these genres of games allow players to create and customize their characters based on physical attributes, abilities, races, and classes that are part of the game storyline, which is usually determined by a Dungeon Master (DM). The DM is usually a player who directs the game as he or she unfolds the game story and the decision-making scenarios that other players might face in the game. Today's online gaming worlds have borrowed the fantasy medieval style scenarios from Dungeons and Dragons as well as its character role customization.

Similarly, MUDs also involve role-playing adventures; however, the interactions among players and the storyline happen on a computer, usually via text. That is, players are given written descriptions of the storyline and expected to act upon them by means of typed commands. Thus, this concept of text-based interaction and the capacity to play with other players over the Internet has resulted in the development of MMOGs and virtual worlds.

There have been some definitions of MMOGs (or its variant MMORPG) as well as virtual worlds, but few have distinguished between these two terms. For example, Steinkuehler (2004, 2006) defined MMOGs as online games in which players can create "digital characters" and interact with other players and objects within a two- or three-dimensional computer graphic environment. Dickey (2007, 2011) also highlighted interactivity as a component of MMOGs but expanded her definition by adding that these are "persistent" and "networked" environments. Interestingly, some authors (e.g., Bell, 2008; Cannon-Bowers & Bowers, 2008) used similar words such as interactivity, persistence, and networked computers, to define virtual worlds. Although MMOGs and virtual worlds share similar technologies, the relationship and concept behind these environments have not been addressed. The reason for similarities in their technology is because MMOGs are, in fact, part of virtual worlds (Schroeder, 2008). In other words, all MMOGs are set in virtual worlds, but not all virtual worlds are MMOGs. Virtual worlds may or may not include games or gaming narratives as parts of their environment; however, MMOGs must have such components.

Thus, MMOGs are virtual worlds that either include games or are games in themselves. Now, virtual worlds can be defined as two- or three-dimensional computer graphic environments in which users can interact with each other or objects in the world via customized digital characters known as *avatars*. This interaction can occur through a graphical user interface, text-chat, or voice over Internet Protocol (VoIP). Moreover, these worlds are (a) *massive*, which means they support a large number of users simultaneously, (b) *persistent*, which means they will continue to function, change, and expand even after a user has logged off, and (c) *networked*, which means that users' computers can be connected through the same online space.

In summary, role-playing games such as Dungeons and Dragons and MUDs have contributed to the origins and development of virtual worlds and MMOGs. Although both virtual worlds and MMOGs share similar characteristics, a distinction has been made regarding these environments. A virtual world has been defined as a broader term used to identify online spaces that support a massive number of users at the same time and one in which users manipulate customized digital characters to interact with the environment and other users. Meanwhile, MMOGs have been characterized as a type of virtual world that either is a game or can include games. With this information in mind, the following sub-section will address research studies that report how these technologies are being used to support learning.

Learning with Virtual Worlds

As the environments for playing games move from physical to online spaces and the number of children playing in these virtual spaces increases, it is crucial to investigate children's interactions with these technologies. Examining what and how children are learning with virtual worlds can be essential to supporting the design and use of these tools for educational purposes. Therefore, this subsection examines the relevant research conducted with virtual worlds for children, focusing in particular on research studies that have provided indications of learning with these environments. This subsection is organized to move from research on educational virtual worlds to research on environments, such as Club Penguin™, designed for entertainment purposes.

An example of a virtual world designed for educational purpose is *Quest Atlantis* (QA). QA is a three-dimensional (3D) environment in which children can engage in inquiry-based learning by exploring and solving quests in its virtual world (Figure 2.1). By exploring and solving these quests, children can build knowledge and information related to science content such as pollution and water quality. Overall, studies with QA (e.g., Barab et al., 2005; Barab et al., 2005; Barab et al., 2007; Barab et al. 2007; Barab, Gresalfi, & Arici, 2009; Siyahhan, Barab & Downton, 2010) have indicated positive benefits for learning.

Figure 2.1 Quest Atlantis virtual world

For example, one of the early research findings with QA has been the positive learning outcomes not only in science content but also in other areas such as language arts and social studies (Barab et al., 2005). Later on, Barab and colleagues (2007) conducted two studies in QA in which the results from the first study were used to improve the second. Both studies have indicated positive learning outcomes as part of this experience. In the first study, there was a significant increase in both the *proximal-level* (i.e., a test to assess learners' concepts related to the content covered in the virtual environment) and the *distal-level* (i.e., a test to assess learners' knowledge in relation to the science content standards) test scores. In the second study, comparable findings were reported with students' scores increasing on both tests. In another study, Barab and colleagues (2007) found similar positive results as well. There was a significant increase in proximal-level posttest scores; however, in distal-level scores, students scored so high on the pretest assessment that almost no room was left for improvement.

Considering the qualitative findings for this study, there were positive suggestions that this experience engaged children in scientific inquiry such as gathering relevant information to solve a problem or formulating and testing hypotheses within a virtual world context. Nonetheless, implementation of this virtual world presented challenges. In some cases, students took a "trivial" approach when interpreting graphs within the world. That is, students relied on their peers to tell them what the correct answer was instead of interpreting and making sense of the information displayed on the graph. Moreover, the researchers pointed out that children's understanding of the science concepts covered in QA was, to a certain extent, superficial unless there was a debriefing moment in which children could discuss these science concepts with their peers or the teacher.

In summary, most of the evidence supports the findings that children improved their science test scores as part of this educational program, which reinforces the use of such technology for teaching and learning. Moreover, technological artifacts are culturally constructed and interpreted by the social groups that use them (Pinch & Bijker, 1989). Even if the artifact was constructed for a specific purpose, such as education, it is still up to the users, in this instance, children, to create meaning out of the experience with the artifact. Thus, a virtual world such as QA is subject to students' understanding and interpretation, in particular its embedded science content. Given this condition, it is important to allow children to reflect on their own experiences with these game technologies as doing so may lead to insights on how children construct their understanding of these virtual worlds. In this study, interviews with children will be used as a method to elicit and allow for reflective moments in their gaming experiences.

On the subject of understanding virtual worlds, there have been a number of studies (e.g., Fields, & Kafai, 2007; Feldon & Kafai, 2007; Kafai, Feldon, Fields, Giang, & Quintero, 2007; Kafai, 2010; Kafai, Quintero, & Feldon, 2010; Kafai, Fields & Cook, 2010; Fields & Kafai, 2010a, 2010b) conducted with *Whyville* (Figure 2.2), another virtual world designed for education, to examine the culture children developed in this environment. Whyville is a two-dimensional online environment in which children are introduced to science content by playing mini-games. They can also engage in other activities such as text chatting with each other, earning virtual money, and customizing their avatar. This particular virtual world is very similar to Club Penguin™. That is, both environments share equivalent structures (e.g., small virtual locations within a large virtual world), gaming system (e.g., playing games to earn virtual money), and social interaction (e.g., players can chat and play with each other).

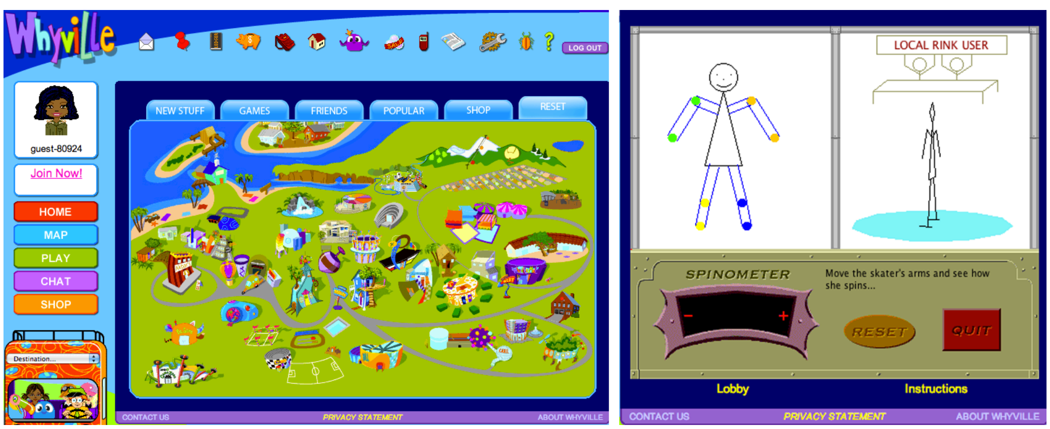


Figure 2.2 Whyville world map and one of its mini-games

Largely, the research conducted with Whyville has focused on understanding the culture created in this environment, including understanding (a) the topics of conversations among players, (b) players' social interactions, (c) players' preferences, and (d) ways players engage in investigations (Kafai, 2010). For the most part, findings from Kafai's research have indicated that children's gaming experiences seem to be successful in this type of environment. For example, primarily the learning outcomes relate to gaming literacy such as how children learned specific actions within the game (e.g., Fields & Kafai, 2010b) or how they produced knowledge out of the game (e.g., Fields & Kafai, 2010a). In one case, Fields and Kafai (2010b) interviewed children and examined their log files to understand how they learn gaming skills specific to Whyville. The researchers noted that an activity such as "throwing a projectile" at another player's avatar had a "snowball" effect among participants. Children learned from their peers how to do this action by either having their peers tell them how or demonstrating the action for them. Additionally, Kafai and colleagues (2007; 2010) indicated that children seem to create their own "theories" regarding the ways Whyville functions. That is, children developed a hypothesis based on their own or other players' experiences regarding the causes and effects of a virtual disease that was spread and caught by avatars in this world.

Given these findings, learning in Whyville could be described as a consequence of children's social interactions. That is, some features of Whyville are conducive to promoting children's interactions (e.g., text chat or discussion board), which consequently can lead children to learn formal and informal content or skills. Moreover, Whyville seems to be a vehicle for introducing children to and letting them explore science content on their own instead of teaching it to them.

Introducing a particular academic content via game play is also a characteristic common to another virtual world known as Club Penguin™. Club Penguin™ is a two-dimensional (2D) environment designed mainly for entertainment purpose in which children can play mini-games and engage in other activities such as customizing their penguin avatar or adopting virtual pets (Figure 2.3). Players can subscribe to a paid-membership in which players have access to all game levels and accessories, or a free-membership that limits the type of accessories players can buy and their access to game levels. Even though the central focus of this world is entertainment, there are still some games that expose children to educational content.

Figure 2.3 Club Penguin™ map and one of its mini-games

In contrast to QA and Whyville, the number of studies (e.g., Meyer, 2009; Burley, 2010; Marsh, 2010, 2011) examining Club Penguin™ has been limited. Most of these have explored children's understanding and motivation to play this and other popular virtual environments for children. Indeed, Club Penguin™ was considered the most frequently used virtual world among a group of primary school students, i.e., 175 children, in the United Kingdom (Marsh, 2011). In addition, children's primary use of the virtual world was playing games instead of interacting with other children online (Marsh, 2010). Furthermore, new literacy practices were common activities identified in these types of environment (e.g., Meyer, 2009; Marsh, 2011). In other words, these virtual worlds have been considered spaces for children to develop technical skills (e.g., how to create and login to an online account) and to practice skills usually acquired in formal contexts (e.g., reading and information seeking).

Besides these findings, some authors (e.g., Burley, 2010; Marsh, 2011) have argued that children create their own understanding of and rules for these environments. For instance, children may decide to "become friends" with other online players based on their penguin avatar's appearance and online possessions, which can be a reflection of their membership status (i.e., having a paid-membership allows players to buy elegant accessories). Even though this friendship selection criterion is not encouraged by the virtual world, children employ it to choose their virtual friends. By employing this criterion, children start to develop their own mechanisms to make sense of and operate within these worlds. This information might not be explicitly associated with children's learning outcomes; however, it provides insights into how children develop an understanding of visual representations and "social status" in Club Penguin™.

This subsection explored findings of research studies conducted in three virtual worlds. These findings were presented based on their indications of learning outcomes and relevance for this study. In general, research studies have indicated positive effects in the use of these tools for learning. Moreover, the studies presented in this section provided information on how children develop and use their gaming skills in such environments. Nonetheless, most of these research studies discussed findings related to science content, which is not the academic content targeted by the games in Club Penguin™. Given that mathematics is an area covered by Club Penguin's games, the following sub-section is organized to examine research studies focusing on digital games in mathematics.

Learning with Math Games

Mathematics is one of the most important school subjects, and, at the same time, it is one of the most challenging subjects for students to grasp. Due to its demanding concepts, most educators and researchers have incorporated math games into primary education to motivate and facilitate students' learning. Several recent studies have been conducted to examine the benefits of using games to enhance children's mathematical understanding (e.g., Ke, 2008a, 2008b; Habgood & Ainsworth, 2011; Chang et al., 2012; Pareto et al., 2012). All the games implemented in these studies were purposefully developed to integrate math content into game play. In general, these studies combine quantitative and qualitative methods (e.g., mixed-methods) or follow a more quantitative approach (e.g., quasi-experimental design, mixed factorial design).

Considering the findings, most studies indicated positive learning outcomes favoring the use of these technologies. For instance, Pareto and colleagues (2012) conducted a mixed-method study to examine the effects of a math game in enhancing students' understanding of basic arithmetic as well as promoting an attitudinal change toward mathematics. Based on their findings, both experimental and control groups improved their scores; however, the change was significantly different for the experimental group. Although the authors indicated that other factors could also be responsible for this difference, they suggested that most of the positive effects could be ascribed to the actual game. After examining the individual questions on the test, the authors found that students in the experimental group showed considerable improvement on questions that referred to base-ten concepts, which was the targeted math content of the game. Moreover, Ke (2008a, 2008b) conducted two studies in a school environment comparing students who used computer math games with students who used paper-and-pencil drills. The findings of this research indicated that there were improvements in both groups; however, there was no significant difference between computer games and paper-and-pencil drills in relation to mathematical skills. Although the author did not find strong evidence supporting the use of computer games to enhance students' math skills, there were significant results indicating positive attitudes toward math in favor of the use of computer games. In addition, the author noted that not all of the games played promoted students' engagement in mathematical reasoning, which could have led game-playing groups to score low on math test performance. In fact, the findings suggested that children used guessing strategies when the game allowed this approach, especially drill-and-practice type of games. Nevertheless, when the math content was well integrated with the game narrative, participants responded with fewer instances of random guessing.

Integrating academic content with game play or the game narrative has been a key challenge in games with educational goals. For example, in order to verify the different degrees of content integration within a game, Habgood and Ainsworth (2011) conducted a mixed factorial design study with primary school students. Although students exposed to all types of content integration (i.e., intrinsic, extrinsic and none) had improvements in test scores, the researchers found that children who played the game with intrinsic content integration scored significantly higher on the delay test than did children in the other groups.

In summary, the positive learning outcomes favoring the use of game technologies might depend on how the math content is integrated with the game play, which involves areas such as motivation. Motivation for learning in digital games has focused on the intrinsic factors leveraged by games as well as how these factors can influence learning outcomes and attitudinal change toward a specific domain such as mathematics. Given this information, the following section discusses the motivational aspects of games as well as empirical research studies conducted in the area.

Motivation and Learning in Games

Children's motivation in playing digital games has been the focus of several research studies. Motivations to play digital games are related to the child's social, emotional, and intellectual needs (Olson, 2010). Indeed, the experience of playing games involves multiple social aspects such as interacting with other players, negotiating the game rules, and teaching others how to play. In terms of teaching others how to play, Field and Kafai (2007, 2010) showed that children's actions within a game were learned from their peers. Children taught their peers how to do certain things and find locations in the game. Additionally, Olson (2010) found similar findings as children reported sharing information such as "cheat codes" and gaming strategies with their peers. Nevertheless, some authors (Ke, 2008b; Linderoth et al., 2004) argued that this exchange of information is often associated with gaming related issues and not the learning content embedded in these games. Interestingly, the reasons for this mismatch of learning (gaming vs. academic content) acquired from these games could be attributed to the fantasy in which a game is set.

Fantasy is an intrinsic motivational component of digital games (Malone, 1981) and is usually the context in which the academic content of a particular learning game is set. Fantasy can be incorporated into a game as (a) *endogenous fantasy*, in which the learning content is an intrinsic part of game play, or (b) *exogenous fantasy*, in which the learning content is an extrinsic part of game play (Rieber, 1996). An example of an endogenous fantasy incorporated in game playing might be to use the game context (e.g., players navigate their character across platforms to escape an icy cave) as a means to learn the academic content (e.g., principles of force and motion). With regards to exogenous fantasy, an example might be to learn about the academic content (e.g., basic arithmetic) as an external factor of the game context (e.g., game items such as blasters can only be acquired if players solve math problems). Some research studies presented findings in favor of games for learning that incorporated endogenous fantasy. Habgood et al. (2011) found that children's scores were most improved when exposed to endogenous fantasy type of games. Moreover, Ke (2008a, 2008b) noted that children would be more engaged and make fewer "wild guesses" when learning was situated within game play.

Indeed, Lepper and Malone (1987) asserted "fantasy activities should contain motivational goals that reinforce, rather than compete with, instructional goals" (p. 279). Thus, the fantasy component for learning through and in games needs to be intrinsically connected with the academic content in order to be an effective learning tool; otherwise, learners can be distracted by other game features (e.g., Ito, 2008; Shelton & Scoresby, 2011) and consequently lack engagement in the intended learning game activities.

Another intrinsic motivational component found in games is challenge. It is frequently connected with the goals a player needs to achieve while playing a game. However, these goals must include outcomes that are uncertain, unfinished, or unclear (Bruner, 1966; Malone, 1981). These uncertain outcomes in games can be referred to s the constraints part of a game environment. For instance, in a game where the goal is to combine numerical symbols to match a number presented on the computer screen, a player may need to attend to adversary factors such as time, speed, difficulty level, and other factors that can prevent a player from easily reaching his/her goal.

The motivation in challenging situations has been explained by Csikszentmihalyi's (1988, 1990) *flow* theory. Flow is the optimal experience that results from a balance between the *challenges* of an environment (or a situation) and the current *skills* that an individual possesses. To illustrate, an individual could engage in an experience such as playing a game because it offers him/her an initial challenge. As the individual plays the game and improves his/her skills, he or she seeks more opportunities within the game that will increase the challenge level of the situation. However, the challenge level needs to meet the individual's skill level. That is, if the challenge level in the game is too far above the player's current skills, he or she will become frustrated and anxious during game play and, consequently, will not experience flow. In contrast, if the challenge level in the game is too far below the player's existing abilities, he or she will become bored as he/she plays the game and, consequently, will not experience flow.

Regarding the use of digital games, challenge seems to be a crucial element to motivate players. For example, Olson (2010) noted that children considered challenge to be a key factor in making a game fun to play. In addition, Rieber et al. (2009) found challenge to be a game element that could leverage children's intrinsic motivation. Ke (2008b) found that, whenever the challenge presented in a math game was "too difficult," children demonstrated signs of distress and started guessing the math answers. In contrast, Moline (2010) found that adolescent gamers, when playing their favorite games, had positive experiences once they faced challenging situations within the game. Thus, examining the challenging experiences that players face during game play could be essential to understanding the circumstances under which players feel challenged, as well as describing the quality of these experiences, and to distinguish between the level of challenge proposed by the game environment and the academic content embedded in the game.

In addition to challenge, curiosity is another intrinsic motivational factor associated with games. Malone (1981) discussed two types of curiosity that could create an intrinsically motivating environment in games: (a) *sensory curiosity*, which involves using multimedia features to capture a player's attention, and (b) *cognitive curiosity*, which involves creating an environment that evokes intellectual conflict. Although both types of curiosity are important in developing an intrinsically motivating game environment, it is cognitive curiosity that sustains and keeps the player returning to the game. Because the information displayed in a game is either limited or conflicting, giving a player an impression that the information is incomplete, the player keeps coming back to decipher and complete the information. Indeed, uncertain or unclear situations such as playing puzzle games can create an intriguing environment in which an individual feels rewarded by the outcome of the activity itself, i.e., finding a solution for a puzzle. According to Bruner (1966), the uncertain outcome of a task is what motivates an individual to pursue it in the first place, as well as the individual's need to control the situation that he or she is facing. Thus, for Brunner (1962), engaging in discovery activities could stimulate curiosity and potentially sustain an individual's attention.

Certainly, digital games can provide spaces in which players can find and explore new things and, consequently, stimulate and sustain their curiosity. For instance, Olson (2010) noted that children enjoyed finding and learning new things in games. Additionally, Shelton and Scoresby (2011) noticed that high school students employed exploratory strategies (i.e., walking around the game environment with their avatar) to collect information needed to solve a problem posed by a game. Moreover, Lepper and Malone (1987) emphasized that curiosity could promote positive effects on learning by stimulating and focusing learners' attention on the activity and tasks presented in the game. That said, Kirschner and colleagues (2006) reviewed empirical studies employing such learning strategies (i.e., discovery learning and other related approaches) in computer-based instruction, and most studies presented negative outcomes for these practices. The authors' criticism of such approaches concerned the minimal guidance given to the learner as well as the expectation that the individual should accomplish everything by himself or herself. According to the findings from this review, learners benefited from guided practice, especially if they were novices regarding the academic content. Conversely, when learners had significant prior knowledge of or expertise with the content, both traditional and discovery learning methods could produce positive learning outcomes. Moreover, Nelson's (2007) findings indicated that just exposing students to a guidance system had no significant gain on science test scores, although students who actually used the guidance system during their gameplay outperformed those who used it infrequently. Therefore, it is important to investigate whether discovery-learning practices can be beneficial for both gaming and academic content learning. In addition, a player's decision to seek help and assistance during gameplay needs to be investigated.

Effectiveness of Game-Based Learning

Although there has been increased interest in digital games for learning on the part of educators and researchers, studies on the effectiveness of these games for educational purposes is still limited (O'Neil et al., 2005). There have been mixed results regarding the effects of games as learning tools. For instance, Randel and colleagues (1992) conducted a review of the literature on the learning effectiveness of games and simulations. The authors analyzed 68 research studies comparing student performance on simulations/games versus conventional instruction. Based on their review, most studies (56%) found no difference between the two approaches, and only 32% of the studies found a difference that favored games/simulations.

In contrast, a meta-analysis conducted by Vogel and colleagues (2006) examined 32 studies on the topic and found significantly greater cognitive gains when individuals were exposed to computer games or simulations than their gains when in traditional classrooms. In addition, the authors noticed that there was a significant effect of attitudinal changes toward learning. Sitzmann (2011) also conducted a meta-analysis on topic; however, different from the other meta-analysis (e.g., Randel et al., 1992; Vogel et al., 2006), the author focused on the use of computer-based simulation games in training or work-related situations. The author examined 55 research studies and found that learning outcomes were higher when trainees were taught with simulation games in comparison to traditional methods. Three aspects of simulation games contributed to the favorable learning outcomes, which were: (a) the use of simulation games to promote active rather than passive learning, (b) unlimited trainee access to simulation games, and (c) the use of simulation games as a complement to other instructional methods.

Despite these benefits, Egenfeldt-Nielsen (2007) advised researchers and educators to be skeptical about the use of computer games for learning. After reviewing a number of studies on the use of computer games for education, Egenfeldt-Nielsen (2007) noticed that most studies were biased and flawed because participants had limited exposure to the intervention, researchers were overenthusiastic about the game, or there was no incorporation of prior research. Moreover, Prensky (2005) argued that the lack of effectiveness in games for learning should not be attributed to the technology itself but to the "bad" design of these games. Indeed, poorly designed games and simulations can have a negative effect on learners as well as on the quality of research conducted with these technologies (Gredler, 1996). A key element of research on the effectiveness of digital games for education is "the measurement and assessment of performance outcomes from the various instructional strategies embedded in the games or simulations that involve the learning outcome of problem solving" (O'Neil et al., 2005, p. 467). Thus, research in digital games must consider a theoretical framework for problem-solving processes and learning outcomes from a game experience.

Theoretical Perspectives in Digital Games for Learning

The theoretical perspectives grounding the work in digital games for learning have been framed under cognitive, socio-constructivist, situated, and motivation learning views. Numerous theories have been implemented in the field of games and learning; however, the theories grounding this research involve cognitive-constructivist theories focusing on problem-solving skills as a part of game play. These theories are discussed in the sections below.

Cognitive-Constructivist Perspectives

According to Piaget's (1983) theory of cognitive development, learning is considered a constructive and gradual process in which individuals, interacting with objects and events, construct their understanding of the world. Through these interactions, individuals acquire and develop their cognitive structures. There are three central processes in cognitive development: (1) *assimilation*, which involves modifying a new experience to be incorporated into an individual's existing cognitive structure; (2) *accommodation*, which involves modifying an individual's existing cognitive structure to fit the experience acquired (Piaget & Inhelder, 1969/2000), (3) *equilibration*, which is a "self-regulating process" (Piaget, 1983) that an individual engages in when faced with cognitive conflicts originated from new input.

Moreover, Piaget (1962) considered play to be an important factor in children's intellectual development. For instance, through play, children can engage in an exercise of practice, which leads them to improve their motor and cognitive skills. In addition, as children play, they start to develop an understanding of how objects in play can be used in contexts outside of play. For Piaget (1962), children's play evolves from practice (i.e., *imitation*) to games (i.e., *games with rules*); it is the latter type of play that this study focuses on. According to Piaget (1962), games can be classified as rule-based activities in which individuals engage in a combination of motor skills such as kicking a ball and cognitive skills such as an individual being confronted by a new situation in the game and using deductive reasoning to resolve that situation. It is through the cognitive skills employed in games that Piaget's cognitive processes are most visible. For example, as children play games, they are constantly activating their cognitive structures to assimilate and accommodate new information during the play. Moreover, playing a game involves trying to reach *equilibrium*, which "is more or less difficult to attain and to maintain depending on the level of intellectual development and the new problems encountered ” (Piaget, 1983, p.108). That is, not only do children’s previous experiences and cognitive structures need to be considered but also children’s interpretation of the situation. As players interact with digital games, they engage in a process of organizing, rearranging, and transforming previous information to accommodate the new input presented in the game. Nevertheless, in order to incorporate a novel situation, a player needs to interpret it and make inferences about how he or she will solve the problem encountered.

Indeed, Simon and Newell’s (1971) theory on problem solving aligns with this concept of interpretation. The authors emphasized that although a problem is initially structured by the environment or by a designer (e.g., teacher, researcher, and so on), solving the problem is still up to the interpretation and inferences that an individual makes concerning the situation. That is, people create mental representations of the problems they have at hand. Indeed, even before thinking about a problem, individuals have already created a system of symbolizing problems in their minds (Simon, 1995).

Overall, problem solving (Figure 2.4) can be defined as a goal-oriented activity (Newell, 1979) in which an individual must find a solution(s) to cope with a set of situations. According to Chi and Glaser (1985), there are four characteristics common to all problems: an (a) *initial stage*, in which individuals are introduced to a problem and its nature; then, solving the problem involves accomplishing some (b) *goal(s),* and in order to do this, individuals must carry out a series of cognitive (c) *operations* to overcome the (d) *constraints* posed by the problem.

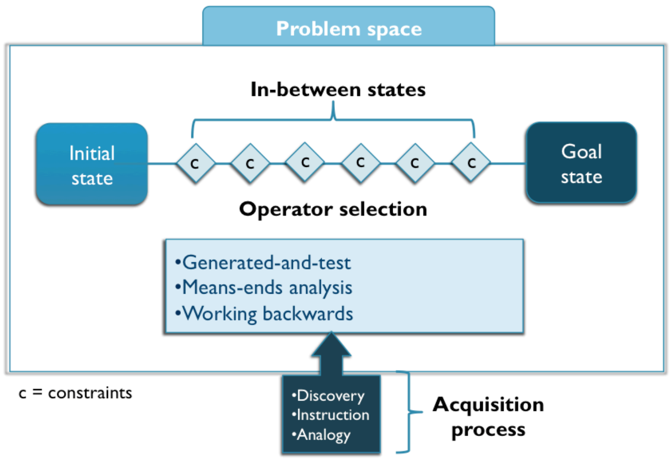


Figure 2.4 Problem-solving process

Besides identifying the characteristics common to similar groups of problems, other researchers have also investigated the cognitive strategies involved in problem solving. For instance, Anderson (2005) identified three ways in which individuals can learn how to solve a problem: (1) *discovery*, in which individuals learn to solve the problem by themselves; (2) *direct instruction*, in which individuals learn how to solve the problem by either abstract instruction given in the problem or someone demonstrating how to solve the problem, and (3) *analogy*, in which individuals make associations between previous and new problems as they employ information learned from one problem in order to reach a solution with another one. Moreover, Glaser summarized three common problem-solving strategies in the cognitive science literature: (a) *generate and test*, (b) Simon and Newell's *means-ends analysis* and *subgoal strategy* and (c) *working backwards* (as cited in O'Neil, 1999, p. 263). First, the generate-and-test strategy involves creating solution(s), either randomly or systematically, and testing them to verify if the solution fits the desired goal (Newell, 1979). For example, as an individual plays a game, he or she might formulate a hypothesis about appropriate actions (e.g., change the position of an object so the character can move to the other side of the screen) and then test it to assess the outcome (e.g., success or failure from moving the character). Indeed, Hong and Liu (2003) discovered this type of thinking strategy when children were playing a problem-solving computer game. Interestingly, the authors noted that the strategy was common among novice groups.

Next, a means-ends analysis and subgoal strategy can be defined as a process of identifying any differences between current and desired goal(s) and this information can be used to select a new operator capable of minimizing these differences. As an example, a player might have to move a character from position A to position B without letting it fall into the water. To solve this situation, the player might have to break down the overall goal into subgoals (e.g., in order to get to position B, the character first needs to go through points x, y, and z) and use appropriate operators for each subgoal (e.g., jump to x, slide under y, and climb z). In fact, Hong and Liu (2003) found a similar type of thinking strategy when an expert group of children was playing a problem-solving computer game. Although Anderson (1993) argued in his theory that problem solving happens within a means-ends strategy, Newell (1979) noted that this strategy requires a supplementary characteristic of the problem, i.e., differences between initial and end goals, which might not be appropriately applied to all problems.

Finally, the working backward strategy involves the problem-solver starting with the end goal (i.e., the solution) to find out the initial state(s) of the problem. For instance, when playing an addition math game in which the solution of the math problem is available (e.g., _+_=10), to win the game, the player must find the potential combinations that match the solution (e.g., 3+7=10; 4+6=10; 5+5=10).

In addition to these strategies, prior knowledge/experience with the content/context of the problem can influence the success in problem solving. Indeed, many researchers and problem-solving theorists (e.g., Chi & Glaser, 1985; Anderson, 1993; O'Neil, 1999) have argued that knowledge of the problem domain can affect problem-solving performance. That is, extensive effort and time with a specific knowledge domain can lead to efficient problem solving and, consequently, expertise in the knowledge domain.

Conceptual Framework

Certainly, one of the main arguments among game scholars and designers (e.g., Salen & Zimmerman, 2004; Koster, 2005; Gee, 2007; Schell, 2008) is that most games foster the problem solving skills needed in everyday life. Indeed, digital games include most problem-solving characteristics and structures. Moreover, players usually employ general and specific strategies to succeed in a game. Besides the strategies, a player's gaming experience and his or her prior knowledge of the game's content will influence his or her success in game play. Thus, the learning concepts and skills incorporated in games should be examined through the problem-solving process involved in the game play.

There are other perspectives associated with games and learning; however, given the nature of most games and the purpose of this study, investigating digital games for learning through a problem-solving lens might result in learning outcomes that actually (or closely) meet the content learning proposed by the game. Therefore, a conceptual framework was developed based on the theoretical perspectives in learning, gaming, and problem solving (Figure 2.5).

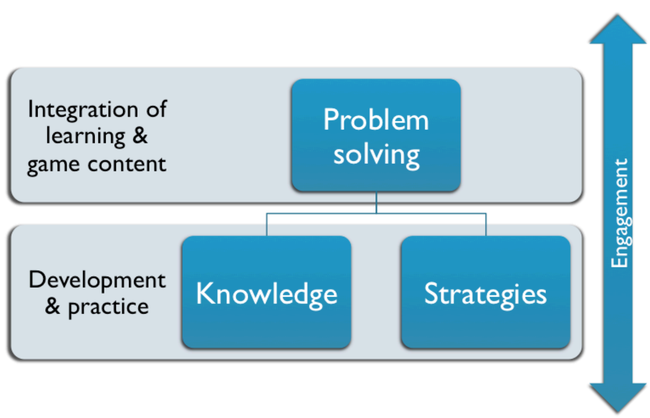


Figure 2.5 Conceptual framework for problem solving in serious games.

In this framework, learning and games are intertwined components of the problem-solving process of game play. That is, children acquire information about the academic content and also practice their gaming and math skills as they play. As previously discussed, prior knowledge and experience influence performance in problem solving. Thus, children who have both domain knowledge and strategic gaming skills, can perform better, thereby making fewer mistakes as they play and, consequently, being more likely to succeed in the game.

In this particular study, two serious games, Bits and Bolts and Pufflescape, were implemented with a group of children during a 10-day game-playing program. Both games include math content as part of their game play, but the content topic of these games differs (i.e., basic arithmetic vs. geometric concepts). Moreover, although the math content in Bits and Bolts is obvious and part of the cognitive process of the game playing, the math content in Pufflescape is concealed and not necessarily an intrinsic part of the game playing. These two serious games are described in more detail in the sections below.

Bits and Bolts

Bits and Bolts (Figure 2.6) is an arcade style game, i.e., a game characterized by fast-paced responses, automaticity, and visual processing (Van Eck, 2006). It is set in a robotic machinery environment in which players match bolt tiles that fall from the top of the computer screen, as in *Tetris,* to build robots. Players have to match the number of bolts in each tile to the number being displayed on the screen. For example, if the number four is displayed on the screen, players can combine two tiles, each holding two bolts, to match the number four. Multiple bolt combinations can be used to reach this goal number such as four tiles with one bolt each (i.e., 4 x 1=4), or two tiles with one bolt and one tile with two bolts (i.e., 1 + 1 +2=4).

Despite these various combinations, to be successful in the game, players must match and combine the multiples of bolts (i.e., multiples of 2, 3, 4, 5, and 6) in order to build a robot.

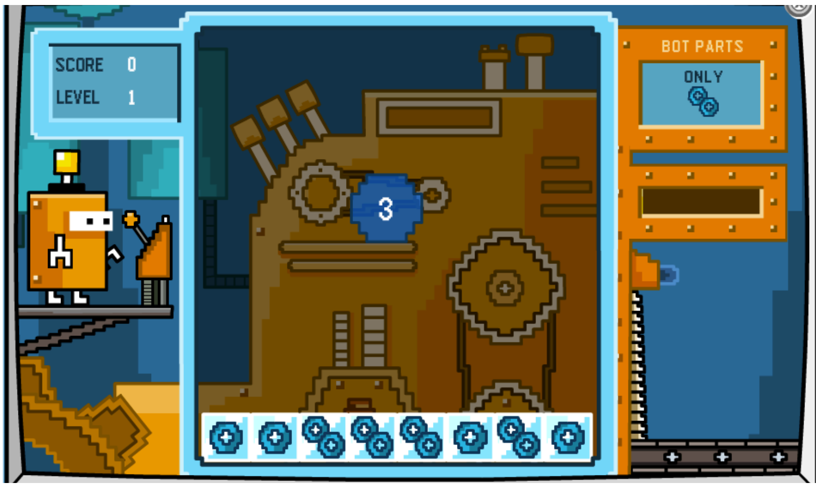


Figure 2.6 Initial stage in Bits and Bots.

Once bolts are matched and combined correctly, the tiles disappear from the screen and players acquire points. Every time a player clears all the tiles from the screen, he/she moves to the next level, or "levels up." As the player progresses, the levels become more difficult with higher numbers as well as increased numbers of tiles. Another challenge in the game is the element of time, or making the combinations as quickly as possible. The longer a player takes to create a combination, the more tiles start to appear at the top of the player's computer screen. Once the screen is full of tiles, the player loses the game. Furthermore, due to its arcade feature, this game does not have a win scenario. Players are encouraged to keep playing the game until they become tired or too bored to continue, which leads players to eventually quit the game.

Considering the problem-solving aspects in Bits and Bolts, the issue in this game begins with a row of random numbers of bolts. The player has to click on the bolts to match the number displayed on the screen. In the initial stage, the numbers to be matched are usually low, such as two or three, and they increase as players complete levels. The end goal in each level is to clear all the bolts off the screen. In order to do this, players can use one of the following strategies:(1) use multiples of two, three, and so on as shown on screen (i.e., game's objective) or (2), use strategies such as key number combinations or count by ones to match the number displayed (i.e., player's personal objective). By following the game's objective, players are able to build robots and earn points. Furthermore, there are several components in the game that create constraints to the player such as (a) *time*, more bolts appear on the screen if players delay their response; (b) *pace*, the speed of the game becomes faster as players complete levels; (c) *number of bolts and displayed numbers*, the quantity of bolts and the number displayed in them increase as players level up; and (d) *mistakes*, bolts are dropped from the top of the screen with wrong answers to the puzzles.

Pufflescape

Pufflescape (Figure 2.7) is an adventure style game, which is characterized by its exploration and puzzle solving activities (Van Eck, 2007). Pufflescape is set inside an icy cave where players have to navigate their puffle (i.e., player's virtual pet in the game) around the environment to collect (a) *puffle O'berries*, which are the puffles' food and (b) *a key*, which unlocks the door that leads to the next level. In order to collect these items, players have to solve puzzles such as manipulating triangle-shaped objects to create inclined planes or rotate polygon shapes to construct a ramp. The game has twenty-three levels, and at each level, players are faced with different type of puzzles to be solved. Moreover, if players collect at least one puffle O'berry, they can access hints about solutions to the game. It is through these hints that players are explicitly exposed to mathematic concepts in the game.

Figure 2.7 Initial stage in Pufflescape.

In contrast with most games, Pufflescape does not have a visible scorekeeping system. That is, players' progress in the game is dependent upon the number of levels they can successfully complete. In addition, if a player is unable to complete a level because he or she cannot move the puffle any further, they can retry that level as many times as they want without being penalized. Given this information, the win scenario of this game is when the player reaches the last level (23rd) of Pufflescape.

The problem in Pufflescape starts with the player's character being placed in a cave, and it ends once the character finds his or her way out of the cave. In order to accomplish this, the player must collect a key that unlocks an exit gate that leads to another area in the cave (i.e., the next level). Players can also set their own personal objectives within the game. For instance, players can collect all items within a level in order to unlock "extreme" levels in the game. Players can also collect one or more of these items to obtain hints on how to solve the problem. In this game, players might use general problem-solving strategies. For instance, players can use a generating and testing approach to create solutions for the problem. These solutions could be reached via random or systematic attempts. Furthermore, players can use direct instructions from the game to problem-solve. That is, the hints in the game can not only help players to problem solve but also promote potential connections between the game play and math content. Moreover, the constraints in Pufflescape vary according to the level of the game. For example, although players manipulate a lever in beginner levels, advanced level players manipulate triangle-shaped objects to create inclined planes. These inclined planes allow the puffle to move up and down the platforms in the game.

Chapter Summary

This chapter reviewed the literature in games for learning. The chapter started with definitions of games and virtual worlds as a means to frame the context of this study. Research conducted with virtual worlds for educational and entertainment purposes were also reviewed and the potential benefits of these tools for education were summarized. Recent studies with school math games were also examined to provide an overview of the use and learning outcomes of these technologies. In addition, this chapter included the motivational factors of games and empirical research studies exploring those factors. Finally, drawing on problem solving theoretical perspectives, this literature review concluded with a conceptual framework for problem solving in serious games.

CHAPTER 3

METHODOLOGY

This chapter provides a description of the methods utilized to conduct a collective case study design of a small group of young children playing two serious games in a part of a virtual world called Club Penguin™. Specifically, the purpose of this study was to determine how children understand, develop strategies for, and engage with these games.

Seven participants were observed, and four cases were selected to support problem solving as an aspect of learning and a key cognitive process of game playing. This chapter is organized in the following sections: (1) research questions, (2) research design, (3) research methods, (4) data quality practices, and (5) summary.

Research Questions

The initial questions proposed in this study addressed both quantitative and qualitative methods in order to examine whether the two serious games could support children's learning in mathematics. Due to changes in the research context and a limited number of participants, the research questions were modified in order to reflect a new method approach to addressing how playing two serious games in Club Penguin™ supported and expanded children's learning experiences. The following three questions informed this study:

1. How do children understand academic and game content in serious games?
2. How do children employ strategies to succeed in playing serious games?
3. How do children engage in or disengage in playing serious games?

Research Design

A qualitative design was used to conduct a collective case study of a small group of young children playing two serious games to support and expand their learning experiences. This methodological approach was applied because of the nature of the research questions, which were framed to understand the aforementioned phenomenon in context. According to Creswell (2007), a qualitative researcher gains comprehensive understanding of a phenomenon "by talking directly with people, going to their homes (…), and allowing them to tell the stories unencumbered by what we expect to find or what we read in the literature" (p.40). Thus, to understand a complex and specific phenomenon such as the one presented in this study, a case study method was identified as an appropriate and useful approach.

A case study can be defined as a "study of the particularity and complexity of a single case, coming to understand its activity within important circumstances" (Stake, 1995, p. xi). Case study research is often used to answer "how" and "why" questions (Yin, 2014) and the objects of study in a case are usually people and programs. One of the reasons for selecting people and programs as cases is based on their bounding properties. An individual can be identified as a case, but when several individuals are defined as "cases," they are often part of a collective case study (Stake, 1995). There are two purposes for conducting case study research: (1) intrinsic, in which the goal is a better understanding of the case by itself, and (2) instrumental, in which the case is examined to support and provide insights into an issue or phenomenon (Stake, 1995). This study employed a multiple-case study, with a total of four cases, and the purpose of the cases were instrumental, i.e., to support and provide insight into problem solving as an aspect of learning and a key cognitive process in game playing.

Paradigm Stance

Research studies are often guided by a paradigm that frames the approach to the research context. Frequently, educational research is framed with the following three perspectives: objectivistic, constructivist, and pragmatic. In an objectivistic perspective, researchers believe that reality is external to the individual and knowledge is a representation of that reality (Jonassen, 1991; Schuh & Barab, 2008). Although in a constructivist perspective, reality is more in the individual's mind and knowledge is constructed or at least interpreted through previous experiences, mental structures, and beliefs (Jonassen, 1991). Nevertheless, these philosophical positions might not be useful for guiding practice. In a pragmatic perspective, knowledge constitutes the action and interaction of human and environment, and reality is a result of experience (Biesta & Burbules, 2003). Based on Dewey's perspectives, reason is an intrinsic rather than extrinsic part of experience (Bredo, 1994). Compared to traditional philosophical perspectives, pragmatism is neither epistemological nor ontological (Schuh & Barab, 2008). In fact, pragmatism could be considered an "anti-epistemology" as Dewey's views of knowledge were not grounded in the distinction between mind and matter (Biesta & Burbules, 2003). This work was framed within a pragmatic perspective, specifically Deweyian pragmatism, to address research problems involving specific contexts.

Researcher Subjectivity Statement

The role of the researcher in a qualitative inquiry is vital. The researcher is the main instrument for data collection and analysis (Merriam, 1988). All data collected is mediated through the researcher's senses. Data are analyzed through the researcher's lenses, which are generated from the researcher's experiences, cultural backgrounds, beliefs, values, and interest in the problem being investigated. Therefore, it is important that I address the personal lenses I brought to this study.

One of the lenses that I carried into this study is my personal history with games. I grew up in an environment conducive to play. Playing games was a means to socialize and connect with and sustain friendships with the other children in my neighborhood. My friends and I used to play different types of games such as board, card, paper-and-pencil, or street games. We also played video games. My first video game console was an Atari 2600. I remember playing the 8-bitcolor games with endless levels and having fun with my friends. Later, when we acquired our first home computer, I recall playing an adventure game, *The Curse of Monkey Island*, with my sister, a game produced and published by LucasArts. We played the games for many hours and days until we were able to complete it. The game had a heavy storytelling component with quests and puzzles throughout. We had to explore around a fictional island to find clues about what kind of actions we had to take in the game. Even though we had fun playing the game, we sometimes felt frustrated when we could not solve the game's puzzles. When that happened, we searched online for cheats or walkthroughs to help us solve them. I believe these experiences as a game player helped me relate to my participants as we might have shared similar emotions and strategies in playing games.

My experiences as a former teacher and media specialist in Brazil are another set of lenses that I bring to this study. First, as a teacher, I often had to communicate with parents and school administrators about students and their progress. The familiarity with this process made my research flow smoothly. Moreover, as a media specialist, I often had the opportunity to observe children playing games in the computer lab. The space offered students an environment different from their regular classroom. It afforded them a way to learn through play. Whenever they were playing the computer games, they were excited, engaged, focused, and on-task. This experience prompted my interest in understanding children's engagement with games and how these tools could support learning.

Although as a female I may have a tendency to identify more with the game play of the girls in the study, I made a conscious effort to refrain from drawing assumptions about participants' game play because of gender. The reason not to emphasize or examine gender as part of this research was to avoid stereotypes. I saw my participants as unique individuals who brought their own preferences, values, and interests to gaming independent of their gender.

Finally, my major advisor was one of the principal agents in designing a set of serious games in Club Penguin™. His involvement in the design process of the serious games contributed to the development of this research. My advisor was also one of the principal reviewers who provided comments on the emergent findings from my research data. Even though his comments were pertinent to enhancing the data analysis, I made certain his personal interests did not influence the findings. Before addressing his comments, I always consulted with my research assistant to verify whether it was appropriate to address the comments in the findings. My research assistant was a first year Ph.D. student in Learning, Design and Technology at the University of Georgia. He contributed to my research by assisting me with the data collection and serving as a peer reviewer for my findings.

Research Methods

This study employed qualitative methods in order to understand the research phenomenon. The qualitative methods included interviewing, which is a method to collect data in the participants' own words (Bogdan & Biklen, 2007), and participant observation, which is a method originated from ethnographic research traditions in which the researcher collects data on social actions and behaviors in context (Saldaña, 2011). The quantitative method involved assessing children's mathematical knowledge before and after a 10-day program. The following sections provide more detail about the data collection, setting, participant selection, and data analysis.

Data collection

Data collection is a process of systematically documenting "patterns, categories, and meanings that humans have created" (Saldaña, 2011, p.31). It provides support and clues about the research phenomenon. In this study, the data collection phase was from February, 2014, to April, 2014, in two settings: a private elementary school in the southeast region of the United States and a participant's home. A set of data collection methods was employed to gather a broader range of evidence. The following sections provide more details about the data collection methods.

Pretest and posttest assessment. An assessment instrument (Appendix E) was designed to measure change in the children's mathematical understanding over time. The instrument was an 11 item multiple-choice computer-based assessment created in consultation with a professor in early childhood mathematics education, who served as an expert to validate the instrument. In addition, a school library professor revised the test according to participants' reading level. Five test items addressed the basic arithmetic covered in Bits and Bolts. These items measured participants' understanding of equal amounts, counting by multiples (of twos, threes and fours) and prime numbers. The other remaining items of the test addressed the geometric concepts covered in Pufflescape. These items measured participants' abilities to recognize same size and shape triangles, identify correct triangles based on their angles and shape format, and identify the angle of a triangle based on the information provided (i.e., the degree measure of an angle is two times the measure of another angle).

The pretest assessment instrument was administered in the first week of the after-school program to verify the participants' prior knowledge of the information covered in the serious games. The questions were presented to the participants as listed in Appendix F. The assessment was conducted during their first day in the after-school program, which varied according to individual schedules. Participants were informed that this activity was an exercise to check their math knowledge. They read the assessment instructions on the computer screen and asked for assistance when they did not understand a question. They were encouraged to complete all items of the instrument and avoid guessing. Their answers were collected via a web-based program and stored in a secure database system.

The posttest assessment instrument was administered in the last week of the after-school program to verify whether there had been improvements in participants' test scores. The questions were randomized. The assessment was conducted during their last day in the after-school program. The same instructions and considerations for the pretest were taken into account when implementing the posttest.

Participant observation. Being a participant observer involves assuming a dual role in the research. As a participant, the researcher takes part in activities appropriate to the situation, and as an observer, the researcher takes note of the activities, people, and events of the situation (Spradley, 1980). As a participant observer, I sought to understand my participants' perspectives in playing games. To gain knowledge in this matter, I created my own student account in Club Penguin™ and played two games to better understand the tasks involved in the virtual environment. I played the serious games that my participants would play during the game-playing program, taking notes on the features and mechanisms of these games. My degree of participation in the game-playing program was a "midrange position" (Saldaña, 2011). I had an active role coordinating the program, but at the same time, my participation was selective. I was not fully immersed in the activities to the same degree as my participants. During the game-playing program, I focused my attention on the events and activities taking place either in the school or the participants' home settings.

Using participant observation as a method of data collection in a case study yielded opportunities and challenges (Yin, 2014). As participant observer, I learned about the research phenomenon through my participants' points of view, which led to a more comprehensive understanding of the study. Nevertheless, my participant role required considerable dedication. At the school site, I often had to contact the technology coordinator of the school to assure children had access to Club Penguin™. I also had to move around among the different computer stations to assist children who were having technical problems. Because of these other activities I had to attend to, I had limited time for observing specific cases. Thus, to supplement and strengthen my participant observation, audiovisual recordings of the children's game playing were collected.

An important activity when conducting observations is maintaining a personal diary or log (Stake, 1995) in which relevant information about the study is recorded. Seeking to record the events and activities in this study, I used a daily planner as my logbook. In my logbook, I kept the participants' schedules, with dates varying based on their availability. I also listed the planned activities and any special events or incidents that happened at the site, e.g., Internet connection issues. In addition to my logbook, I used a notebook for *jottings* (Bernard, 1995). I would write down any information, moment, or incident that caught my attention during the fieldwork. Other techniques employed during my observations were also noted, such as informal interviews with my participants and peer review observation checks with my research assistant prior to and after game sessions.

In addition to the traditional methods of data collection, digital technologies can provide new sources of data for qualitative researchers (Saldaña, 2011). Taking advantage of digital technologies to better understand the research phenomenon, I implemented audiovisual recording methods to capture my participants' interactions within the virtual gaming environment. I recorded the audio and captured a screen video of their game play on my computer using Quick Time Player software. The video recordings were collected on most days in the program, but I usually alternated the video recordings between participants. The reason to alternate video recordings among participants was to include multiple perspectives and ensure that some participants did not feel ignored (Bogdan & Biklen, 2007). I watched all the video recordings and transcribed relevant descriptions and conversations to inform the cases.

Overall, I used a combination of field notes such as jottings, log entries, extracts from audiovisual recordings, and even head notes (citing Ottenberg, DeWalt & DeWalt, 2002), which are the notes that do not get written down but are recalled by the researchers. Appendix G contains a log of field visits with date, day of week, time, participants' pseudonym, serious game playing, and the number of hours spent in the field.

Interview. To better understand a case, it is important to conduct interviews. Researchers conduct qualitative interviews to gain knowledge on how people understand and interpret a research phenomenon. Additionally, interviews are one of the most important sources of data in a case study research and a technique that most case study researchers employ (Yin, 2014). I conducted interviews with closed and open questions to clarify information and generate descriptions of participants' perceptions and experiences (Roulston, 2010). An interview guide (Appendix F) was designed to elicit information about participants' understanding of two serious games during the game-playing program as well as the mathematic content presented in those games. These preplanned questions were used as a guide to explore other related questions during the course of the program.

Interviews can range from structured to unstructured, from planned to spontaneous moments. Even though I planned to conduct formal interviews with my participants, some interviews happened spontaneously while they were playing or whenever an opportunity arose (Saldaña, 2011). Because of participants' diverse schedules, the interviews were conducted individually or with multiple participants at a time. Visual materials such as drawings and game screenshots were used to stimulate participants' response. Interviews were recorded using devices such as digital voice recorders or computer screen recordings.

Setting and Participant Selection

A purposeful sampling (Patton, 2002) strategy was employed in this study in order to identify the settings and participants that could clarify the questions under study. The selection process for this case study began by identifying settings in which I could implement a research-based game-playing program, which has been a common approach among research endeavors in virtual gaming environments (e.g., Siyahhan et al., 2010; Kafai, 2010). The overall purpose of the game-playing program was to provide a physical space in which children could play online games and socialize in a safe community environment within and outside of online spaces. The focus of the program was to expose participants to and encourage them to learn about mathematics through play. Playing two serious math games was included in the program as a means to examine how these games supported and expanded children's learning experiences.

Settings. An elementary school was identified as the most appropriate research site for recruiting participants and conducting a research-based game-playing program. Before selecting the settings, I contacted three other elementary schools in the southeast region of the United States in order to conduct this research. I had multiple meetings and email exchanges with assistant principals and media specialists to confirm the logistics and feasibility of my study. Because of technology issues and a lack of commitment from some schools, the final research settings were a local private school, Bright Spirit (pseudonym), and the home of one of the participants.

Bright Spirit is one of three private schools located in an affluent rural county in the southeast region of the United States. The county covers approximately 121 square miles with a population of approximately 32,808. Bright Spirit is an independent co-educational day school offering pre-school through high-school grades. Bright Spirit's campus has 14 academic buildings, including media centers and athletic facilities. Given that Bright Spirit often offers students after-school programs, I decided to conduct this research in its school facilities.

The other research site for this study is a participant's home, which is located in a consolidated city-county in a southeast region of the United States. The county covers approximately 186 square miles with a population of 116,714. The house is a small rented dwelling in an upscale residential area. The neighborhood is typically composed of college students and small families. This area is also known for its historical residences and local businesses. Although this research site was selected because of convenience (Miles & Huberman, 1994), it became a case of contrast to the cases selected from the school.

Participants. A total of seven children between the ages of six and 10 years old participated in the game-playing program. Six of the participants in this study were enrolled in

Bright Spirit School, where I visited the site from Tuesdays to Fridays for about 50 to 100 minutes. The remaining participant was not part of the aforementioned school, and I visited her at her home. The purpose for selecting this specific cohort population was based on the target age audience of the virtual environment Club Penguin™ (i.e., children aged six to 10 years old). All participants took part in similar activities in the game-playing program. The home participant was the only one who played the game for longer periods (i.e., about 60 minutes) and was not asked to complete math assessments given the nature of her setting.

The selection of cases for this study was based on typical or representative cases (Stake, 1995). In addition to the typical cases, the following two criteria were used to refine the selection: (a) the grade level of participants, which was appropriate and relevant to the content covered in the serious games, and (b) engagement with the serious games, which varied among the four participants. Table 3.1 below summarizes the participants who were part of this study and highlights the four cases in this study.

Table 3.1

Summary of Demographic Profile of Participants

Pseudonyms	Grade level	Site	Ethnicity
Ingrid	Kindergarten	Home	Latino/Hispanic
Susie	Grade 1	Bright Spirit	White
Emma	Grade 1	Bright Spirit	White
Elizabeth	Grade 2	Bright Spirit	White
Rachel	Grade 3	Bright Spirit	White
Ben	Grade 3	Bright Spirit	White
Clara	Grade 4	Bright Spirit	White

Ethical considerations. Prior to conducting this study, ethical considerations were taken into account. Research proposals for the school and participant's home were submitted and approved separately (Appendix A) by the Institutional Review Board (IRB). The principal from the elementary school level of Bright Spirit was contacted about this research opportunity. Once permission from the principal was secured, an approval letter was submitted to the IRB as an amendment. Parents were informed about the research-based game-playing program opportunity via letters (Appendix B) distributed to their children at the school site and through other public announcements such as school news. Parents who agreed to let their children participate in this research opportunity were asked to sign a parental permission form (Appendix C). Before the beginning of this research, participants received written communication describing the activities taking place throughout the course of game-playing program, and individual assent forms (Appendix D) were collected from each participant. All of the information designed for the children was written according to the lowest reading level of this cohort population. If children had difficulty reading or understanding any information, I explained it in simple terms. Any confidential information and identifiers were removed and replaced with pseudonyms.

A researcher can be delightful company for participants, but the researcher's presence can also be a burden (Stake, 1995). To avoid being a burden in this study, I considered the needs of my participants and other stakeholders involved in this research. For instance, the initial research proposal was modified from including twenty visits to ten visits because school administrators and parents were concerned about the effects of long time period exposure to games. Moreover, I kept track of time during the game-playing program to avoid any delays to parents' schedules. I set my phone alarm to ring ten minutes before the 50-minute session was up. I instructed participants to resume their activities and directed them to the school front desk where parents often waited for them.

Data analysis

Only qualitative data were analyzed in this study. Quantitative data were reported in each case; however, no statistical analysis was conducted. A particular qualitative data analysis strategy was used to construct the cases: interaction analysis (Jordan & Henderson, 1995). This analysis technique was conducted to examine the interaction of participants with the virtual environment. Other practices borrowed from Grounded Theory methods (Charmaz, 2006; Corbin & Strauss, 2008) were implemented to identify recurring patterns and themes throughout data collected.

Interaction analysis can be defined as an interdisciplinary method for examining "the interaction of human beings with each other and with objects in their environment" (Jordan & Henderson, 1995, p.39). A primary focus of interaction analysis is the investigation of human activities and their use of tools. The researcher analyzes verbal and nonverbal communication that people engage in during activities. The researcher also examines the tools used in those activities in order to learn about common practices, problems, and solutions. Interaction analysis is an appropriate analytical strategy for digital data, specifically video recordings. Video recordings allow for the replay of interactions and corroboration of observations.

Considering the video recordings collected, I used several strategies from interaction analysis in this study. First, I proceeded through the video data inductively, identifying common patterns and routines. The video recordings from the home participant were the first to be examined because data collection in the participant's home began earlier than that in the school setting. Common patterns and routines in the home participant's video data served as a framework for observing the video recordings from the school setting. My transcription from the video recordings usually included annotations of screen-based activities such as the objects participants were manipulating within the game or mouse cursor movements.

Following Jordan and Henderson's (1995) guidelines, I chunked the video data based on the events happening within a game session. Using a prototype video analysis tool under development (Rieber, 2014), I marked the beginnings and endings of events based on participants' activities within the virtual environment. I used gerunds (e.g., "playing Bits and Bolts" or "visiting penguin's igloo") to label these events to provide a sense of action and sequence to the data (Charmaz, 2006). Only events related to Bits and Bolts or Pufflescape were transcribed. As these events were transcribed, I wrote memos (Corbin & Strauss, 2008) to record my initial analyses of the data. I used my initial "DCB" to separate the memos from transcription and nonverbal annotations in the video analysis tool.

Jordan and Henderson (1995) also suggested that the analyst attend to segmentation, especially the transition from one segment of an event to another. I followed these procedures to observe any segmentation patterns when participants were about to disengage from playing a game. These segmentation patterns were often indicated by repeated mistakes made when a participant was about to leave the game or move the mouse cursor near the exit button. I also attended to *turn-taking*, especially when actions were taken in response to verbal communication and vice versa.

Conducting interaction analysis is laborious and time-consuming work (Jordan & Henderson, 1995). I reviewed and replayed the video recordings multiples times before writing up the data report. Given that the transcription and nonverbal annotations alone were not sufficient to make sense of the data, I often returned to the video recordings and reviewed them.

This activity took a considerable amount of time. I had to go back and forth within the transcriptions, field notes, and video recordings to identify clues about the research phenomenon. The final findings from this study were reported as descriptive cases with a detailed profile of the four participants and their experiences playing two serious games.

A step-by-step of data analysis. Once all data had been collected, I was overwhelmed by the amount of content generated, especially from the video recordings. I was unsure where to start and which strategies to use to make sense of the data. Thus, my first step in the data analysis process was to select a unit of analysis, i.e., home, and examine its data sources in order to identify common patterns. First, I read my field notes generated from ten visits to a participant's home. As I was reading these field notes, I highlighted relevant information and I made side notes to seek further information in other data sources, i.e., video recordings. Then, I started watching and transcribing all nine video recordings from the home participant. At that time, I used a paper-and-pencil method to record the transcriptions because it was easier to observe the video recordings and transcribe the audio content in a side notebook than to keep switching between computer screens to watch the video and type the audio content. After all audio from the home video recordings had been transcribed, I realized I had to take the do the following with the remaining data set: (a) seek data reduction, as not all data transcription was relevant to answer my research questions, and (b) include screen recording transcriptions, as significant data came from actions and events taking place on the computer screen.

Before starting my data analysis from the school setting, I had the opportunity to use a prototype video analysis tool under development (Rieber, 2014) to organize and facilitate my data analysis process. This video analysis tool (Figure 3.1) had the capability to store video recordings and allowed for separated audio and screen transcriptions. There were also video control capabilities that allowed video analysts to chunk and segment video content into short video clips. Video analysts were also able to tag data content with short words or labels.

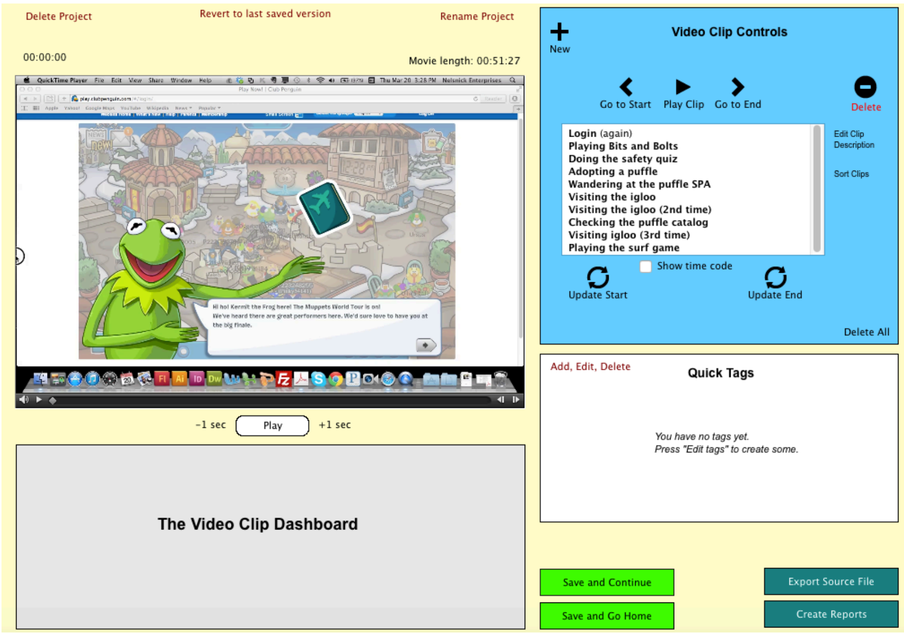


Figure 3.1 Screenshot of the prototype video analysis tool

While using this tool to analyze my video data, I followed a series of steps and procedures to complete my data analysis. First, I loaded all video recordings from the school participants to the video analysis tool, labeling each video according to participants' pseudonyms and the school visits date. I analyzed the school videos from each participant separately to acquire a more comprehensive understanding of each participant as well as their interactions with the games. As a means to data reduction, I used the tool's video clip capabilities to chunk the video data. I labeled each video clip based on the activities participants engaged in during the game-playing sessions. Instead of transcribing all audio and screen content from the videos, I purposefully transcribed data content related to playing Bits and Bolts and Pufflescape, as those were the serious games targeted in this study. As I transcribed the audio and screen content, I used the video analysis' tags to label important information occurring within the video clips of participants playing Bits and Bolts and Pufflescape (e.g., counting by key combinations or creative play). Once audio and screen transcriptions were completed, I printed the video reports to sort the data and find common patterns among participants. With the video reports, I also had access to the amount of time participants spent playing the serious games in this study. At this point of data analysis, I reviewed printed reports and video recordings to ensure I was not missing any relevant information in the data set. I also took this approach to confirm that my data interpretation was an accurate representation of the events and actions that occurred in home and school settings.

Data Quality Practices

Researchers in qualitative studies must account for the process they used to arrive at findings and ensure rigor and quality. There are several guidelines and criteria to assist them in learning, practicing, and perfecting excellent qualitative work (Tracy, 2010). To ensure that "quality" practices were taken in this study, I followed the procedures below.

Engagement in the Field

I was engaged for approximately two months (i.e., 31 visits) with fieldwork at two different research sites. These visits to the research sites allowed for repeated observations of the research phenomenon (Merriam, 1988). As I observed and interacted with participants in their settings, I built rapport with them, which was essential to the data collection and to learning more about the phenomenon of interest.

Triangulation

Employing triangulation practices allows for *uncontestable descriptions* (Stake, 1995) that support what the researcher sees and observes in the field. To support my observations in the field, I used two types of triangulation: investigator triangulation, which means to have more than one researcher in the field collecting and interpreting the data to collect (Bryman, 2011) and data triangulation, which means having multiple sources of data collection strategies to confirm the findings.

In terms of investigator triangulation, I had a research assistant at the school site. He collected field notes and provided his interpretation of the data. During fieldwork, we often had peer debriefing moments to check our observations prior to and after sessions. Comparing our field notes allowed for corroboration of our interpretations. The research assistant also served as a peer reviewer for the findings.

For the process of data triangulation, I gathered multiple sources of data such as video recordings, audio recordings, and written field notes to confirm and contrast the findings. Video recordings allowed me to correct any misinterpretations from paper-and-pencil observations in the field. In fact, video recordings can afford a comparison of the researcher's bias with the machine's bias, which is automated and lacks the reconstructive bias of the researcher (Jordan & Henderson, 1995).

Delimitations

Seeking to better understand children's experiences with serious games, this case study is bounded by a specific set of cases taking place in specific contexts. The serious games examined during children's play focus on a specific subject (i.e., math) and are part of a particular virtual environment, Club Penguin™. The purpose of this study does not include, and might not be applicable to, envisioning the outcomes for these cases or other cases that might share similar features. Additionally, there was no intention in this research to provide grand generalizations (Stake, 1995) beyond these cases presented in this research. The focus of this research was to generate a descriptive report from the cases so teachers and parents could develop personal interpretations about the applicability of these cases to similar situations they may be facing with their own children.

Chapter Summary

This chapter summarized the purpose of a case study for understanding how playing two serious games in Club Penguin™ supported and expanded children's learning experiences. All design issues focused on the following research questions: (1) How do children understand academic and game content in serious games? (2) How do children employ strategies to succeed in playing serious games? (3) How do children engage in or disengage from playing serious games? The chapter described the study design with a case study approach and the research methods implemented. Methodological descriptions covered the setting and participant selection and the data analysis. The chapter listed the processes undertaken to ensure a quality study. The next chapter presents the collective case study of a small group of young children playing two serious games.

CHAPTER 4

A CASE STUDY OF SERIOUS GAMES

This chapter is presented as two main cases: serious games at home and serious games at school. The cases presented in this chapter are the stories of four participants: three participants were first and second grade students enrolled in a local private school and one participant was a kindergarten student at a local public school. I visited the kindergarten student at her home. All four participants were part of a 10-day game-playing program where children were encouraged to play games for learning purposes, but also had a chance to select games and activities of their choice during sessions. Participants' names, their families and their schools have been changed to provide as much anonymity as possible.

I started my investigation in early February 2014, and completed the study in early April 2014. The use of pre- and post-tests, video recordings, interviews, and observations provided a rich source of data for the study. The cases presented below were chosen based on the following criteria: (a) the age of the children, which was appropriate and relevant to the content covered in the serious games; and (b) engagement with the serious games, which varied among the four participants. The cases are presented in two sub-sections: playing Bits and Bolts and playing Pufflescape. Both sections present children's learning experiences with the games, their engagement, and strategies employed during game playing. This chapter ends with a cross-case analysis of the similarities and differences among the four cases.

Serious Games at Home: The Story of Ingrid

Ingrid was a small and slender girl with whom I had a chance to work for about two months. At the time of this study, Ingrid was six-year-old and was a kindergarten student at a public school. Ingrid had small brown eyes and an olive skin tone. She often wore her straight long brown hair loose during our visits. Ingrid lived with her parents and a younger brother in a small house in a college town. Her house was located in a very clean and quiet neighborhood surrounded by young couples with children.

Ingrid's mother, Amélia, and I met through common Brazilian friends during a social event and since then we became friends. Although Amélia was Brazilian, her husband was American. He often traveled to Brazil for research purposes so he spoke fluent Portuguese. Because both parents spoke Portuguese at home, Ingrid spoke the language frequently. In an informal conversation with Amélia, I realized it was a ground rule for the family to speak Portuguese at home as a way of exposing and stimulating her children to speak their mother's native language. Being acquainted with me through her mother, Ingrid normally spoke to me in Portuguese. But during my first visit, Amélia suggested I speak with Ingrid in English to help her understand my questions better, especially if those questions were related to my research. As her mother recommended, I often spoke with Ingrid in English during my visits, though Ingrid often replied back in Portuguese. Sometimes, she started a sentence or even responded to my question entirely in Portuguese. In addition to speaking the language, Ingrid also used expressions typical of the Brazilian culture. For example, Ingrid called me "auntie Daisyane" in Portuguese - an affectionate way of calling someone older and close to parents' age in the Brazilian culture.

As I talked with Amélia about my research, she told me Ingrid was very good in math and her reading level was at or higher than her grade level. Amélia also confessed to me that she rarely allowed her children to play any digital games at home. Amélia often monitored and limited her children screen media time. Her parents typically encouraged non-digital formats of activities such as reading a book, riding a bike or outdoor play.

I had a total of nine visits with Ingrid. My visits with Ingrid were scheduled on the weekends, usually on Saturdays, and after lunchtime when her younger brother was sleeping and less likely to disturb his sister. Given the home context, no assessments were administered with Ingrid. Amélia was always at home whenever I visited Ingrid. Amélia either did house chores or her homework from college while I worked with Ingrid, usually in the dining room. But if any other family members were in the house at that moment, Amélia suggested another room (e.g., living room or Ingrid's bedroom) that Ingrid and I could use for about an hour. During my visits, I frequently asked Ingrid to play Bits and Bolts or Pufflescape. I often alternated the games during visits. The sections below describe the story of Ingrid playing Bits and Bolts and Pufflescape.

Playing Bits and Bolts

As described in Chapter 2, Bits and Bolts (Figure 4.1) is a game in which players click with the mouse cursor on bolt tiles presented on the screen. The bolt tiles fall down from the top of the game screen, similar to the Tetris game. Players click on the tiles to match a numerical digit presented on the screen. Once players click on a correct combination of bolts, each clicked bolt tile explode and disappear from the screen. Whenever players make correct combination of bolts, they earn points, which is displayed on the left side of the screen. Every time players clear all bolt tiles on the game screen, they move to the next level. The activity players perform in each level of Bits and Bolts is similar. The difference between levels is that higher numerical digits are presented and the number of bolt tiles increases when players level up. In addition, the game's pace becomes fast, with more bolt tiles being dropped from the top of the game screen.

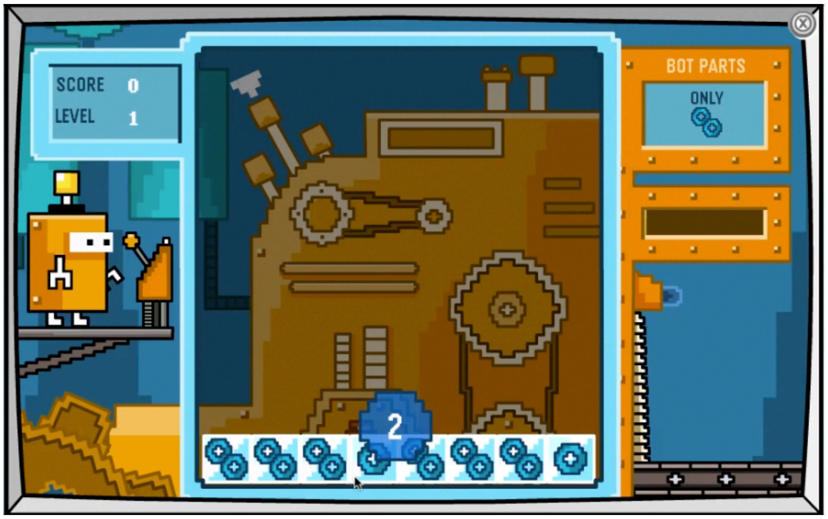


Figure 4.1 Screenshot of the initial screen of Bits and Bolts

Unclear understanding of the game. During my first visit to Ingrid's home, I asked her to play Bits and Bolts for me. I guided her through the virtual environment of Club Penguin, telling her where to click or go to reach the game location. Once the game screen was loaded, two buttons were displayed (i.e., start and instructions). I asked Ingrid which one of the buttons she should click first. Instead of verbally replying my question, Ingrid just clicked on the "instructions" button. This was a common way that Ingrid interacted with me. She usually preferred to perform an activity or showed me something in the game instead of replying to my questions verbally.

When the instruction screen was presented, I asked Ingrid if she wanted me to read the instructions for her and she nodded her head yes. The content of the game instructions (Figure 4.2) was displayed into four machine-looking blocks and presented as textual and visual information. The textual information was introduced in single sentences with math terms being presented such as “multiples” or “prime”. The visual content on the screen complimented the text and displayed actual images and symbols used in the game playing. As I read the instructions for Ingrid, I asked her what numbers were displayed on the screen to verify if she could recognize those numbers. Ingrid was able to identify the numbers correctly as she answered “three” and “six” for my questions.

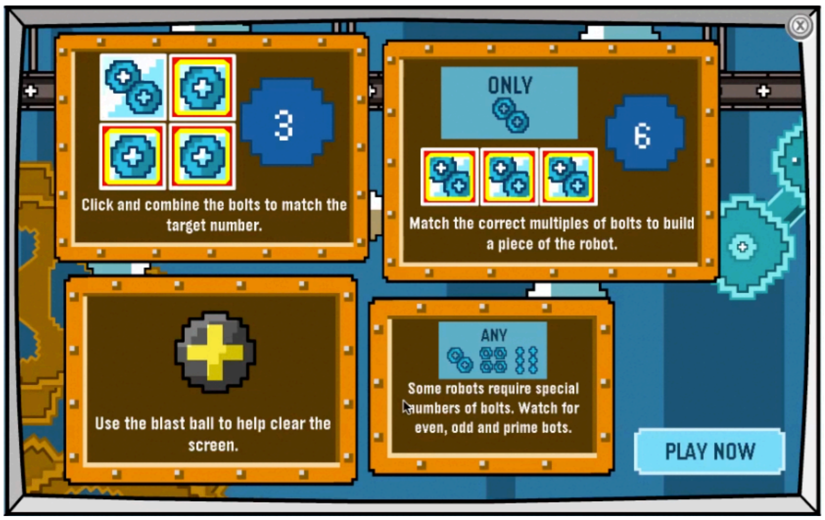


Figure 4.2 Screenshot of the instructions of Bits and Bolts

After I read the instructions, Ingrid started to play the game. Seeking to confirm that Ingrid understood the instructions, I asked her “what number is this one?” Ingrid immediately replied with the correct answer, “two.” I followed up with another question, asking if she knew which bolt tiles matched the number two displayed on the screen. Ingrid responded “this one,” clicking on a two-bolt tile at the bottom of the screen.

While playing, Ingrid made a few mistakes here and there. Ingrid appeared sad, saying “awe” with a certain disappointment, whenever she made mistakes in the game. Sometimes, she even acknowledged the game, saying “I know” that was an incorrect combination. Her mistakes often happened when the targeted numbers were prime numbers such as five and seven. It was unclear to me whether Ingrid understood the goal and subgoals of the game. For instance, seeing she was making more mistakes during a certain moment of her play, I asked her if she thought the game was getting difficult and she replied “it’s because I’m clicking only where I want to.” Later, I asked her if she meant she was clicking wherever she wanted and not counting the bolts. Ingrid answered me saying, “I’m clicking where I think it goes.” Where Ingrid thought it should go resulted in more incorrect combinations. Ingrid was avoiding counting. She clicked randomly on the bolts in order to add up to the targeted number on the screen. Her actions reminded me of students using guessing strategies on homework or a test when uncertain of the answer. Consequently, Ingrid made more mistakes in the game when she used this strategy, which led her to ask for the “bomb” to clear the tiles on the screen. Overwhelmed with the amount of tiles on the screen, she quit the game. During the seven minutes of play, Ingrid reached the third level of the game and achieved a score of 417.

At the end of this visit, I interviewed Ingrid about the games she played on that day. When I asked her what she could remember from the games, Ingrid did not seem to recall them. Given it could be difficult for her to recall the games and the tacit knowledge involved in playing, I showed her screenshots of the games to elicit information. Checking if she could remember anything from Bits and Bolts, I asked:

D: Do you remember this one here? What did you do in this game?

I: Hmm… I needed to take the “ice cubes.” Is that the name? Is it what I said? Take?

D: Mhm.

I: And earn coins.

When asked if Ingrid remembered what the game was about, her response was “uh-huh.” Although Ingrid’s short and negative answer was an indication of her not remembering the game, her answer could also be an excuse to not ask her further questions about the game. Her reasons for avoiding more questions about Bits and Bolts might be related to her inability to articulate her thoughts of the game. As aforementioned, Ingrid's actions within the game appeared to be without attention to the rules as she clicked wherever she wanted to clear the tiles. Therefore, Ingrid's understanding of the game goals might have been unclear.

Soft punishment system and distractions at home. The next time Ingrid played Bits and Bolts, she made mistakes as soon as she started to play the game. Ingrid incorrectly combined one-bolt tile with a two-bolt tile in order to match the number two displayed on the screen. In our previous game session, Ingrid successfully demonstrated she was able to identify the number two and find its correspondent bolt tile. Still, this time she made a mistake. A few seconds later, she incorrectly matched the number five by clicking on three two-bolt tiles. When I asked her about the mistakes, she waited to respond and said: "I like when it breaks." Ingrid's comment referred to the bolt tiles that had just broken into small pieces and disappeared from the screen when she made a correct combination of bolts. Ingrid liked clearing the tiles because she earned more points in the game, as she mentioned later.

Although Ingrid seemed to understand that clearing tiles meant combining bolt tiles correctly, her actions to make correct combinations appeared to depend on chance instead of counting and clicking on bolt tiles to match the targeted number on screen. For example, Ingrid clicked randomly on the tiles as they occasionally matched the number on the screen. Her game strategy was merely a trial-and-error approach, which led her to make more mistakes throughout the game play. Whenever I asked why or what happened in that situation, she remained quiet or said she did not know. She did not demonstrate much concern when mistakes were made at this time, even if more tiles were dropped from the top of the screen. It appeared she was apathetic to the situation. Her apathy could be a result of the soft punishment system in the game.

Whenever Ingrid made a mistake, the game feedback was: an "x" mark on top of the tiles she had clicked, a shaken game screen for a few seconds and a sound effect indicating that the combination was wrong. There was no point deduction from the player's score. The punishment was more tiles dropped from the top of the screen, which for Ingrid, more tiles to be cleared meant earning more points. Since she was motivated to accumulate points, perhaps a game consequence of losing points for incorrect matches might motivate Ingrid to better learn the game. Such a game design might increase and sustain a child's interest in the game.

In this session, Ingrid played the game for almost ten minutes. Throughout her game play, she made a total of forty-four mistakes; nearly five mistakes per minute. She did not "beat" the first level of the game, but she did build at least two robots and made bombs blow up tiles in the game. Ingrid did not seem to understand she had built robots using multiples of bolts. Although she cleared more tiles during her second session as compared to the first session, her score was lower. Her poor performance could be a result of a couple of distractions Ingrid had while playing the game. She had to pause the game at least three times. The first time was to say goodbye to her father and brother who were leaving the house to go to a birthday party. A few minutes later, her mother offered to make a vegetable juice for us and we paused the game again. The third time was to get some water. These intermissions compromised Ingrid's game play as her attention had been divided between the game and other events happening at her home.

Too many questions, no response. During the next time playing Bits and Bolts, Ingrid spent a little more than six minutes playing the game, and her performance in the game indicated some improvement. Ingrid made fewer mistakes than her previous time playing the game. A total of twenty-six mistakes were made throughout the game -almost four mistakes per minute.

In addition, Ingrid was able to move quickly -in less than a minute- from the first to the second level of the game, but she cleared fewer tiles (174) and had a lower score (253) than her previous times playing Bits and Bolts. Although the low number of tiles cleared and the score could be a result of the small amount of time she spent playing the game, another factor that happened during our session on that day could have contributed to that result.

Before Ingrid started to play Bits and Bolts, one of her neighborhood friends, Carrie, dropped by to play. Carrie watched Ingrid play the game for a few minutes until Ingrid's mother stopped by the room and asked her to come back in an hour because Ingrid was free to play with her by that time. While her mother was talking with Carrie, Ingrid seemed distracted by their conversation, making more mistakes while playing the game. Once Carrie left, Ingrid continued playing and said: "Oh, my God." Hearing that, I asked her a couple of questions such as if she thought the game was getting difficult or how she was doing in the game. She made mouth noises or sighed, but she did not answer my questions. I started asking questions in Portuguese and then switched to English as I noticed she did not reply. Still, I did not get any answer from her. When she finally answered one of my questions, she mumbled: "I don't know." At first, I thought Ingrid avoided answering my questions because she was upset that her friend had to leave her home. After examining the video recordings, I noticed more questions were asked during this specific session of Bits and Bolts than others. The number of questions posed could be overwhelming for Ingrid to answer to the point she just ignored them. In addition, the amount of questions could interfere with Ingrid's game play and concentration.

Needless or undesirable counting in the game. In her forth time session with Bits and Bolts, Ingrid played other games of her choice in Club Penguin™ before playing the requested game. When she realized the game requested was Bits and Bolts, she said in a sad tone: "awe…

this again". Not surprisingly, Ingrid did not play the game for too long. She played it for a little more than two minutes, and she reached the third level of the game. Throughout her game play, she made a total of ten mistakes; approximately five mistakes per minute. Similar to the previous session, she built a robot, but seemed unaware she built a robot. Ingrid employed the same strategies she used previously to succeed in the game. She continued to click randomly on the screen and this time, she moved the mouse up and down quickly in order to guess the correct tile combination.

Once Ingrid exited Bits and Bolts, I asked her a couple questions about the game. Ingrid had difficulty answering my questions. She typed on the pre-built chat box while I was talking to her. I tried to get her attention a couple of times, but she was distracted with the computer. I decided to draw a paper version of Bits and Bolts' game screen (Figure 4.3) to elicit information. Based on the drawing, I asked her which tiles she should click. Ingrid indicated all of them. Her reasoning to click on all of them was because "it explodes." When questioned whether they need to match the number displayed, her response was "sometimes not, and sometimes yes." Unsure if her answer referred to individual bolt tiles or the actual combination of them, I circled a few tiles on the paper and asked her how many bolts were there. Ingrid counted them and said: "seven". Since the combination did not match the targeted number five, I asked her if it matched. Ingrid shook her head no. But when I questioned why clicking on all tiles if it did not match the number five, she mumbled: "I don't know."

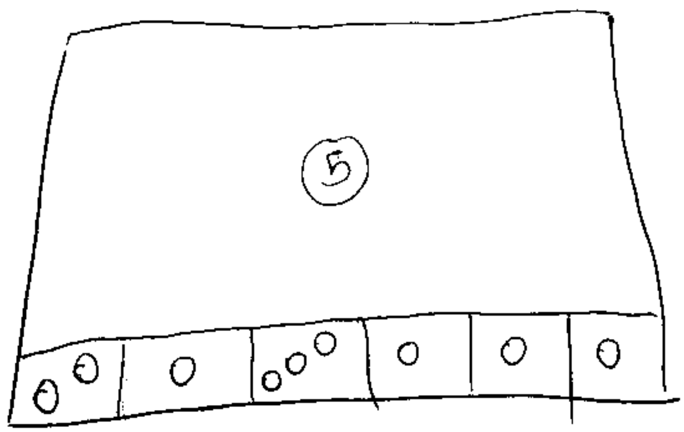


Figure 4.3 Paper version of Bits and Bolts game screen

Ingrid was unable to provide an explanation for her suggestion of clicking all the tiles presented on the paper. Her inability to provide an explanation could be a consequence of Ingrid's unclear understanding of playing the game. For instance, Ingrid was able to count numbers, as she demonstrated in this session, but avoided while playing the game. Her reasons for not counting during play might be related to the activity being needless or undesirable. As a needless activity, Ingrid may have not counted in the context of the game because she could depend on chance or luck. As an undesirable activity, Ingrid might not enjoy practicing it while playing. The task of counting, on top of other game elements to be attended to, might be demanding and unpleasant for a child who is still developing that skill.

Play investment. Another time, Ingrid played Bits and Bolts for less than three minutes. Her score (106) and the amount of tiles cleared (77) during this session were not as high as her previous one. Ingrid moved from the first to the second level of the game in just a few seconds. Once on the second level of the game, Ingrid started to make mistakes when trying to match small numbers such as three or four. I asked her questions about how she was doing in the game and if she was counting to match the numbers presented on the screen, but she did not answer my questions. Almost a minute after Ingrid had been playing the second level of the game, the screen was quite full of bolt tiles. Ingrid shouted: “Bomb! I need the bomb!” Given that there were no bombs to clear the tiles, Ingrid moved the mouse around the center of the screen in an attempt to still succeed in the game, though her chances of beating this level were slim. Ingrid made a total of sixteen mistakes throughout the game; a little more than five mistakes per minute.

Overall, Ingrid appeared to depend on external factors such as bombs or chance to be successful in the game. Indeed, she was not investing much time or ability to triumph in Bits and Bolts. Her lack of investment might be associated with her value and interest in the game, which seemed low. Ingrid appeared to not enjoy playing Bits and Bolts as much as other games or activities in Club Penguin™. For example, she preferred Pufflescape to Bits and Bolts, as she mentioned during one of my visits. Ingrid also played other games, including Pufflescape, longer than Bits and Bolts.

The last session. The last time I asked Ingrid to play Bits and Bolts, she started the game saying: “Oh, brother! This is easy”. She was doing well on the first level of the game until she made a mistake trying to make the number four. At that moment, there were only three tiles left for Ingrid to level up (Figure 4.4). The tiles were set up, from left to right, in the following order: two-bolt tile, two-bolt tile and one-bolt tile. Ingrid clicked the tiles in the reverse order, i.e., moving from right to left. Consequently, her tile combination added up to five instead of four. Upset with that situation, Ingrid said in a surprised tone: “How come I’m not in the next level yet?” She played the first level for a little more than one minute until she reached the next level. Once she had reached the second level of the game, Ingrid moved her mouse close to the game exit button. It seemed as if she wanted to quit the game, but was expecting my permission. Because I did not explicitly say whether she could quit the game, Ingrid continued to play.

Ingrid made a couple more mistakes as she played the game's second level. By the end of the session, she made a total of seven mistakes throughout the game, close to three mistakes per minute. Even though the amount of mistakes were less than in her previous sessions, Ingrid's interest in playing the game did not last any longer. She played the game for less than three minutes and her goal did not seem to beat the game but to earn coins. For instance, while Ingrid was still playing the game's second level, she read her current score and then asked me the amount of coins. I replied that she had eight coins so far. Ingrid seemed surprised that she only had that amount. She continued to play the game a little longer just to earn more coins and then she quit it. Her score (121) and the amount of tiles cleared (86) during this session were a little higher than the previous session.

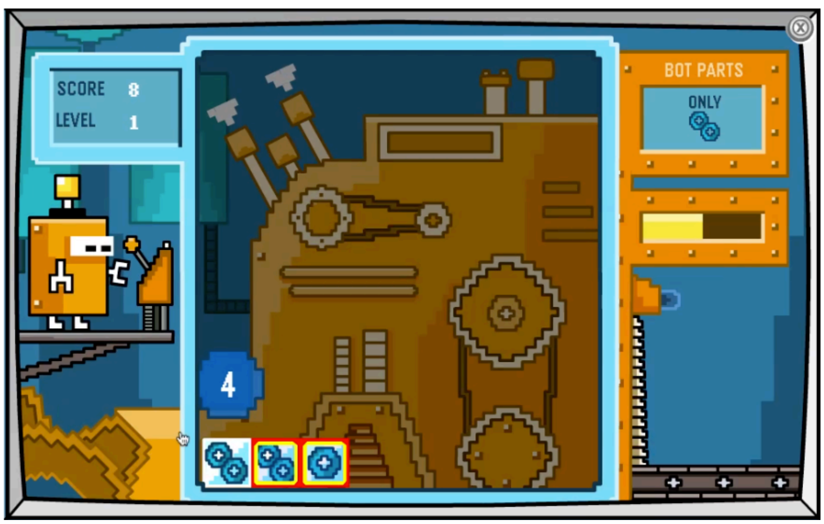


Figure 4.4 Ingrid trying to complete the target number four

Based on the observation sessions, Ingrid was able to count the bolts in order to match the targeted number on the screen. However, she often chose not do so when playing the game. Her reasons to avoid counting and engage in guess attempts could be a reaction to the quick pace of the game. As the player cleared tiles, more tiles were dropped from the top of the screen. Given that Ingrid was still developing her counting skills, a fast-paced game wherein counting is the main task could have been overwhelming for her. Based on the decreasing time spent playing Bits and Bolts, Ingrid did not seem to be engaged in the game. It appears Ingrid employed a guessing strategy in the game to avoid counting while she played the game I had requested. Ingrid's behavior toward Bits and Bolts was similar to students who quickly finish their homework, without checking their work, just to engage in tasks they enjoy. In Ingrid's case, she likely played the game for a small amount of time with little engagement, because her ultimate goal was to play other games or engage in other play activities (e.g., nurturing her puffle, buying virtual items or editing her avatar) in Club Penguin™.

In summary, Ingrid showed some signs of improvement in the game as she made fewer mistakes toward our last session. It appeared Ingrid avoided counting, as she randomly selected tiles on the screen. Whenever asked about the reasons for mistakes in the game, Ingrid did not seem to know what had happened, almost as if it was the fate of the game. Moreover, the time Ingrid spent playing Bits and Bolts decreased. She moved from nine to less than three minutes of play. Her decrement of time in Bits and Bolts could indicate her lack of engagement in the game. Although Ingrid started to move to the second level of the game quickly, the game did not sustain her interest or attention. Several factors may have contributed to Ingrid's limited attention or interest in the game. One factor was the distraction within the environment where the game was located. Bits and bolts had to compete for Ingrid's attention since there were more interesting and fun games and activities in Club Penguin™. In addition, the home environment triggered other distractions as family members and their activities around the house pulled Ingrid away from the game. Another factor was the fast pace of the game. It was challenging for Ingrid to succeed in a game that required quick counting since she was still developing her counting skills. Moreover, Ingrid may have perceived the task in Bits and Bolts as monotonous because there was little variation from one level to the other.

Playing Pufflescape

Pufflescape (Figure 4.5) is an adventure style game set inside an icy cave where players have to navigate their puffle (i.e., player's virtual pet) through platforms, ramp and half-pipe to collect Puffle O' berries and a key, which unlocks the gate door to the next level. The game has twenty-three levels. There is no visible score keeping system. Players' progress in the game is based on the level reached. Players can retry a level as many times as they want without being penalized. In each level, players are faced with different types of problem solving activities in order to collect items in the game. For example, players have to collect the three berries, which is one the most difficult objects to collect in each level of the game. It usually requires players to manipulate levers and shapes to make a ramp, identify and recognize angles and even apply notions of motion to launch their puffle. Players often use the Heads-Up Display (HUD) to assist them to complete this task. The HUD is an orange technical drawing presented on top of the game screen with information and hints about the solutions of puzzles in the game. It is through the hints that players are explicitly exposed to mathematic concepts, including theorems and formulas, in the game. Players only have access to the HUD if they collect at least one berry.

Figure 4.5 Screenshot of the initial screen of Pufflescape

In my first visit to Ingrid's home, I suggested she played Pufflescape. Ingrid had just finished playing Bits and Bolts and now she was moving her penguin avatar to the Pet Shop area in Club Penguin™. Once Pufflescape's game screen loaded, Ingrid tried using the mouse to play the game as she had previously done with Bits and Bolts. Because her puffle was not moving as she clicked on the mouse, she questioned: "what do I do?" Before I even began to explain, Ingrid said "Ah!" noticing the arrow buttons highlighted on a wood sign at the top of the game screen. She pressed the arrow keys to move her puffle around. At the beginning, she did not use the heads-up display (HUD) and continued advancing to more challenging levels in the game. Unable to pass one of the levels on her own, I suggested she explored the icons at the top of the screen for help or hints. Once Ingrid clicked on the HUD, I asked her about the objects she could use to help her decode the information presented on screen:

I: What is this?

D: It's telling you to grab something, right? Where is it? Where is a thing that looks like this one?

I: Here.

D: Right.

After becoming comfortable in a level, she turned off the HUD saying “I don’t need it” anymore. As she moved to another level in the game, Ingrid appeared to make the connection that objects glowing on the screen were objects with which she could interact by moving or grabbing them within the game space. In addition, she only collected one berry and the key in each level she played. Still, Ingrid realized the goal involved collecting the three berries as she said: “I’m not collecting three.”

Throughout the course of her game sessions with Pufflescape, Ingrid usually played each level of the game. She repeated levels she had previously completed rather than continue from the last level reached. Given this situation, the sections presented below were divided based on the levels of the game she played and their relevance to build Ingrid’s case.

First level: no need for HUD. When playing this level of the game, Ingrid used the arrow keys on the computer keyboard to move her puffle from the left to right side of screen and vice-versa. As she navigated her puffle around the cave, she collected the key and berries hovering above platforms in a cave. The icy nature of the cave allowed the puffle, which was trapped inside what it looked like a hamster ball, to roll fast over the platforms. Collecting all the berries in this level involved manipulating a wooden-looking lever on the ground floor of the cave to turn into a ramp. With the correct inclination for the ramp, Ingrid was able to launch her puffle to aboveground platforms. Through the course of our sessions, Ingrid never checked the HUD in this level. But Ingrid sought to collect all the berries. The following paragraphs present Ingrid’s problem solving process in collecting the three berries in this level.

The second time Ingrid played this level of Pufflescape she said: “Ah?! I already know that is arrows,” referring to the arrows glowing on the screen. In less than half a minute, Ingrid collected the key and moved to the second level of the game. Surprised by how fast she moved to the next level, Ingrid said: “this one was easy!” Initially, her goal was to achieve the next level instead of acquiring all berries.

The next session playing the first level, Ingrid tried to collect the three Puffle O’ Berries. First, Ingrid manipulated the lever turning it into a ramp before her puffle even reached the ground level. Ingrid aimed to get her puffle to jump on the ramp, but instead her puffle jumped toward the key. Ingrid shouted, “I didn’t want this,” because the gate door opened. Her reasoning for not opening the door at this point was to prevent her puffle from escaping the cave before she collected the three berries, as occurred in our second game session. Ingrid restarted the level. On her second trial, Ingrid had her puffle on the ground and started to set up the ramp to get the three berries. Ingrid rolled her puffle over the ramp and launched it toward the platform on the left side of the screen. Unfortunately, she was not able to collect the berries. Her puffle hit the wall of the cave and bounce to the ground floor without collecting the berries. Unwilling to continue trying, she decided to move forward to the next level of the game without the three berries.

Only by her fourth session playing the game, was Ingrid able to collect all the berries in the level. First, she set up the ramp before she even got her puffle on the ground floor of the cave. Once the ramp was set up, Ingrid rolled her puffle off the platform. Her puffle landed on top of the ramp. From the impact of the fall, her puffle bounced back and moved the lever position down. Ingrid commented on her puffle’s action saying, “my puffle is heavy.” After that, she launched her puffle to the aboveground platform and collected the three berries.

The last time she played Pufflescape, Ingrid had mastered her strategy of setting up the ramp first, collecting the three berries and the gate key to move to the next level of the game. Ingrid also made improvements in her timing to complete all the tasks in this level.

Second level: generating enough speed. Ingrid used similar arrow key movements to roll her puffle around the cave. Collecting the three berries in this level involved manipulating the lever and positioning to a 35^{o} angle to turn into a ramp. With the lever in this position, players launched their puffle to the aboveground platform to collect the three berries. Another viable option was to gain speed to launch the puffle. On the left side of the aboveground platform, players rolled their puffle to generate speed from and jump to the opposite platform. The following paragraphs present Ingrid's problem solving process in generating speed to collect the three berries.

When Ingrid played this level of Pufflescape for the second time, she said "I don't want it to be too eas… it's easy again, I guess". I asked her if she knew how to do it, but she did not reply and started to move her puffle around the game. First, Ingrid collected one of the berries and tried to collect the other ones hovering above the gate door. While clicking on the HUD, Ingrid questioned if there were any icicles to be used as ramp. I asked her what she thought she should do in that particular situation, but she did not reply. Ingrid started to manipulate the lever as shown on the screenshot below.

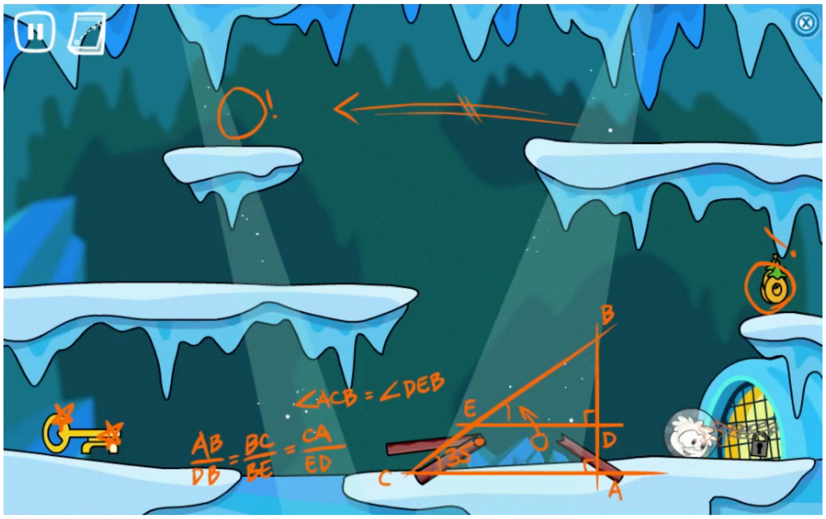


Figure 4.6 Ingrid manipulating the lever in Pufflescape

As presented in this screenshot (Figure 4.6), Ingrid appeared to not understand what to do with the lever or the exact position needed to create a ramp. Instead of positioning diagonally according to the line segment “CB”, Ingrid positioned the lever horizontally according to the line segment “ED”. After manipulating the lever, Ingrid moved her puffle to the other side of the screen to collect the key. Once the key was collected, she said: “Yes! But I want to get this,” referring to the three Puffle O’ Berries. Ingrid started to move her puffle toward the gate direction; however, her puffle was unable to move any further. Realizing the current position of the lever was blocking her puffle from moving, Ingrid said a little frustrated: “Argh! I need to close this.” Ingrid brought the lever to its initial position and tried to collect the berries without the ramp. Ingrid cried: “no!” as her puffle entered through the gate door instead of jumping on the platform above the gate. After two minutes playing this level, Ingrid tried to sound positive saying, “thankfully, I got one!”

Next time Ingrid played this level, she was determined to collect the three berries. After three attempts, she collected all the berries and the key. On her first trial, she set up the ramp before her puffle even reached the ground floor of the cave. Her puffle landed on top of the ramp, but had low speed to reach the platform where the berries were located. Ingrid tried it anyway, but failed in her attempt. Unable to figure out by herself how to solve the level, she clicked on the HUD. As she observed the information on the screen, Ingrid followed the line segment “CB” with her mouse cursor and said a little frustrated: “I don’t wanna… redo, redo, redo.” Ingrid decided to reset the level, instead of playing as it was. For Ingrid, resetting the level was easier than manipulating the lever and moving the puffle back and forth to reach the desired platform. Ingrid reset the level twice to collect the three berries. On her first attempt, she set up the ramp before her puffle reached the ground. With her puffle on the lower platform, Ingrid gained speed with her puffle, but not enough to reach the platform where the three berries were located. On her second attempt, she continued to set up the ramp before her puffle reached the ground. With her puffle on the lower platform, Ingrid generated enough speed for her puffle to jump off the platform and collect the three berries. After the berries, she quickly collected the key and moved on. Because her puffle was able to jump the platform without the ramp this time, she tried to employ the same strategy in subsequent sessions that she played on the second level.

The last time playing this level, Ingrid did not set up the ramp beforehand. She tried to employ the same strategy she had done before, which was to generate enough speed to jump to the platform where the three berries were located. Ingrid attempted this strategy, but failed to reach the platform. With her puffle on the ground, Ingrid set up the ramp to launch her puffle to get the three berries. She launched her puffle toward the platform, but it did not reach enough speed to jump up to the platform. After two failed attempts, Ingrid decided to not collect the three berries. After collecting the key, she moved to the next level of the game saying, “at least I got one. ”

Third level: get the key first or fail. To move through this level easily, Ingrid had to follow these steps: (1) leave the lever at its initial position so the puffle could jump to the platform where the key was located, and then (2) move the lever up, at an approximate 35^o angle position, to jump to the platform where the three berries were located. Because Ingrid did not follow these steps, she ended up struggling and failing to succeed in this level. The following paragraphs present Ingrid's problem solving process in generating speed to collect the three berries

When Ingrid played the third level of Pufflescape, she said "uh-oh! This is going to be difficult". Indeed, Ingrid spent more time playing this level than the first or second level of the game. First, Ingrid collected one of the berries by having her puffle jump off the main platform in the level (Figure 4.7). Once her puffle was on the ground, Ingrid asked "now what?" Uncertain of what to do next, Ingrid checked the HUD, which she called "map". The HUD presented the force formula, or the product of mass and velocity divided by time, as useful information to solve this level of the game. Typically, conceptual laws of motion and forces are taught in eighth grade (see Georgia Performance Standards). Ingrid, a kindergarten student who was still learning how to read, was introduced to the force formula. Although Ingrid needed some basic understanding of force and its components to make sense of the formula, she was able to experiment with it in the context of the game.

Figure 4.7 Ingrid playing the third level of Pufflescape

As Ingrid continued to play this level, she turned the HUD on and off a couple of times. Ingrid suggested she might need to redo the level. When I asked if she could click on the HUD again, she said “no!” Then, we had the following conversation:

D: Could you move this one here [referring to the lever]?

I: Hummm… [moving the lever all the way to the left side of the screen]

D: Can you only move this way?

I: I think this is for him to… puff.

D: What if you move this way?

I: It will close.

Ingrid moved the lever beyond the “close” position, which got it stuck. I clicked on the reset button so Ingrid could restart the level. Ingrid moved the lever back and forth and tried to check the HUD, which was inaccessible at that time because her puffle had not collected a berry yet. Feeling a little frustrated with lack of support, she said: “I don’t know how to do this”. Then, I suggested she use the mouse to move the lever, but Ingrid replied: “then I couldn’t get this, this or this” referring to the berries on the screen.

After a few unsuccessful attempts, Ingrid checked the HUD again and said she had an idea. First, she reset the level. With the puffle in its initial position, she rolled it toward the direction of the key. Her puffle gained enough speed to jump off the platform and collect the key, all in less than half a minute. Assuming Ingrid did it by chance, I asked her how she did it. Instead of telling me how to and providing a rationale, Ingrid said: "I'll show you. I can do it again." She clicked on the reset button and started the level again. Ingrid followed the same procedure she did before to complete the task. Ingrid rolled her puffle forward, generating speed to jump to the platform where the key was located. Even though Ingrid was too young to comprehend the force formula, she determined the necessary speed for her puffle to jump and reach the target.

The next time Ingrid played this level of Pufflescape, she focused on collecting all berries in the level. First, she collected the one located on the platform where her puffle was on. Then, she decided to collect the most difficult one, the three berries, which were located on the top platform. Ingrid used the lever to make a ramp and had her puffle jump up to reach the top platform and collect the three berries. After successfully collecting the three berries, her puffle fell down from the top platform and Ingrid commented in a sad tone:

I: Now, what should I do?

D: Can't you come here?

I: I'm gonna see if this works…

Ingrid tried to find easier solutions so she did not have to manipulate the lever. For instance, she moved her puffle to the bottom of the hill and then moved it back up in order to gain speed to jump up to reach the key. But Ingrid was not successful in her attempt. Her puffle barely reached the platform where the gate key was located. Thinking that her attempt failed by accident, Ingrid tried the same strategy again without success. Appearing to be annoyed with this situation, Ingrid said: “I wanna redo, redo, redo” and clicked on the reset button. While playing the level again, Ingrid collected one of the berries hovering above the same platform where her puffle was. After collecting the berry, her puffle kept moving, following the laws of motion, and fell down from the platform without collecting the key. Unwilling to figure out the problem, Ingrid said she wanted to play another game. Seeking to understand her reasons for quitting the game, I asked:

D: Why? Is it too difficult for you?

I: No, I just want to.

D: Why?

I: Gibberish [I don’t know]

When asked if she was tired, she positively nodded her head. Ingrid left the Pufflescape.

The fourth time Ingrid played this level, she attempted to collect all berries in the level as she did before. Interestingly, Ingrid did not want to let her puffle fall down from the platform and when that happened she reset the level. One of the reasons to avoid letting her puffle fall down was related to the actions she took to get her puffle back to the platform. For example, Ingrid had to maneuver the mouse up and down to manipulate the lever and use the arrow keys to roll her puffle back to the platform. For a young child like Ingrid, this task could be challenging. Resetting the level was an easy solution to bring her puffle back to its initial position.

After resetting the level, Ingrid collected the three berries by using the lever as a ramp. Ingrid also collected all the other berries in this level. The only object left was the key to open the gate to the next level. Ingrid made several attempts to collect the key, but she failed. Voicing frustration with the situation, Ingrid blamed her puffle for her lack of success: “I can’t get my puffle to stop being naughty!" After four minutes trying to collect the key, she whined: "Ai! This is difficult." Seeing her frustration with the level, I asked Ingrid if she wanted to quit this game to play another. Ingrid suggested quitting Pufflescape to check the amount of coins earned by playing the game.

The fifth time playing the level, Ingrid said: "this is the difficult one," recalling she struggled with this level before. Ingrid attempted first to collect all berries in the level as she did in previous sessions. Ingrid only made two attempts to collect the three berries before quitting the game. First, she used the lever as a ramp to launch her puffle to the top platform. Without gaining enough speed to reach the desired platform, her puffle fell on the ground. Failing in this attempt, Ingrid went for a second trial. In her second attempt, Ingrid used the lever as a ramp again, but this time she moved the lever higher than usual. Ingrid positioned the lever upright, at 90-angle degree. Ingrid launched her puffle up, but once again she failed to reach the desired platform and collect the three berries. Unable to determine on her own the appropriate strategy to reach the three berries, Ingrid quit the game.

The last time playing this level, Ingrid attempted first to collect all berries, as she did in previous sessions. First, she used the lever as a ramp to launch her puffle to the top platform. She succeeded in her attempt to reach the desired platform. Consequently, Ingrid collected the three berries. She also collected the remaining berries in this level. The only object left for Ingrid to collect was the gate key. She made two attempts, but failed to collect the key. After her second unsuccessful attempt to collect the key, Ingrid stopped playing the game to check the amount of coins earned. Seeing the amount of coins she earned, I suggested she continued playing the game to earn even more coins. Ingrid made two attempts to collect the key. Failing both attempts, she did not want to play anymore and quit the game.

Overall, this level was challenging for Ingrid. Sometimes, she collected the key but not all the berries. Other times, she collected all the berries but not the key. Ingrid had to leave the lever at its initial position so her puffle could jump to desired platform and collect the key first. Only after collecting the key, Ingrid could move the lever up, at approximate 35 ^{o} angle position, to jump up to the platform where the three berries was located. Not following this sequence of steps, Ingrid continued to fail in collecting all items in this level. Even tough Ingrid had to go through several unsuccessful attempts, she was able to observe principles of motion and forces in practice as she pressed the arrow keys to move her puffle up and down, speed up and jump platforms.

A hint of creativity. In the fifth level of Pufflescape, Ingrid had to roll her puffle up from the bottom of a snowy hill to generate speed so her puffle reached an aboveground platform near the gate. Usually, when the puffle reached the platform, it continued to stay in motion, leading the puffle to fall off. Preventing her puffle from falling off the platform, Ingrid used an icicle hanging at ceiling of the cave as a brake. This icicle was designed to function as a ramp, launching the puffle to collect the three berries and reach the opposite platform. The following paragraph presents Ingrid's problem solving process in stopping her puffle's motion.

Ingrid played the fifth level of Pufflescape during my fourth visit to her home. At a first glimpse of this level, she said: "this doesn't look too difficult…but it might be a little bit." Ingrid managed to launch her puffle up the aboveground platform, collecting one of the berries. Then, Ingrid clicked on the HUD to check what to do with the icicle available in this level. Ingrid tried to use the icicle as a ramp per indication of the HUD, but she ended up finding another purpose for it. Ingrid used the icicle to stop her puffle from moving and falling from the platform (Figure 4.8). Her puffle fell several times before she reached this solution. In this event, Ingrid used the icicle to achieve her own goal, instead of the one proposed by the game. This was a creative solution from Ingrid as she faced the problem of preventing her puffle from falling off the platform.

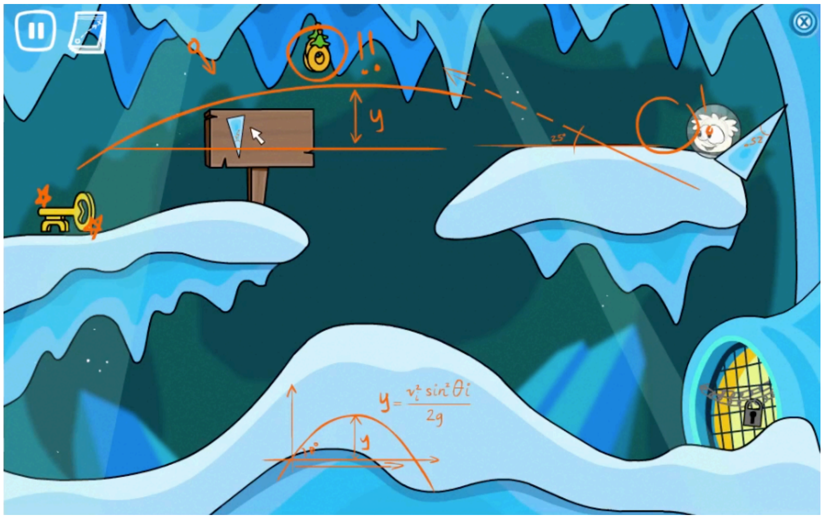


Figure 4.8 Ingrid playing the fifth level of Pufflescape

Decoding the HUD. The purpose of HUD was to provide hints and information about solutions for the puzzles in each level of the game. Sometimes, decoding the HUD was difficult because there was extraneous information beyond what was needed to solve the puzzles in the game. Thus, following paragraphs present Ingrid's attempts to understand the HUD in two different levels.

Ingrid played the seventh level of Pufflescape during my fourth visit to her home. In this level, Ingrid had to bring her puffle down from an upper-level platform. Then, Ingrid used a block of ice to make a small bridge above the water so her puffle crossed platforms. By making this bridge, Ingrid was able to collect the berries hovering above the water. Collecting the three berries involved gaining speed to reach the top platform or use the block as ramp to launch the puffle. Collecting the key involved bringing the puffle to the water with enough speed to dive or submerging it with block of ice to collect the key in the water.

When Ingrid played this level, she collected the key and most of the berries. Determined to collect the three berries, Ingrid sought the assistance from the HUD (Figure 4.9) to complete the task. Ingrid said nicely: “Map, could you help me?” Once she clicked on the HUD, she attempted to decode its information. “I need to get those three,” Ingrid said pointing to the circles in the HUD. But the information was not intuitive enough for Ingrid to decode by itself as she later mentioned: “the map doesn’t show well for a child.” Ingrid reset the level and was able to collect one of the berries. Still, Ingrid pondered, “how can I get it there?” to collect the three berries. There were two blocks presented in this level, but Ingrid was unable to identify which one to use, and how to reach the berries. Struggling to reach the top platform with her puffle, Ingrid gave up on collecting the three berries. She collected the key and move on to the next level of the game.

Figure 4.9 Ingrid playing the seventh level of Pufflescape

Ingrid played the eight level of Pufflescape during my fourth visit to her home. In this level, Ingrid had to make her puffle jump off platform to bring it down to the ground floor. Then, Ingrid used three ice blocks to make a bridge above the water so her puffle crossed and reached the gate door. By having her puffle cross the bridge, she was able to collect the three berries.

When Ingrid played this level, she was able to interpret the HUD. In contrast with the seventh level of the game, the information presented in the HUD appeared to be clearer for Ingrid. Ingrid placed one of the ice blocks hanging from the ceiling above the water. Ingrid attempted to get her puffle on top of the ice block. Unable to do this task, Ingrid consulted the HUD to assist her in this level (see Figure 4.10). Since the HUD displayed three-square red scribbles above the water, Ingrid said: “So all three go on here, right? It looks like.” Ingrid placed the three ice blocks above the water as presented by the HUD. Ingrid was able to collect all the items for this level, including the three berries.

Thus, there were moments when Ingrid was able to understand the information presented by the HUD as indicated when she played the eighth level of the game. Still, there were other moments when she was not able to decode the meaning of the scribbles and how to use objects available in a level, as indicated when she played the seventh level of the game. In the seventh level, there were two blocks, but Ingrid was unable to identify which one to use and how. Thus, it appeared Ingrid interpreted the HUD when the information was based on her prior knowledge of experiences and no extraneous information was presented.

Figure 4.10 Ingrid playing the eighth level of Pufflescape

In summary, Ingrid faced a paradox of successes and failures in her problem-solving process playing Pufflescape. She often used trial-and-error approaches to solve the puzzles in this game. Ingrid was able to observe principles of motion and forces in practice as she played the game. One of the levels Ingrid struggled the most was the third level of the game. Even though failure in this level was unpleasant and source of disengagement with the game, Ingrid invested more time playing this level of the game than other levels. There were also signs of creative play in the fifth level of the game. Ingrid used the object in the level to attain her own goal instead of the one proposed by the game. Finally, Ingrid appeared to interpret the HUD when the information was based on her prior knowledge of experiences and no extraneous information was presented.

Bright Spirit School

Bright Spirit is a private school located in an affluent rural county in the Southeast region of the United States. The school administrators provided me with an opportunity to hold a research-based after-school program at its facility. The program was held from Tuesdays to Fridays, with two sessions being offered on Tuesdays and Thursdays. The schedule of the program varied per participants. I contacted parents via email or phone to identify the best dates and times to work with their children.

My research assistant, Leo, attended most sessions with me. We arrived twenty minutes prior to the first game session with participants. Per recommendation of administrators, we parked our cars at the pre-k school parking lot to avoid the elementary school traffic. As regular classes finished, students were brought to the elementary main hall; a room surrounded by glass walls. The glass walls facilitated the job of staff members to call the name of students as their parents arrived at the hall door to pick them up. The children whose parents were picking them up stayed seated in rows on the floor while children participating in extended hour activities stayed seated at cafeteria benches. These benches were located at the hall stage and served as a waiting area for program counselors and students. I usually met my participants at these cafeteria benches.

Once all participants who were enrolled in the first game session arrived, Leo and I took them to the classroom assigned to our program activities. The classroom usually had a computer cart with mini PC laptops. Unfortunately, most of the PC laptops were slow and needed software updates. The software updates interfered in this research because playing Club Penguin™ required computers with the most recent version of Adobe Flash Player software. Thus, Leo often had to go through a series of laptops until he was able to find a few that participants could use during our sessions. One of the participants even helped in this process. She indicated which computers worked better for her. We often used those computers as she suggested.

Before I started my research at Bright Spirit, I told school administrators about the problems I had faced with Internet security and access to Club Penguin™ in another school. School administrators sympathized with my story and guaranteed I was not going to deal with these problems in their school. The technology coordinator for the school created a special password-protected network for my research. Through this network, participants were able to access Club Penguin™. Even though this special network was step up, participants still had problems accessing Club Penguin™. There were at least two days in the program when students were not able to play the games because of network issues. During those days, participants talked among themselves or did their homework in order to "not was time," as a participant mentioned.

Serious Games at School: The story of Susie

Susie was a small 7-year-old child with whom I had the chance to work during an extended hour program in a local private school. Susie was an amiable, quiet and kind-hearted girl. She had wavy shoulder-length dark blonde hair and big blue eyes. I met Susie twice a week, Tuesdays and Thursdays, for about a month at the school. I usually picked her up at the playground area because she was part of the second game session of the day. Once our session was over, I took Susie to the school front desk where her father was already waiting for her. Susie's father was one of the school teachers and was always cooperative with my research. He volunteered information about his daughter's play with Club Penguin™ at home. He told me Susie enjoyed playing Club Penguin™ games at home and appeared to not be tired of playing them.

During our sessions, I observed Susie's progress from playing games and engaging in Club Penguin™'s activities at home. For instance, Susie played Card-Jitsu for the first time during our visit on early March. Card-Jitsu was a card game in which players took turns choosing a card from their deck to battle other players. The goal of the game was to earn virtual "belts" to become a ninja. Each card held an element (e.g., fire, snow and water), a color and a numeric value. According to the Club Penguin™ website, players won a match if they collected either three different element cards or the same element with three different color cards. Susie played four matches that date and on all four matches, she lost to her opponents. Two days later, Susie had already earned a white belt. After playing and winning other matches that day, she earned a yellow belt.

There were other evidences of Susie's engagement with Club Penguin™. For instance, compared to other participants in the same after school program, Susie had a lot of coins. Susie earned 1,208 coins in the first week of our after school program while other participants had between 269 and 854 coins. By the end of our sessions, Susie had already acquired rare pets. She had rainbow puffles, which were only available after a player completed a set of tasks in the Puffle Care Quest, and golden puffles, which were available after a puffle dug 15 gold nuggets. She also engaged in the current events happening in Club Penguin™. For example, there was a Muppets World Tour in Club Penguin™ around mid-March. Members dressed their penguin avatar as one of the Muppets' character. Members also performed tasks to collect objects and rewards from the Muppets. Seven days after the opening of the tour, Susie already completed all the eight tasks.

During this game-playing program, Susie took a pretest and posttest assessment related to math concepts. Her score on the pretest was already the highest score possible, but her posttest score dropped one point. On the posttest, Susie provided an incorrect answer to a multiple answer question that all other participants misunderstood. Indeed, Susie provided the correct choices, as she did in the pretest, but also added two other incorrect choices. One of possible explanations for her score to drop could be a lack of clarity in the question since other participants did not provide correct answers either. Another possible explanation could be related to the game she played. The question she provide an incorrect answer targeted content presented in Bits and Bolts. In the game, players had certain flexibility to combine bolts to match a targeted number on the screen. After playing this game in the program, Susie might have misunderstood the question. Instead of answering only the options with the same bolts to make the number twelve, she provided all possible options.

Playing Bits and Bolts. Bits and Bolts was a fast-paced game in which players cleared tiles on the screen by matching correct bolt combinations. During our sessions, Susie often played Bits and Bolts for approximately eight to twelve minutes. Once, while she was playing the game, Susie told me she had played Bits and Bolts at home by herself. When I asked her if she liked the game, she said "uh-hu" in a positive tone. The highest level she reached in our sessions was the fifth level of the game. When playing the game, Susie often made mistakes when trying to build prime numbers. The following paragraphs illustrate this information.

In our initial session, Susie and I talked about the games she had played in Club Penguin™ so far. Then, I asked Susie: "could we play, for just a little bit, Bits and Bolts? And then you can choose another one that you want to play." Susie agreed "uh-hu." In the first level of the game, Susie was asked to combine bolts to make small numbers such as two, three, four and five. Within twenty-five seconds of gameplay, Susie had already moved to the next level of the game. In the second level, higher numbers such as six, seven and eight were displayed on screen. Susie took longer to move to the next level. During this level, I noticed Susie had problems in making the number seven. For instance, she clicked on a two-bolt tile and moved her mouse over to another two-bolt tile to click, making a total of four bolts. After that, she stopped her mouse movements for a few seconds. Slowly, she maneuvered her mouse across the screen, looking for specific bolts to complete the number. She clicked on the only one-bolt tile on the screen at that moment and waited for more tiles to be dropped. There were other tiles (e.g., two-bolt tiles) on the screen, but Susie did not click on them. Once she completed the number seven, I asked her what she had to do there and she said, “I had to wait”. Susie waited for one-bolt tiles to be dropped from the top of screen to continue her task of making the number seven. Using single bolts to complete this task might be an approach to make counting easier for her. This incident could also be a condition from learning key number combinations at school. For example, a key number combination to make seven often used the number four and the number three. Although Susie did not use a three-bolt tile to make the number seven, she did use three one-bolt tiles to complete the number.

Within less than two minutes playing in the third level, Susie made her first mistake. She had to make the number seven again. She had the following pieces to make the number: three one-bolt tiles, one two-bolt tile and one three-bolt tile. The tiles were randomly distributed on the screen as shown on the screenshot below.

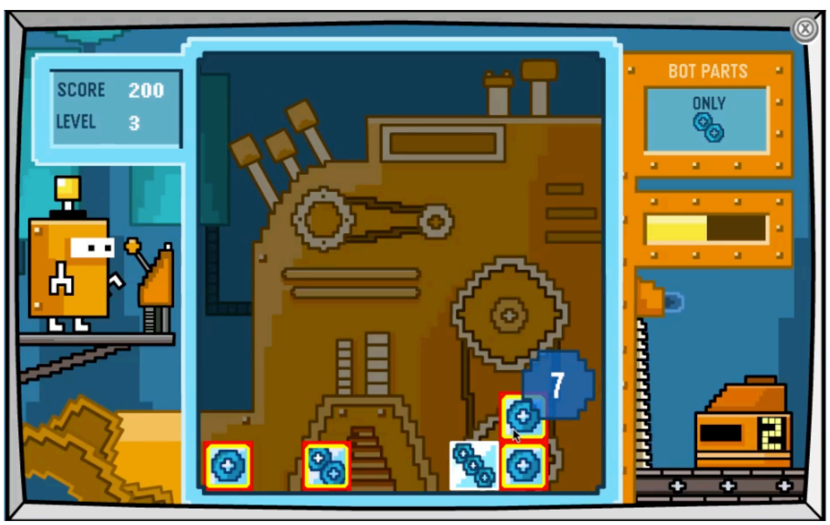


Figure 4.11 Screenshot of Susie’s Bits and Bolts gameplay

First, Susie clicked on the tiles positioned on the left side of the screen before moving towards the right. She moved her mouse over the three-bolt tile and stopped there for a few seconds.

Next, she moved her mouse over the one-bolt tiles and clicked on them. With only one tile left, Susie clicked on the three-bolt tile, which added to eight instead of seven. When I asked her why she did not get that one right, she said, “I didn’t mean to press three.” She made another mistake with the number seven again and this time there were other pieces available to make the number, such as a one-bolt tile. During this session, Susie reached the fifth level. This was a marked improvement from her last time at play, during which she only reached the second level. When asked if she had reached that level the last time we played, she said: “I didn’t even get to level two the last time”.

In our final session, Susie played Bits and Bolts for me again. She told me she played the game “for a little bit at home”. I noticed improvement on her time as she played throughout levels. For example, it took her eight seconds to move to the second level and less than a minute to move to the third level of the game. Her time improvements could be a result of her playing at home and at school as well as her familiarity with the game structure. Moreover, when Susie had to make the number seven in the third level of the game, she did not make any mistakes compared to what happened in one of our early session. She was able to complete the task three times in a row without any problems.

Player’s understanding. When the numbers started getting higher for her (e.g., when the task required making numbers above eleven) and the amount of bolts available on the screen increased (e.g, bolts of three or four) she decided to quit the game. Once she finished playing the game, I asked her what the game was about. Her understanding of the game was that a player “has number on the mouse and can get that number.” Susie did not explain how the player got the number on the mouse, but she was able to demonstrate her understanding of the game by playing. She also knew the cognitive skills involved while playing the game. For instance, when I questioned how the game was helping her with school work, she said: “at adding”. Susie was still practicing adding skills in school and the game might have been helping her practice those skills.

Playing Pufflescape. Pufflescape was a game characterized by its exploratory environment and puzzle-solving activities. Players navigated their puffles inside an icy cave to collect berries and a key to escape the cave. Susie played most levels of Pufflescape during our game sessions. The highest level she reached was the twentieth level of the game. Susie reached the ninth level of the game. After playing the game for a while, Susie shared her understanding of the game with me as I asked her questions. She said players “need to get the key to unlock the door” and once the door was open, players “could go on” to other levels in the game. She thought the game was easy sometimes, but did not indicate why. But she also thought the game was difficult in collecting the key and manipulating shapes.

The next session depicts Susie’s difficulty in maneuvering the assets in the game to achieve the goal of collecting the key. Susie played Pufflescape from the highest level achieved in her previous game session, the ninth level. In this level, Susie brought her puffle down from a top platform, on the left side of the screen, to a half-pipe on the ground floor. The goal was to roll her puffle over the half-pipe to reach a platform - hovering in the center - where the key was located. Susie had to collect the key first before moving her puffle to other platforms located on the right side of screen. The reason for this procedure was to prevent her puffle from being trapped near the gate door (Figure 4.12). Once her puffle reached the ground floor near the gate door, Susie was unable move it back to collect the key and move to the next level.

Susie got her puffle trapped twice playing this level. I asked her what she could do differently. After pondering for a while, Susie had an idea. She had already removed the three pieces of snow glowing from the top platform and attempted to use these pieces to create some sort of ramp. Susie was unable to complete this task. The shapes of the pieces were odd and the pieces did not stack up on top of each other. After unsuccessful attempts with the pieces of snow, Susie clicked on HUD to check clues on how to solve the problem. I asked if the square represented her puffle and if it should be at that position to jump to the top platform. Susie agreed saying, “oh, yeah!” She pressed the reset button and attempted to catch the key first. But once again, her puffle fell and got trapped near the gate door. She tried to move her puffle back several times, using the same strategy of stacking up the pieces of snow without any luck. Then, Susie pondered, “how are you supposed to get it out if you fall?” I told her to get the key before her puffle fell near the gate door. Only after her fourth time resetting the game, was Susie able to collect the key before falling near the gate door. Susie demonstrated a great amount of perseverance during her play at this level. When faced with a problem (i.e., getting her puffle trapped) in this level, she considered possible solutions. Although her solution was unfeasible, Susie employed tacit knowledge she learned from previous levels such as building ramps from objects available in the game.

Figure 4.12 Screenshot of Susie’s puffle trapped platform

Susie continued to play the game until she reached the thirteenth level. At some levels, she did not have much trouble completing them. She was able to collect the key and often level up without consulting HUD. Susie usually consulted HUD only if she was unsure how to collect the key on her own. Two points could be made about Susie's gameplay in Pufflescape. First, Susie appeared to have enough prior knowledge experiences to find possible solutions to complete the levels, thus, her reasoning for not consulting HUD often. Secondly, Susie appeared to not be persistent as other participants in collecting the three berries. Therefore, there was not an evident need to seek the HUD assistance.

The next session playing Pufflescape, Susie completed the levels of the game at a fast pace as indicated in our conversation:

D: Susie has already played to the level thirteen, wow! So let me put it down. (As I was writing down on my research notebook, Susie completed level thirteen]

S: Now, fourteen.

D: Did you just finish?!

S: (giggled)

D: Oh my Gosh! You didn't let me see that. Oh gosh. Ok. Fourteen. There you go and counting (...) Fifteen! Oh my Gosh! And counting.

S: (giggled)

Later in our conversation, I realized that Susie had previously played these levels at home.

S: This one is really hard (referring to level seventeen on Pufflescape).

D: Have you played this one before?

S: Uh-hu. I got sick this weekend

D: Oh, so you've already played the whole thing

S: Yes!

D: So you've finished... so you've played the whole thing already? Have you gone through all the levels?

S: No (giggled). I couldn't get that one (referring to level seventeen).

Apparently, Susie liked to play Pufflescape since she played it at home while she was sick. After this conversation, Susie completed the seventeenth level of the game without much problem. She continued to play Pufflescape until she reached the twentieth level of the game. Unable to solve this level at this time, she decided to quit the game.

Susie was able to collect the key in each level without consulting HUD. Once again, the events in this session supported aforementioned points about Susie's gameplay: prior knowledge experiences to find possible solutions to complete the levels without consulting HUD and lack of persistence in collecting the three berries. Susie could also be learning how to solve the levels at home and demonstrating her acquired knowledge and skills in the game at school.

Player's understanding. In one of our last sessions, I used screenshots of Pufflescape to ask Susie about her understanding of the game and HUD. Susie said HUD was telling her "where to go to get everything and where to drag the shapes." I pointed to one of the formulas presented on the screen and asked her if she knew what it meant. Susie said "no." Later, I showed her a screenshot of the first level of Pufflescape. I asked her about her understanding of triangle ABC. Susie thought: "it's supposed to be where you put a shape, but I don't know where the shape is". For Susie, HUD assisted in solving the puzzles presented in the game. HUD provided clues about the objects to be collected and placement of shapes. Although Susie did not understand formulas or theorems presented in the game, she did understand math as representational of the objects in the world, i.e., shapes of the icicles. Susie was also able to identify angles in the game. She often matched the position of shapes and levers according to the angle degree position presented on the screen.

Serious Games at School: The Story of Emma

Emma was a tiny and slim 7-year-old child with whom I worked during our extended hour program in a local private school. She had straight light brown hair and brown eyes. I met Emma once a week, on Wednesdays, for about a month. During our first meeting, Emma told me she liked to play games, but she was not very good at math. Indeed, Emma's score on the pretest assessment was the lowest compared to other participants. While taking the computer assessment, Emma struggled with the questions. She even asked to stop the test at some point. Emma only continued working on the assessment because I told her there were only a few questions left and after completing those questions she could play Club Penguin™. Unfortunately, Emma's posttest score was not submitted correctly through the computer system. Without her score information, no further description or explanation could be provided.

Playing Bits and Bolts. Bits and Bolts was a fast-paced game in which players cleared tiles on the screen by matching correct bolt combinations. Emma played the game in one of our first sessions, she read the instructions, which took her about two minutes, and misread some of the words. For instance, instead of reading "multiples", she read "metal pieces". She also read "place" instead of "pieces". Other reading errors included: "require", which she read "recruit", and "even", which she read "every." Once she finished reading the instructions, Leo, my research assistant, had the following conversation with Emma.

L: What did you understand from the instructions?

E: Most of it. Except that I don't know what "premy" [prime] is.

L: Ok. But take a look at this. What do you think you have to do with the bolts?

E: Like... try to make a robot with it?

L: uh-uh. But how?

E: I guess put them together.

Leo asked me to stop by Emma's computer station. He was unsure whether he could provide further explanations on the instructions. When I arrived at Emma's station, she said: "I don't know what 'premy' is." I asked her if she had gone through even and odd numbers at school and she replied "yes". Then, I told her prime bolts were just like prime numbers. Satisfied with this explanation, Emma started to play the game. She played the game for about seven minutes and stayed in the first level the whole time. Her score was very low compared to other participants who played this game for the first time. Throughout her game playing, Emma mentioned the mouse not working a couple of times. Although she blamed the mouse, I noticed Emma clicking on the right instead of left mouse button, which could have been the cause of her problems. Besides problems with the mouse, Emma did not know exactly how to "put together" the numbers in Bits and Bolts. For example, she asked how to attach the bolts. Sensing her frustration building, I asked Emma if she wanted to try another game. She replied "yeah. I don't want to play Bits and Bolts anymore. It's hard because it never worked." Given misreading the instructions, Emma's understanding of how to play the game might have been compromised, which led to her conclusion that the game "never worked." Despite her misreading, Emma was able to identify the ultimate goal of building a robot, which other participants were not able to indicate. She had the overall goal understanding, but not the task-level understanding. Others could accomplish the tasks but did not always connect the tasks to a larger goal, or the purpose the tasks served.

The second time Emma did not understand how to achieve the goal of building the robot, in terms of the rules to get the pieces to connect. For example, I asked Emma to play Bits and Bolts, she appeared to be unmotivated with my request. She told me: “I don’t know how to do fractions,” thinking the game was about fractions, and “I hardly even understand that.” Since she mentioned fractions, instead of addition, it appeared she did not understand the game. Emma was reluctant to play the game saying “not Bits and Bolts. I don’t wanna play Bits and Bolts.” I asked her to play it for at least five minutes, but she agreed to two minutes of play. As she started to play the game, she realized the goal was “to find” the numbers. After getting a few numbers right, it appeared Emma was learning how to play the game. She played the game for seven minutes. Although she was unable to level up during this session, her score improved compared to her previous time playing the game.

Playing Pufflescape. Emma had mixed feelings about Pufflescape saying she liked the game, but it was hard for her. She often played the game for about six minutes. During our game sessions, the highest level she reached was the eighth level of the game. The following episodes illustrate Emma’s play and understanding of the game.

When Emma played Pufflescape in one of our first sessions, she was able to get to the fourth level of the game without consulting HUD. During this session, Emma did not seek to collect all the items available in the level either. Her focus was to acquire the key and move on to the next level. Perhaps, because Pufflescape was not a game she chose freely, she did not invest a lot of time playing it. Emma even said: “I don’t wanna play Pufflescape all the time”, but did not say why. Throughout her play, Emma thought the levers and shapes were optional because she often generated enough speed with her puffle to jump platforms. For instance, in the fourth level of the game, Leo suggested Emma used the lever as a ramp, as she had done previously in the first level, to reach one of the platforms. Emma said: "you can use that thing if you want, but you don't have to." After she finished playing the game, I asked her if she did not like the game and she replied: "I liked it but except that is hard." Later, Emma and Clara, another participant in the program, shared their thoughts on the game being difficult:

C: Because you have to get all that stuff.

E: I know. And some you can't even get to.

C: So far away (said it in slow tone voice to indicate the distance of these objects)

E: I know. It's so far away (said it in the same slow tone voice as Clara)

D: So the stuff you're saying you cannot get... Why can't you get it?

C: It's hard!

E: Because it's hard.

D: Just that?

C: Yes!

D: But aren't games supposed to hard? Or are they supposed to be easy?

C: They're supposed to be...

E: Uuu... I know.

C: Right in the middle like Thin Ice.

Thin Ice was a simpler version of Pufflescape. Players moved their puffle through a maze, melting the ice on the floor and their goal was to reach the door to escape the maze. For both participants, Pufflescape was considered a "hard" game because of the position and location of objects to be collected. For example, the three berries were usually difficult to collect because players had to grab and rotate shapes. Players also had to manipulate levers, turning into ramps, to launch their puffle to platforms. In addition, collecting the three berries often required the assistance of HUD. When asked if they thought they were learning something from Pufflescape, Emma replied: “how to learn these things” referring to the arrow keys, which are used to navigate puffles around the cave.

The second time Emma played Pufflescape, she played the game for approximately six minutes. She played the first level of the game twice because she “liked it.” Emma often depended on her puffle’s motion and speed to collect the objects or reach platforms in the game. She knew that she could use the lever to make ramps but she preferred not to, as indicated on the following conversation:

> E: Why doesn’t it go up? (referring to her puffle that could not reach the platform without the ramp) Do you need some sort of ramp? Wait! Use this (referring to the lever) Yeah. Well, that doesn’t work.
>
> D: But you need to be on the other side, right?
>
> E: Yeah and then it will launch my puffle. So it does work.

At the end of the session, she did not use the ramp to collect the three berries. She attempted to gain speed with her puffle to reach the platform, but failed. Unable to reach the platform with her puffle’s motion, she gave up collecting the three berries and moved on to the next level. Emma might have depended on her puffle’s motion to reach the platform because it was an easier solution for her – and it had worked in her previous game session–than manipulating the lever to find the right position to make a ramp. Although Emma sought to collect the three berries, she was unable to complete this task in this session. One reason she did not collect the three berries could be because she did not seeking assistance from HUD. Indeed, Emma played up to the fifth level of the game without consulting HUD during this session.

Perhaps, Emma was unaware of HUD as she never clicked on it through our game sessions in this program.

After reaching the second level of the game in this session, Emma asked to play another game. I encouraged her to play this game a little longer, but Emma replied “noo… I wanna play something else. Can I buy some clothes?” Emma ended up playing more levels of the game, but she used a few strategies to avoid playing the game as indicated in the conversation below:

D: Just one more?

E: Ok. But that’s the hard one! Luckily, it isn’t hard. (Emma said the second sentence in a soft voice)

D: But you can do it! I know you can do it, Emma!

E: I know it’s not hard. I was just saying that so I wouldn’t have to do it.

D: Ok. For a little bit?

E: Ok. Fine.

Emma played the level, but I had to negotiate with her to continue playing. Given this negotiation of play, I thought Emma did not like playing the game. But she said: “I like it, but it’s hard. I like it, but I just want to buy some clothes.” Although Emma said she liked the game, she provided reasons to avoid playing it such as “it’s hard” or her desire to do something else such as “to buy some clothes.” Indeed, she continued to play the game because of her motivation to “buy some clothes.” For example, once I reminded her she could earn money playing a game like Pufflescape, Emma mentioned: “I wanna play hard so I can get more money” and continued playing the game until her mother came to pick her up. Her game session ended early because of her mom.

The last game session, Emma played the game for about five minutes. She started her play from the fifth to eighth the level of the game. Emma neither consulted HUD to complete the levels nor moved the game objects in these levels. She depended on her puffle's motion and her prior experience with the game to move through the platforms. Although Emma was successful in completing the levels, she did not collect all items in the levels. For instance, she attempted to collect the three berries, but it appeared she did not understand how to accomplish the task. Consulting HUD might have helped Emma collect these berries, but she did not exhibit an understanding of HUD as a resource.

Serious Games at School: The Story of Elizabeth

Elizabeth was an average build 8-year-old child with whom I worked during our extended hour program in a local private school. She had long blonde wavy hair and blue eyes. She was funny and cheerful. Leo and I met Elizabeth twice a week, Tuesdays and Thursdays, for about a month. There were usually two other participants playing with Elizabeth during those days. Elizabeth had an 11-year-old brother enrolled in the middle school who often came to pick her up after our game sessions. I noticed Elizabeth and her brother shared mannerisms. She often used expression such as "dude" or "punk" in a friendly manner when talking with other participants in program.

In our first session, after completing the computer assessment, Elizabeth tried to login to Club Penguin™. Unfortunately, she was unable to access the virtual world due to complications with her penguin account. Elizabeth subscribed with her father's email address to Club Penguin™. Unfortunately, the email was filtered as a junk mail and her father was not able to check and activate her account prior to our first session. In our second meeting, her penguin account was still an issue because her username and password did not match. Because she forgot her account information paper at home, I allowed her to play the game with my penguin account. Later, Leo helped Elizabeth create another penguin account, but this time we used her mother's email. I reminded Elizabeth's mother to check her email. Her mother checked it on the same day, activating Elizabeth's account in Club Penguin™. Because Elizabeth had created multiple penguin accounts, she was often confused about the correct login and password for her account, which delayed her play sessions. After this incident, Leo and I decided to keep a record of participants account information to ensure time was not wasted in upcoming sessions.

During the program, Elizabeth took a pretest and posttest assessment related to math concepts. Her score on the pretest and posttest were the same. Elizabeth had only one incorrect answer on the tests. It was a multiple answer question, which other participants misunderstood. A possible explanation for her incorrect answer might be related to a lack of clarity in the question since other participants did not provide correct answers either.

Playing Bits and Bolts. During the first time Elizabeth played Bits and Bolts, she did not make considerable progress in the game. For instance, Elizabeth spent about twelve minutes playing the first level of the game. By the end of her game play, she still had not reached the second level of the game. Elizabeth appeared to be unmotivated to play the game because she said "it is hard." Later, Leo asked her questions about which numbers she had difficulty with. She answered "odds."

Her second time playing Bits and Bolts, Elizabeth made much progress on the game. Elizabeth had just logged into Club Penguin™ and I asked her to play Bits and Bolts. During this session, the Muppets World Tour was a current event in the virtual environment and Elizabeth was unable to find the place where the game was. While the tour was going on, buildings and shopping areas in Club Penguin™ had different looks and colors. Elizabeth wanted to do a safety quiz in Club Penguin™ “real quick”, but I asked her to play Bits and Bolts before doing the quiz. I told her after playing the game she could work on her safety quiz. While Elizabeth was trying to load Bits and Bolts, I was talking with another participant in program. This participant and I were negotiating how long they should play Bits and Bolts. This participant wanted to play the game for four minutes while I wanted them to play a little bit longer. Elizabeth shared her opinion, saying four minutes “was too long” for her. Still, she played the game for more than eight minutes and reached level seven of the game. Elizabeth played the game in a fast paced manner, spending less than a minute on each of the first five levels of the game. She made a few mistakes, a total of six, while playing the game. Most mistakes started to happen while she was playing the seventh level of the game. Some factors appeared to contribute to her mistakes such as higher numbers to count and match, fast pace and tiredness. Elizabeth also had delays in the game to register her mouse clicks. For instance, in a brief conversation with Rachel, a participant in the program, Elizabeth indicated this problem:

E: I’m clicking these things, people!

R: Yeah! I know. It never notices when you click it...

Later, as Elizabeth was clicking on a set of bolts to make the number nine, she faced the same problem:

E: What?! Nine… three, three, three. Come on! (Elizabeth clicked on a bolt, but the game did not register her mouse click) I love these kinds of games that I get so stressed. Yes!

D: Why do you think this one is stressing you out?

E: Because I clicked it and nothing happened!

Although Elizabeth and other participants seemed to attribute this problem to the game, the school Internet connection could also be a factor in this delay. There were days in the program that participants were not able to play or access Club Penguin™ at the school due to Internet connection issues.

Elizabeth's behavior and attitudes toward Bits and Bolts were conflicting. While playing Bits and Bolts, I asked participants which games were their favorites so far. Elizabeth said: "this right now. It's so cool." Right after she said that, a pop-up message appeared on the screen, indicating her current score and a button that read, "continue". Elizabeth clicked on the button, but said: "I don't wanna continue." A few minutes later, Rachel and Elizabeth discussed the length of their play:

R: Ok. How long have I been playing so far?

E: How long have I been playing? Because I don't wanna play anymore.

R: I've been playing forever. Three hours or so.

D: Three hours?!

R: It feels like it.

Even though this conversation indicated Elizabeth wanted to quit playing the game, her behavior and attitudes were conflicting. For instance, Elizabeth continued to play the game, even after saying she did not want to play it anymore. Elizabeth also implied that Bits and Bolts was her favorite game. Selecting Bits and Bolts as her favorite game could be a result of her playing the game at the moment I asked the question. Still, Elizabeth appeared concentrated and focused on the game. After Elizabeth had been playing for eight minutes, I stopped by her computer station to turn the volume down on her computer because Rachel complained about its noise. As I did that, Elizabeth looked at me shocked and surprised, saying: "Am I done yet?!" Then, she said: "oh, good", realizing that our game session was not over yet. Elizabeth re-focused on playing the game. At the end of her gameplay, Elizabeth was happy with her progress and score in the game: “Woohoo! My score is 679”.

In her last playing Bits and Bolts, I paired Elizabeth with Rachel to walk me through the game. Both children took turns playing levels of the game. This event provided me with some insights of their understanding of the game. When I asked what the game was about, Elizabeth provided the following answer:

E: So, you’re clicking stuff and like, uh, you’re adding it, like you have to click to make the right answer…

D: Uh-uh.

E: It’s almost like adding...

D: Ok.

E: And so addition and stuff.

Given Elizabeth’s response, she understood the game was about addition, but she did not mention other topics presented in the game such as multiples or prime numbers. Because these topics were implicit in the game activity, Elizabeth appeared to not consider them as part of the game or at least related to the goal of the game. Moreover, one of the game goals was to build a robot using multiples and a goal Elizabeth overlooked because of the fast-paced nature of the game. Elizabeth may have focused on the main screen of the game where the bolts were dropped without paying attention to the activities happening on the sides of the screen (the motion of the robot as it was built).

When we talked about the learning in the game, Elizabeth and Rachel indicated no gain of knowledge or skills from playing this game because they learned how to add and subtract in kindergarten and first grade. Still, they agreed they might have liked to learn addition or subtraction through a game such as Bits and Bolts, if they were in pre-k.

When we talked about improvements to Bits and Bolts, their responses resonated with their motivation to play the games placed in the virtual environment of Club Penguin™. Their suggestions were sometimes exaggerated or unfeasible, but they suggested allowing players to earn puffles, which at the time of this study cost 500 coins, and losing or earning coins by getting the correct or wrong numbers when playing the game.

Playing Pufflescape. The first time Elizabeth played Pufflespace, she understood the goal but not how the assets in the game could be used to help her reach the goal. For instance, she did not understand how she could use the objects presented in the game to help her puffle reach the key to unlock the gate. Even when she clicked on HUD, Elizabeth had difficulty decoding the instructions presented on the screen, which she called "red tips". Elizabeth called the act of checking HUD as "cheating." Although she did not like cheating, Elizabeth continued checking HUD to help her advance to further levels in the game.

The next time Elizabeth played Pufflescape, she said she had played the game the night before at home using the iPad mini. Elizabeth demonstrated improvements in her play. She reached the fifteenth level of the game and spent less than a minute to complete most levels. And she rarely consulted HUD to collect the objects in the levels.

While playing the first level, Elizabeth collected one of the berries and the key to the gate. Then, Leo asked Elizabeth about the glowing object. Elizabeth replied to him saying, "you can lift it up". Leo asked her about the purpose of the lever and after a few seconds Elizabeth stated the purpose of lever was to make a ramp. Leo continued asking her about the ramp, but

Elizabeth did not answer his question and basically said, “I don’t need that, I just want to go home” referring to the puffle’s home as she moved her puffle through the gate door.

During the second level, Elizabeth lifted the lever to make a ramp before even starting to move her puffle around the platform. Elizabeth was able to collect all the berries, which she called “coins.” After completing the level, she mentioned how she “didn’t even cheat” in this level by not consulting HUD.

While playing the third level, Elizabeth collected all the berries by manipulating the lever and turning it into a ramp. She also used the lever to stop her puffle from moving or falling from the platform at times. By manipulating the lever, Elizabeth realized that she could make her puffle pass through the lever if she continued to press it with the mouse. Indeed, she liked to use these objects, i.e., the lever or the icicle, to achieve her own goals or needs, instead of the ones proposed by the game. In this level, Elizabeth struggled to collect the key. She spent more time (i.e., about six minutes) to complete this level than previous ones. She even asked to skip this level of the game after many unsuccessful attempts to collect the key. Tired of trying on her own, Elizabeth clicked on HUD. From consulting HUD, she was able to see a hint of the precise position to place the lever to collect the key. Elizabeth decoded HUD’s instructions and collected the key.

Elizabeth moved through other levels easily. She often collected one of the berries and the key through the levels. She avoided consulting HUD until she reached the seventh level of the game. Elizabeth said: “I forgot how to do this! I need the hint… So I need to go to the ocean and get the key so it will tell me the hint I need.” After collecting the key, Elizabeth clicked on HUD. Although she did not need the hint to collect the key anymore, Elizabeth still placed the ice block on the shape highlighted on the screen, demonstrating how to solve this level with HUD information.

When Elizabeth reached the ninth level, she shouted: “Oh, I did this one. It’s so hard. I don’t get what you do with those things”. The “things” mentioned were ice pieces blocking the platform where the three berries were located. Elizabeth often manipulated the objects in the levels to use as a ramp or to build up a ramp. Thus, just removing a set of pieces to reach a platform was unusual play for Elizabeth.

Elizabeth continued to move through the levels easily, but she struggled to complete the twelfth level. She kept rotating the icicles to fit in the ramp, but she could not match the piece correctly. Tired of figuring out how to match the pieces, Elizabeth ended up leaving them unmatched and moved on to collect the objects in the level. Elizabeth stopped playing the game after Rachel mentioned she had played Pufflescape and was now doing something else. Elizabeth spent a total of twenty minutes playing Pufflescape during this session.

The last time Elizabeth played Pufflescape, I paired her with Rachel to walk me through the game as means to provide insights of their understanding of the game. They played the game in my computer with the same puffle and just took turns between levels. As Elizabeth and Rachel walked me through the game, they took turns playing the levels in the game. Rachel started playing the first level of the game and providing instructions on how to move the puffle around: “you have to use the arrow keys… collect …roll down…roll off… get the key and roll pass the ice.” I asked Rachel to wait before she rolled the puffle through the gate door, but she did not attend to my request. Thinking I wanted Rachel to collect the three berries, Elizabeth said: “You don’t have to get all the coins. Let me have a turn.” Elizabeth started playing the second level and determined to collect the three berries. While Elizabeth kept playing, Rachel provided her with directions, which sometimes clashed with Elizabeth's actions during play. For instance, Elizabeth was trying to collect the three berries:

R: That way. No, you can't (Elizabeth used the mouse to move the lever). You've got to use the arrow keys.

E: Woohoo (Elizabeth set up the ramp while the puffle was on the opposite side of the ramp)

D: But now, you cannot go there.

E: Oh, yeah!

Elizabeth put the lever on its initial position and rolled the puffle over to collect the key. Elizabeth thought I wanted her to collect all the berries for this level, but Rachel disagreed:

E: Now, I have to get all the coins.

R: No. No, you don't.

E: Oh, it's not connected.

R: You just have to get...

E: But she wants me to so it's not my fault.

R: You don't need to do that, seriously.

E: Oh, I seriously need to.

R: Now, you're going on the wrong direction

E: I might... deedeedee. Oh, boom!

D: She got it!

E: I just schooled you.

R: Those are stamps anyway (Elizabeth called the berries "coins" and Rachel referred to them as "stamps").

As a result of collecting all the berries, Elizabeth unlocked the extreme levels and thought she had a second turn in the game. Upset with the idea of Elizabeth having a second turn, Rachel shouted: “no, no, no fair” and quickly took over the computer to have her turn. Seeing the third level of the game, Elizabeth begged Rachel to let Elizabeth play during Rachel’s turn: “Oh, I love that one! Please? Please let me do it and then she’ll get to have a second turn.” Rachel ignored Elizabeth’s request and continued to play. Elizabeth and Rachel had different game styles when playing Pufflescape, which led to some tension between the two. For instance, Elizabeth commented that Rachel “did it wrong” because she did not collect all the berries in a level. Meanwhile, Rachel seemed aggravated with Elizabeth’s need to collect all the objects in the level as shown in the following conversation:

E: I gotta do that ‘cause I gotta get that coin, don’t I?

R: Nope!

E: Oh, I want to!

R: Ok. This is…

E: Yay! That was dumb. Ok.

R: [sighed] You don’t need that. You can jump up yourself [referring to Elizabeth using the ramp to jump off the platform]

Elizabeth was also more knowledgeable than Rachel regarding HUD and their use in the game. She told Rachel to “press the cheats”, as she called them, to help her solve the fifth level in the game. Moreover, when I asked Elizabeth what “the cheats” meant in that specific level, she said:

E: It means to get that right there 'cause that was where the key was [meaning that the goal was to get the key] and so you put that [referring to the icicle] right there [referring

> to the red scribble where the 25 degree was located], put that right there (…) and then you put like a ramp and go like *choo* and you go down like that and you go there.

Overall, the cheats served to help Elizabeth achieve the game goal during play.

Cross-Case Analysis

The cross-cases analysis presented in this section was generated from the four aforementioned case reports. Each case report provided a description of participants' play with two serious games: Bits and Bolts and Pufflescape. The case reports provided an insight on children's engagement and understanding of those two serious games as well as their gaming strategies. The themes presented below are a result of this cross-case analysis.

A Mixed Understanding of Serious Games

The cases presented in this study indicated that children had a mixed understanding of the serious games. In terms of Bits and Bolts, half of the cases demonstrated an unclear understanding of this game, with one child using random mouse clicks and another struggling to complete the task-level in the game. Some possible reasons for this unclear understanding might be: (a) a soft game punishment when incorrect combinations were made and (b) a misunderstanding of game instructions. First, the soft game punishment in Bits and Bolts might have led one of the children to disregard the consequences of her mistakes while playing and to consider incorrect combinations as acceptable. Meanwhile, the misunderstanding of the game instructions may have happened due to misreading. In one of the cases, the child misread several words in the instructions and was unable to complete the task of combining bolts in the game. Still, most cases (i.e., three out of four) suggested that children understood Bits and Bolts as a math game. While two of the three cases reported the game was about addition, one case indicated it was about fractions. In this particular case, this misunderstanding of the topic covered in Bits and Bolts could also be a result of the aforementioned misreading of game instructions.

In terms of Pufflescape, children's understanding of the game appeared to be intuitive. Their knowledge on how to play the game seemed to build as they progressed through the levels of the game. Indeed, the first level of Pufflescape was set up to be an instructional level for players. For example, in the first level, a flashing sign with arrow keys displayed on the game screen led children to guess how to play the game, i.e., pressing the arrow keys on the computer keyboard in order to roll the game character over platforms. Additionally, glowing objects on the first level set up a pattern for players. By manipulating these glowing objects through trial and error, children were able to predict that similar glowing objects in upper levels of the game could be manipulated. In most cases, children were aware of HUD -a game tool that offers assistance to players in solving puzzles presented in Pufflescape- and how to use it in the game context. In a particular case, one of the children appeared to be knowledgeable about HUD. She appeared to know how to use it to reach platforms and collect the items available in each level of the game.

Although children demonstrated their understanding of Pufflescape through play, they were unable to articulate the academic content covered in the game. Children could recognize some shapes, but they were unable to specify which kinds of shapes (e.g., triangles, squares) were in use or associate the shapes with math. Some possible explanations for not associating math with Pufflescape might be related to: (a) academic content exposure being hidden, and (b) mathematical skills being implicit to the game. Considering the academic content exposure, most math content was only visible to players if they clicked on HUD. The content presented in HUD were usually angle degrees, formulas, and theorems, which were overlaid on top of game objects such as icicles or ramps. Because the content was only visible through HUD, some players missed the academic content exposure when they did not click on HUD. For example, in a particular case, one of the children never accessed HUD during the game-playing program, which might have led her to miss any connection between academic content and the game. As for mathematical skills in Pufflescape, the academic content was implicit to the game to such an extent that children might have disregarded its presence. When playing the game, children were not required to calculate any formulas or use theorems, but rather to apply this information intuitively in context. For example, children had to position in-game objects to certain angle degrees to reach top platforms in the game. Instead of distinguishing these objects based on their shapes (i.e., triangle, square), children differentiated them by their game context (i.e., icicles or a block of ice).

In summary, all participants played Bits and Bolts and Pufflescape, but their understanding of these games was different. The differences in understanding might be a result of the diverse nature of these games. In Bits and Bolts, the math content was overt; with players having to use mathematical skills, such as counting, to play the game. On the other hand, the math content in Pufflescape was covert; with players being exposed to content on demand and mathematical skills being implicit to game playing. Comparing children's play performance between those two serious games, children performed better in Pufflescape. All children in this study were able to advance to higher levels of the game (with the lowest level reached during the game-playing being level eight) compared to Bits and Bolts (with the highest level reached during the game-playing being level seven). In contrast, children were able to identify math in Bits and Bolts, but were unclear about the academic content in Pufflescape.

Shortcuts and Creativity in Serious Games

Children used multiple strategies when playing the serious games in Club Penguin. These strategies varied based on the content covered in the game as well as the nature of the game. Considering Bits and Bolts, most cases in this study reported children using strategies such as key number combinations and counting by multiples or by single digits to reach to the target number displayed on the screen. In a particular case, one of the children used random clicks or guessing as a strategy to succeed in the game. Although her strategy was not always successful, she was persistent in this strategy to avoid counting. Despite the ability to count, this child was reluctant to perform this task while playing Bits and Bolts. A probable reason for her resistance might have been that counting was an undesirable activity for her, especially during her playtime. Indeed, playing a game that involved counting could be undesirable in a game environment where there were more appealing and desirable activities for young children, such pet caring or clothes shopping.

As for Pufflescape, children often sought shortcuts and easier strategies to proceed through the game levels. For instance, two of the children sought easier solutions to reach the game goal and subgoals. They frequently used their puffle's motion to reach top platforms instead of using levers and icicles to make ramps, as recommended by the game. Using the puffle's motion to complete this game task was an easier solution for these children because it required no mouse manipulation. Conversely, using levers and icicles to make ramps required mouse manipulation, which might have been a challenging task for children to perform as they were still mastering it.

Pufflescape also provided hints for players to be successful in the game. The hints were available on demand, through HUD. Most children used HUD assistance to solve puzzles presented in game, especially when they were unable to solve by themselves. Children often clicked on HUD to identify the objects to be used as ramps or their correct placement on the game screen. Even though the purpose of HUD was to assist children to succeed in the game, children attempted to limit or avoid referring to HUD during play. In one case, the child had enough prior experiences to find possible solutions by herself and, as a result, she limited her HUD consultation. In another case, the child avoided using HUD because she perceived the act of consulting HUD as cheating. In only one of the four cases did a child not consulting HUD progress through the game. This child was able to reach to level eight of the game without any HUD consultation. A common pattern among those three cases was a lack of persistence in collecting all items in the game, especially the three berries. Because of this lack of persistence, children might have been unaware of HUD or avoided it for the wrong reasons. Only one child from all four cases was persistent enough to collect all items in the game, which consequently resulted in her to consulting HUD multiple times. Thus, children's use of HUD was limited and avoided when possible.

In the midst of playing Pufflescape, all but one of the children demonstrated signs of creative play. These children used game objects such as icicles, levers, or pieces of snow differently from their original purpose or design in game. Two of the three children used icicles and levers as brakes instead of ramps. Both used these objects to stop their puffle from rolling off platforms. The other child attempted to use pieces of snow to build a ramp instead of just removing them from the platform. Although these objects were constructed for specific purposes in game, children in this study decided to use these objects in ways game designers may have not anticipated. Children used these objects to solve new situations faced in the game in order to achieve their own goals within the game.

Limited Engagement in Serious Games

Most children showed signs of engagement with Pufflecape in contrast with Bits and Bolts. For example, two cases reported children playing Pufflescape outside (i.e., home) the game-playing program. Of these two cases, one case reported a child playing the game even when she was sick at her home. Children also appeared to invest more time playing Pufflescape, with one case reporting a child investing almost forty-minutes of her playtime in the game. Only one of the four cases reported a child having mixed feelings about the game. This child voiced her perception of the game as being difficult. For her, the demanding nature of the game likely contributed to her quitting and moving on to other activities in Club Penguin™.

As for Bits and Bolts, two cases reported children showing signs of disengagement with the game. In both cases, children voiced displeasure with playing Bits and Bolts. In one of the two cases, the child's playtime decreased from seven minutes in early game sessions to less than three minutes in her last game session. Similarly, other children also decreased their time playing Bits and Bolts during our game sessions. Only one of the four cases reported a child playing the game longer (eight to twelve minutes), and playing at home without being urged to play.

In summary, the children's engagement playing the serious game in Club Penguin was limited. Most children decreased their playtime with Bits and Bolts and voiced displeasure with playing this game. In contrast, children showed more signs of engagement with Pufflescape by playing the game for a longer time than Bits and Bolts or playing the game outside of the game-playing program.

CHAPTER 5

CONCLUSION

The purpose of this research was to examine children's learning experiences and engagement with two serious games within a virtual world for young children, Club Penguin™. The questions guiding this research were: (1) How do children understand academic and game content in serious games? (2) How do children employ strategies to succeed in playing serious games? (3) How do children engage in or disengage in playing serious games? In this chapter, I provide a summary of findings and describe each of the major findings. I also discuss implications to theory, practice and future research. Finally, I include a section delineating limitations to the research.

Summary of Findings

In order to conduct this study, I began to investigate and define terms related to games and virtual worlds as well as to understand how these technologies could be employed to leverage learning. I reviewed previous studies conducted in virtual worlds for children and pre-teens similar to Club Penguin™ as well as research with computer-based games featuring math. I also explored the motivational components of games that could promote engagement. Although positive experiences were reported, there was still controversy regarding the learning outcomes of gaming technologies. This controversy targeted either the quality of the studies or the quality of the games themselves as the cause of the mixed results. In terms of the quality of the games, the problem could rely on the poor or absent integration of game elements with learning content.

Cognitive-constructivist theoretical perspectives were used to frame this study. Given these perspectives, problem solving was identified as an essential construct of the cognitive process of game playing as well as an aspect of learning. This construct was divided into two sub-constructs: game content, which involves the players' understanding of the gaming system and its embedded academic content, and game performance, which involves the players' strategies to succeed in the game. Motivational components of games were also examined to indicate engagement (or lack thereof) in play.

Originally, a mixed-method design approach was determined as an appropriate fit with the cognitive-constructivist perspectives. Due to technology constraints in the selected research site, I was not able to conduct my research because participants did not have access to the serious games, which were an important part of my study. Given this unexpected situation, research logistics and methods had to be changed. A new research site was needed to conduct my study. I contacted public and private elementary schools in the southeast region of the United States. Fortunately, I was able to find a private school where I could conduct my research in an after school program and a mother who was willing to let me visit her home to work with her child. Given these two different sites, a case study approach was found to be the best fit for this study.

I spent almost two months doing fieldwork in the selected private elementary school and visiting one child's home. The primary data collection consisted of approximately 23 hours of the participants' game-play screen and audio recordings. I used QuickTime Player software to capture the participants' game play and record their verbal communication while playing the game. Other data were collected in order to inform the research questions. They included approximately two hours of audio recording, 10 pages of field notes, and six pre- and posttest assessments.

I then reviewed and analyzed aforementioned data collected. First, I divided the data into two categories: home and school. Later, these categories evolved into main case studies. Initially, I reviewed the data from the participant I visited at home, selecting the relevant pieces of information to transcribe. Priority was given to data that indicated the learning experiences, engagement (or disengagement), as well as strategies employed in playing the serious games. The chunks of data were organized to report the results of the home visit and served as the basis to structure and organize the data collected at the school. Summarizing findings by research questions, the next section outlines how children understood academic and game content in serious games, followed by how they employed strategies in these games as well as their level of engagement or disengagement.

How children understood academic and game content in serious games

The academic content of Bits and Bolts was more visible and explicit for participants than Pufflescape. Children were introduced to academic content through the game instructions. As children read, or had the instructions read for them, they were able to recognize terms (i.e., multiples or prime numbers) and numbers related to math. In playing the game, children practiced counting and identified symbols, which were important skills for basic arithmetic.

Participants understood the content of the game as addition, a mathematical operation of arithmetic. Not all participants perceived addition in the context of a game as playful. Playing Bits and Bolts became a chore that participants were avoiding. Negotiations to play the game occurred through the course of the program. The potential outcomes of playing Bits and Bolts, i.e., clearing tiles and earning coins, did not trigger participants to invest time and effort into the game (Juul, 2005). Some participants even employed a trivial approach (Barab et al., 2007) to the game by clicking randomly on the tiles in an attempt to guess the correct combination.

In terms of Pufflescape, the academic content was implicit and hidden from participants. The participants' understanding of the game content was developed through play and depended on participants' action in the game (Piaget, 1983). The participants understood that the game involved manipulating objects, such as levers and icicles, to collect the key and escape the cave. The children also identified matching angles and geometric shapes as part of the game. The participants perceived HUD, one of the game components, as hints about the actions to be taken in the game. The theorems and formulae presented in HUD were extraneous because children did not understand them.

How children employed strategies

When participants played the serious games in this program, they used several strategies to attain the game goal and be successful in the game. Strategies for playing Bits and Bolts were two: counting and guessing. Counting was an intrinsic part of the game and involved participants determining the number displayed on the screen by clicking on and adding bolts. Children often used single bolts to assist and facilitate their counting. Children also applied key number combinations to match bolts in the game. One particular participant in the program took wild guesses (Ke, 2008a, 2008b) as a means to succeed in the game. The participant clicked randomly on the bolts to match the targeted number. Correct combinations were made by chance or luck.

Strategies for playing Pufflescape were different from the ones for Bits and Bolts because of the degree of problem solving involved. While problem-solving activities in Bits and Bolts were low and almost nonexistent, these types of activities were prominent in Pufflescape. In each level of Pufflescape, children were presented with a problem that had an initial and a goal state. The initial state of the game was set inside an icy cave where the player's character, i.e.

puffle, had to be rolled over platforms from its starting position to the goal state. The goal state was achieved when the puffle escaped the cave, which involved players overcoming a set of constraints such as manipulating game objects to make ramps and launching their puffle to collect objects. Overcoming these constraints often meant using strategies similar to the ones taken in a problem-solving process (Figure 5.1).

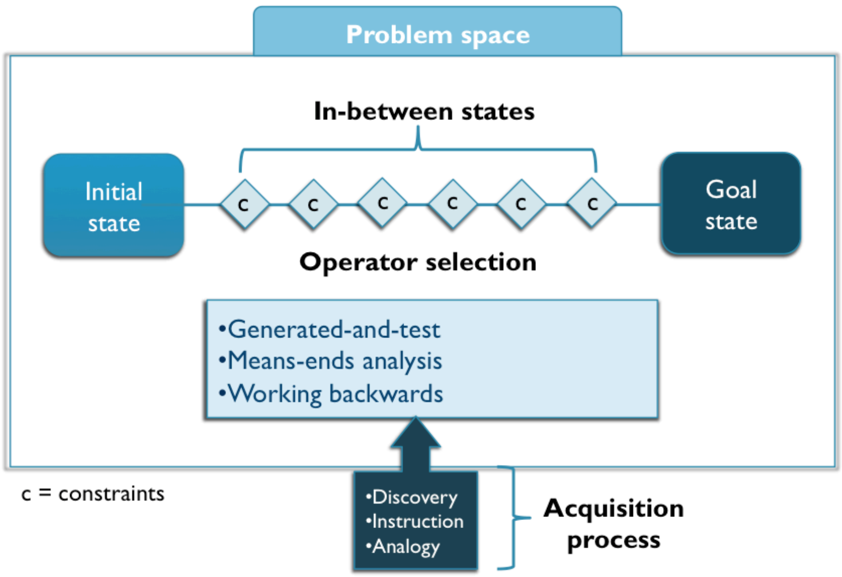


Figure 5.1 Problem-solving process

Considering the problem-solving process, participants in this study used either a generate-and-test or means-ends analysis strategy to succeed in Pufflescape. The generate-and-test strategy was a common approach used to find feasible solutions when participants faced the constraints presented in the game. Participants randomly tested and verified if their solution(s) fit the desired goal. On the other hand, the means-ends analysis strategy was barely used by participants, especially those younger in age. The limited use of this strategy might have been related to a deficiency in distinguishing the differences between current and desired goal(s) in the game and ways to minimize them. For instance, after many failed attempts to find a solution to the problem posed in the game, one of the participants often reset the game level instead of considering ways to minimize the differences between current and desired states in the game.

Participants often depended on two methods of learning to solve problems in Pufflescape: discovery and analogy (Anderson, 2005). By discovery, participants learned how to solve the problems by themselves. Using in-game objects, children experimented and tested their solutions to reach the goal state. Through discovery, creative acts (Runco, 2007) emerged as participants attempted to solve subgoals posed in the game. Participants also learned to solve the problems through analogy. For example, resources and information used in one of the game levels, such as using icicles to build a ramp, were applied similarly to subsequent levels of the game as means to problem solving. Nevertheless, applying information from one level to another led to functional fixedness, in which children used objects in the game level according to their usual function (i.e., to build a ramp) rather than manipulating them in novel ways.

In summary, Pufflescape presented a higher degree of problem solving than Bits and Bolts. As a result, participants in this study often used problem-solving strategies, such as generate-and-test and means-ends analysis, to succeed in Pufflescape but did not use them same strategies in Bits and Bolts. Consequently, the degree of problem solving in those games might have contributed to children's engagement or disengagement, as discussed in the section below.

How children engaged in or disengaged in serious games

Participants' engagement and disengagement in the serious games varied because of factors such as fantasy, challenge, and curiosity. Participants were often disengaged in playing Bits and Bolts because of their unclear understanding of the game. Most children were unable to understand the ultimate goal of the game, i.e., building a robot with multiples of bolts. Besides the unclear understanding of the game goal, some children misunderstood how to play the game, i.e., clicking on bolts randomly to succeed in the game. Even when children understood how to play the game, their disengagement continued. Their disengagement persisted because children were already familiar with the game task, i.e., counting. This task continued to repeat itself throughout the levels of the game. Thus, participants perceived this repetitive nature of game as an endless activity. Quickly, children quit playing the game to engage in activities that were more appealing and less exhausting to them, such as pet caring and clothes shopping. Indeed, researchers (Ito, 2008; Shelton & Scoresby, 2011) found that some gaming features can distract players from the educational content.

In contrast, Pufflescape provided children with a more optimal flow experience (Csikszentmihalyi, 1990) as game challenges and children's skills were balanced in play. In Pufflescape, children engaged in solving problems to reach the goal state of the game. The problems posed in the game offered an optimal challenge for children, which might have made Pufflescape more engaging to play. Indeed, as noted by researchers (Rieber et al., 2009; Olson, 2010), optimal challenge in games can be a key factor to make them fun to play for children. In addition to optimal challenge, Pufflescape presented children with new and different problems in each level of the game, which fostered children's cognitive curiosity (Malone, 1981). This result corroborated with Olson's (2010) finding of children enjoying finding and learning new things from games.

Both Bits and Bolts and Pufflescape presented endogenous fantasy (Rieber, 1996) as an intrinsic motivational factor to their game play. That is, the learning content in both games was situated within the game context. But how the learning content was presented in those games varied. While the math content was overt in Bits and Bolts, the content was covert in Pufflescape. Children were aware of the mathematical skills being used to play Bits and Bolts.

In contrast, the mathematical skills used in Pufflescape were implicit to the game play and children were unable to identify them as math. This factor might have contributed to children's preference in playing Pufflescape over Bits and Bolts. Another contributing factor could be the high degree of problem solving in Pufflescape. That is, learning and game content were intertwined in the problem-solving process of game play as presented in Figure 5.2. Consequently, this integration might have led to the children's increased engagement in playing Pufflescape.

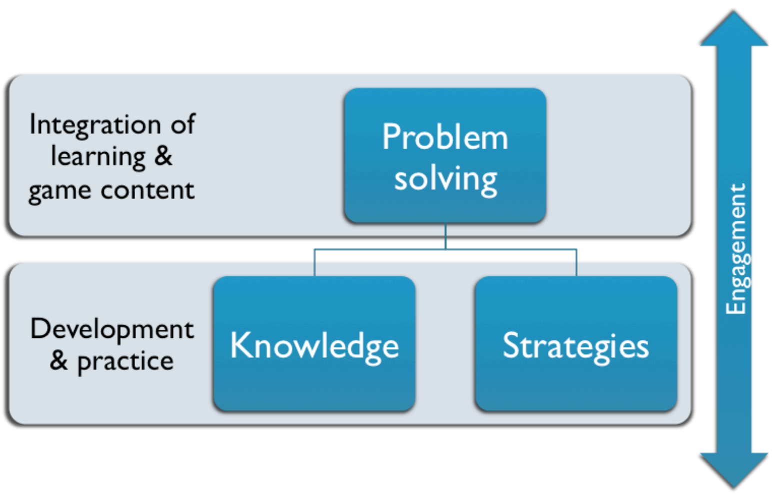


Figure 5.2 Conceptual framework for problem solving in games for learning

Conclusions

An aspect of learning and gaming examined in this study was problem solving. Problem solving could be considered an intrinsic part of playing Bits and Bolts and Pufflescape. Three components of this phenomenon were observed in this study: content, strategies, and engagement. These components are discussed in the sections below.

1. Enhanced engagement as a result of intrinsic and covert academic content.

Both serious games examined in this study were designed to promote both players' engagement and learning. To a certain degree, these games covered math content as part of the game play. Playing Bits and Bolts involved the practice of basic arithmetic content, such as counting and addition. Playing Pufflescape involved practice of geometric content, such as angles and shapes. Pufflescape also included physics content related to principles of force and motion. The exposure of content in these games was also different. In Bits and Bolts, the content was overt. For instance, most children identified Bits and Bolts as a math game and noticed addition as part of the game play. In Pufflescape, the content was covert. Children were unsure of what and if academic content was involved in the game. These factors contributed to the children's engagement and sustained attention to one game over the other.

Both games included endogenous fantasy (Rieber, 1996) as a motivational element to engage children with both the game and academic content. That is, academic content is an intrinsic part of game play. Nonetheless, the degree to which the academic content was intrinsic to these games varied. The academic content in Pufflescape was hidden. Most geometric content in the game was presented through a Heads-Up Display (HUD). By clicking on HUD, children were exposed to angles, theorems and formulae to solve puzzles in the game. Children applied this content as they manipulated levers and icicles to make a ramp. Children also observed and applied principles of force and motion as they generated speed, allowing their puffle to jump platforms. As children played with Pufflescape, they had an opportunity to learn about the academic content incidentally. That is, children's learning experience was unintentional, unstructured and resulted from some other activities, a process also known as incidental learning (Marsick & Watkins, 2001). Through incidental learning, children had control over their learning experience, deciding if and how to engage with content presented in HUD.

In contrast, the content of Bits and Bolts was visible. Children consciously had to employ counting skills in the game. They disengaged from playing the game often because of its content and repetitive nature. In terms of content, one of my participants explicitly said: “unless it’s my homework, I don’t like doing math.” Children perceived the math in the game and avoided playing it. There were several ways in which children attempted to avoid playing the game. Children often said they had played Bits and Bolts in our previous session so they could play Pufflescape in our current one. Children also negotiated the amount of time dedicated to play Bits and Bolts, which was usually short. One participant even used guessing as means to avoid counting in the game.

Besides content, the act of counting and adding bolts appeared to be perceived as tedious. For example, children had to count while playing the game and this was an activity that most of them had already learned how to preform in school. Since counting did not provide any new challenge for children in this study, they may have grown bored with the game because of the repetitive nature of the task. Repetitive tasks that do not teach, but provide practice with familiar academic content are a component of drills (Alessi & Trollip, 2001). And drill-practice features applied to the context of game have received criticism. Researchers (Papert, 1998; Bruckman, 1999; Okan, 2003; Egenfeldt-Nielsen, 2007) criticized these features in games because of the lack of meaningful activities grounded in constructivist learning theories. Bits and Bolts also did not appear to stimulate children’s cognitive curiosity (Malone, 1981) throughout the levels. Each level of the game was similar, with the main difference being a higher and more numbers of bolts. Thus, children seemed to think they were still playing the same level. As one of them mentioned, the game “pretty much goes on and on forever.”

With Pufflescape, children had a dissimilar experience. Children were provided with a different problem on each level of the game. This feature of new challenges in the game nourished the players' need for competence (Rigby & Ryan, 2011). This impression of novelty also stimulated children's cognitive curiosity (Malone, 1981), which resulted in enhanced engagement with the game. Pufflescape provided more optimal challenge to foster a flow experience (Csikszentmihalyi, 1990) than Bits and Bolts. Children had to manipulate levers and grab icicles within the game in order collect berries and a key to escape the cave. When facing challenges to collect these objects, children depended on HUD as a reference tool. Children also had more flexibility and autonomy (Rigby & Ryan, 2011) playing Pufflescape. For instance, children had the choice to use or not use the lever and icicles to solve the problem in a level. The objects in the game were also repurposed by the children to stop their puffle from moving or rolling off a platform. In contrast, Bits and Bolts did not provide much freedom within the game. The task in Bits and Bolts was more structured. The choice children had in the game was limited to bolt selection.

2. Using shortcuts to succeed in serious games

Many strategies can be used to solve problems. In this study, children used different strategies to succeed in playing the serious games. Strategies for playing Bits and Bolts often involved counting and guessing; while strategies for playing Pufflescape involved common problem-solving strategies based on literature (e.g., Simon and Newell's 1971; Chi and Glaser, 1985; Anderson, 2005). Even though the strategies used in both serious games differed, there was a common pattern to select these strategies and to succeed in playing. This common pattern was to seek shortcuts. Children often sought strategies that provided an easy path to an undesirable activity. For example, guessing was a strategy used to avoid counting in Bits and

Bolts. Although guessing was an ineffective method to succeed in the game, it could be considered a shortcut in terms of taking an easy path to avoid counting.

Another example was children seeking easy and alternative solutions to solve the levels in Pufflescape. Easy and alternative solutions in Pufflescape involved avoiding manipulating levers or icicles to reach the various platforms in game. Children depended on their puffle's speed, which meant applying principles of force and motion intuitively, to achieve their goal. Even though there were some successful attempts, this strategy was not always reliable. Thus, this strategy could be considered a shortcut because children sought easy solutions to avoid in-game object manipulation.

The use of such strategies when playing Bits and Bolts and Pufflescape appeared to be related to children's motivation. These strategies were used to avoid an undesirable task in the game, but in an attempt to still be successful. Nonetheless, their attempt was temporary and often based on luck or chance.

3. High degree of problem solving in serious games fosters creative acts

Problem solving can be defined as a goal-oriented activity (Newell, 1979) wherein people find solution(s) to overcome a set of situations. Initially, the problem is structured by the environment or by a designer. The way people approach the problem is subjective and based on the inferences people make of a situation (Simon & Newell, 1971). Problem solving can lead to creative acts (Runco, 2007) as people find new and original solutions to a problem.

The game play in Pufflescape was set to provide a higher degree of problem solving than Bits and Bolts. Children navigated their puffle through platforms and manipulated objects such as levers and icicles to reach a key and berries in the game. In an attempt to solve the levels, children sought to identify the right position of a lever or an icicle to build a ramp and launch their puffle to various platforms. But because of the puffle's motion, making a puffle stay on the platform became another problem or a subgoal (Anderson, 2005). In attempt to solve this subgoal, creative acts emerged. Children repurposed levers and icicles as a brake to stop their puffle from moving. Children thought of new and useful way to use objects in the game, and consequently, attain their own goals.

Limitations of the Study

There were several limitations with this study. First, due to the challenge of getting the approval of K-12 schools to conduct this type of research, only a small number of participants were recruited. In addition, this sampling population was recruited from a local private school in a wealthy area of Southeast region of the United States, which limits the variation among cases.

Another limitation of this study was the number of cases presented. I was able to generate only four cases from data collection. Three cases were drawn from data collected in the school setting, while a single case was constructed from the home setting. Additional cases from other home settings might have provided a more robust and comprehensive case comparison. The reasons for this limitation were two: (1) inability to find local parents willing to commit to this research, and (2) time and resource constraints. Some parents were unwilling to allow their children to participate in this research because of the extended screen media exposure. Other parents appeared to be reluctant because of their unfamiliarity with the commercial game environment.

Data collection has been another limitation of the study, especially in the school context. For instance, I alternated the video recordings among participants in attempt to be inclusive. Because of the video recording alternation, I was unable to have a comprehensive understanding of a single participant's progress with serious games during the game-playing program.

Additionally, there were Internet connection issues in the school setting. These issues limited participants' play in the program and also contributed to data collection limitations. That is, I had to attend to technology issues instead of attending to my participants and their game play.

Unlike other researchers (e.g., Holt, 2011; Steinkuhuler, 2006), who devoted years studying their participants and the game context participants played, the time available to conduct this research was limited. I was only allowed approximately two months with participants. Parents and school administrators set this time constraint because an extended game-playing program was unfeasible. Both parties indicated children were young and unable to sustain their attention in a program for long period of times. Besides this time constraint, limited access to participants and their play restricted my ability to confirm participants' responses when they referred to playing the serious games at home.

Another limitation was the young age of participants. Because of their age, participants were unable to provide articulated responses about their understanding of the games or the cognitive process involved in playing them. Their limited responses resulted on a reliance of observation data to draw clues about their thought process. Additionally, participants' selective memory was an issue because they were unable to recall experiences or events occurring at some point in the program (e.g., games played).

Considering that these serious games are part of a virtual world full of entertainment activities, it can be difficult to account for players choosing or sustaining their attention to these games. In other words, serious games embedded in a virtual space surrounded by "fun" activities received less attention. Children preferred to engage in other activities such as buying virtual clothes or playing with their virtual pet instead of playing serious games.

Due to my involvement as well as other individuals in this research project in the design process of these serious games for Club Penguin™, research bias was introduced to this study. The reasons for selecting this specific virtual environment, Club Penguin™, as well as the serious games, Bits and Bolts and Pufflescape, were a consequence of my participation in the game design team.

Recommendations

Findings from this study provide recommendations to game designers and parents as well as researchers in the field of game and learning. This section is divided into two sub-sections: serious game design and future research suggestions. With regard to serious game design, this sub-section offers recommendations to create a balance between learning and academic content in future serious game design. With regard to future research suggestions, this sub-section proposes three studies that examine: (1) similar research approach using games in a different context, (2) different research approach using games in a similar context, and (3) different research approach using game elements in an educational context.

Serious Game Design

Games designed to foster learning need to find a balance between academic content and game elements in order to promote learning and engagement. Identifying the optimal balance between these two areas is beyond the scope of this study, especially in light of the fact that only two serious games were analyzed. Nevertheless, recommendations for future serious games design are provided.

One of the recommendations for future serious games is to avoid repetitive tasks that are associated with academic content. For example, when playing Bits and Bolts, children had to click on a series of tiles to add up to a number on the screen. On each level of the game the children kept doing the same activity, which led some of them to get bored and play the game for a short period of time. If a repetitive task needs to be part of the game, it should be associated with an activity that children actually enjoy such as buying products for their avatar or goodies for the virtual pet.

Children in this study enjoyed spending their virtual money on furniture, clothes and other accessories for their avatar and pet. Children's intrinsic motivation to buy virtual products provides an opportunity for game designers to create practical activities requiring basic arithmetic such addition and subtraction. For example, players could have a check balance in which they could add their virtual coins earned and subtract them after they buy their virtual products.

Moreover, serious games similar to Bits and Bolts and Pufflescape should not be used as stand-alone games. Even though both games provide instructions for players, guidance is limited. Players can figure out how to play the games on their own but their understanding of the goals of the game or its content can be distorted. For example, when playing Bits and Bots, participants did not seek to reach the game goal, i.e., use multiples to build a robot. In the case of Pufflescape, the math content presented in the heads-up display of the game was oftentimes above the children's cognitive level. Thus, to maximize the positive effects of these types of educational media, parents (and teachers, if these games are used in schools) should observe and guide children whenever needed.

Most of these games are targeted to young children who are still learning how to read, identify, and recognize words. Instead of using graphics and text to communicate instructions for a game, animated videos could be more appropriate for this audience. These animated videos could show the actions players need to engage in to reach the goal of the game. In addition, math terms such as multiples or prime numbers might not be part of young children's vocabulary. Therefore, pointing to a glossary or even having a quick lesson that explains these concepts in the game could be beneficial for children to understand the concepts covered in the game.

Furthermore, the academic content covered in serious games should be relevant and appropriate to children's cognitive level in order to help them understand and make sense of games. If the academic content presented in the game is new to children, it should build upon the children's previous knowledge or be designed in the game within children's zone of proximal development. Ideally, each level of a serious game should explore a new topic related to the academic content, building on the previous topics covered in the game. This could promote curiosity and strengthen the challenge in the game.

Future Research Suggestions

As mentioned early in this chapter, the research presented in this dissertation had some limitations, which raised more questions and suggestions for future research. Indeed, if I had the opportunity to redesign this study, I might have considered conducting it in a home or another environment where more control over the Internet connection would be possible. Thus, this section provides three future research suggestions to be pursued in the field of game-based learning. Future research suggestions are organized as following: (1) similar research approach using games in a different context, (2) different research approach using games in a similar context, and (3) different research approach using game elements in educational context.

First, there is a need to implement similar research approaches using games in different contexts to expand the body of knowledge in game-based learning. For example, instead of an after-school program, future researchers might design a research-based summer camp for elementary school-aged children. The summer camp can be devoted to playing serious games and learning the basics of game design. In order to avoid any Internet connection issues, the summer camp can take place in a computer lab at a higher education institution. The research focus might be on the lived experiences of children participating in the summer camp and how serious games can support and expand these children's learning experiences. From this experience, children might learn the core concepts of game design as they play the serious games. Children can also reflect upon and discuss their understanding of and engagement with these games. Participant observation and focus-group interview methods can be used to gathered data on children's engagement in and understanding of games. Artifact data such as the participants' concept art, level design, game concepts, and screen captures might be collected as well to provide a better understanding of the phenomena of serious game design in a summer camp.

Secondly, future research should consider the holistic approach of game-based learning. Instead of conducting research with existing serious games, researchers can focus on understanding the comprehensive process, from creation to implementation, of serious games. For instance, researchers might build a partnership between K-12 schools and higher education intuitions to design, develop, and assess a serious game-based program. In developing this program, a long-term research project using a Design-Based Research (Barab & Squire, 2004; van den Akker, Gravemeijer, McKenney & Nieveen, 2006) approach can be designed. This might be a three-phase research project implemented over the course of a year. In the first phase, instructional technology graduate students collaborating with K-12 teachers can identify topics and content that K-12 students have difficulty grasping in the classroom. A variety of subject areas including, but not limited to, mathematics might be covered. In the second phase, instructional technology graduate students can develop the serious games in consultation with K-12 teachers. Finally, instructional technology graduate students can evaluate the effectiveness of a serious game-based program being implemented in K-12 schools. The effectiveness of this program might be evaluated by measuring the students' motivation toward the subject covered in the games as well as the students' prior knowledge of the game content.

Given the findings presented in this dissertation, certain game elements, such as virtual currency, seem to foster children's engagement in playing serious games. Thus, future research should investigate the effectiveness of game elements in educational contexts to promote learning. For instance, researchers might study gamification approaches, defined as the use of game design elements in non-game contexts (Deterding, Dixon, Khaled & Nacke, 2011), in K-12 or higher education settings. Since there has been a limited amount of research focusing on gamification and even fewer studies examining the use of a single game element or technique in education (Dicheva, Dichev, Agre & Angelova, 2015), researchers may consider observing a single game element such as virtual currency in classroom environments. Virtual currency can be examined in order to understand how students use and spend their goods in classroom activities. The students' academic performance and engagement in the course should be measured to support the effectiveness of this technique in the classroom.

Summary of the Study

The idea of combining education and entertainment into a game technology is not a new one. Pioneering work in the field started in the early seventies. Since then, multiple forms and labels of educational games have emerged as a result of technological advancements and new approaches to integrate academic content into games. This study examined young children's engagement and learning with serious games in a virtual world. Much of the research on this topic has demonstrated mixed results related to the effects of games as learning tools. With my research work, I provide contributions and support the work of researchers and instructional designers in the growing sub-field of educational gaming. In order to complete my data collection, I designed a 10-day game-playing program. The game-playing program allowed me to observe, interview, and collect children's game play screen recordings. My findings indicated that children were more engaged as a result of intrinsic and covert academic content, that strategies to succeed in the games involved cheating, and that a high degree of problem solving fostered creative acts. By sharing children's stories through this research, I expect that instructional designers and teachers will be able to use these insights to design better games and be better able to plan for their use in both formal and informal settings.

CHAPTER 6

EPILOGUE

There is an old saying: “nothing in this world worth having comes easy.” And it is true for the completion of this study. This section uncovers the barriers I faced in the process of conducting research with young children and using new technology in a school setting. The purpose of this section is to provide a descriptive narrative of the obstacles encountered in this research. Future researchers and practitioners can benefit from reading this section as they might anticipate and better plan for these obstacles when designing after-school programs or conducting similar research. All names presented in following the sections are pseudonyms.

Delay in Processing IRB Approval

First of all, I faced many barriers to receive IRB approval. It took almost four months to receive the approval of IRB office to conduct my research. One of the reasons for this delay was the lack of a tracking system at that time. Originally I had submitted my research proposal with consent documents to IRB via email, but the consent documents were lost between the submission and revision process. A long series of email exchanges took place between the IRB reviewer and myself to understand what occurred with the original consent documents, further delaying the processing time to receive IRB approval.

Once all documents were submitted and located another issue led to delay in processing time: a request to describe procedures often administered by school staff at a rural charter elementary school where I was planning to conduct my research. As this study was a research-based after-school program, the IRB reviewer asked me to address school bus policies and procedures beyond my knowledge and authority as a researcher. Explaining how to escort students to the school bus stop and what to do when a child misses a school bus should be treated as supplemental information and not an essential component to receive research approval. The IRB reviewer should have given further consideration to procedures that address protecting the rights and welfare of human subjects involved in the research rather than focusing on school policies and procedures that researchers are required to comply with.

Lastly, the delay in approving this study was also a result of inconsistency in the review process. The IRB reviewer often made suggestions to the research proposal and consent form documents to only later change these suggestions yet again. This became an ineffective review process, as it was unclear which recommendations were requirements for approval and which were suggestions to improve readability.

Technology Issues in Shine Spring School

Due to a four-month processing time for research approval, I had less than a month to coordinate and collect data in Shine Spring School before summer break. I contacted the school's assistant principal, Mr. Bravo, to discuss the logistics for conducting this research. Mr. Bravo indicated I could work with Ms. Jones, an art teacher interested in games for educational purposes, to schedule my visits to the school.

A few days later after contacting Mr. Bravo, I went to Shine Spring School to distribute the consent forms and explain my research to students. Ms. Jones greeted my research assistant and me at her classroom door. As we were walking into the classroom, Ms. Jones told her students about her visitors. She asked her students to behave properly and to sit down on the carpet area in the classroom to listen to her visitors. I introduced my research assistant and myself and explained our purpose for being at their school. Once students were informed about the opportunity to play games in this study, they seemed excited. Students started telling me which games they liked to play such as *Uno* and *Sorry*. I told them Club Penguin™ was the game they were going to playing in this program. The majority of students appeared to be familiar with Club Penguin™ as some indicated having an active penguin account and playing it with friends and relatives often.

Even tough students were eager to play Club Penguin™; they never had a chance to actually play it in the school. The reason for this inconvenience was due to Club Penguin™'s website being blocked. Apparently, Club Penguin™ was considered a social networking site which students were unable to access through school computers. Ms. Jones suggested we try her teacher's login to check whether students could have access to the game environment. With Ms. Jones' login, students were able to access Club Penguin™'s website, but they were still unable to play the game. Every time students tried to login with their penguin account to Club Penguin™ a pop-up error message appeared.

In light of this new event, I worked with the school's media specialist, Ms. Olson, to troubleshoot and solve the problem. We tried to change the computer firewall settings and to use a proxy server to bypass school's Internet firewall without success. Ms. Olson contacted Club Penguin™'s technical support to make them aware of this problem and possibly find a solution. Club Penguin™'s technical support informed her that they could not troubleshoot or provide assistance for publicly accessed computers. Assistance in accessing Club Penguin™ through the school's firewalls could only be provided to school network administrators through correspondence via their official school emails. Ms. Olson contacted Mrs. Park, the school district Director of Information and Technology Services, to let her know about this issue. Mrs. Park contacted Club Penguin™'s technical support. Mrs. Park turned some of the firewalls off, but students were still unable to play Club Penguin™ in the school. Mrs. Park communicated to Ms. Olson that she could not turn off any other firewalls because students' safety might be jeopardized. Consequently, I could not conduct my research at the school anymore and I had to find a new research site.

Resistance From Home Schooling Network

Given the technology issue at Shine Spring School, I sought other research sites. First, I tried to set up a summer camp with the university or the local library, but these endeavors did not work. It was already too late in the summer break to implement a camp as most parents had already registered their children for other existing camps. Then, a former instructor of mine, Dr. Charles, put me in touch with Jane, a master's student who was part of a home schooling network. Jane and I exchanged emails to discuss the research opportunity and the specifics of the home schooling program.

Jane explained that the parents in her home schooling network often taught their children at home but sought supplemental instruction from Pleasant Academy. Pleasant Academy offered several classes from which parents could select. Classes were held at non-profit organization buildings in different locations. Jane offered to contact the director of Pleasant Academy to determine if a research-based game-playing program could be held in their facilities. The director of Pleasant Academy told Jane she could not allow this kind of program in their facilities. Her explanation to Jane was that if she allowed one person to conduct a research-based program in Pleasant Academy she would be unable to turn anyone down in the future. Nevertheless, the director of Pleasant Academy said to Jane she could contact individual parents in the group to see if they were interested in participating in the study. After talking to the parents, Jane informed me she could not finding any families willing to participate in this study.

Jane told me that, like the director of Pleasant Academy, the families were also resistant to my research. This resistance was partially because of Club Penguin™ being a product owned by Disney. According to Jane, Disney had been involved in controversial issues dealing with Christianity which had been discussed in the past by the Pleasant Academy director and parents. Though Pleasant Academy had no religious affiliation, both parents and administration tried to distance themselves from any company or message opposing their religious beliefs.

Jane also thought parents were resistant because of their unfamiliarity with the research. The fact that parents were unfamiliar with Club Penguin™' s game environment, or with me as research administrator, might have contributed to this resistance. In the end, Jane had the impression that she was receiving one excuse after another from parents who were unwilling to participate in the study.

Lessons Learned

Even though I faced many barriers to conducting this research; I learned a few lessons from this experience. First, I realized I had to plan ahead and anticipate delays in receiving research approval when new technology and minors were involved. Another lesson learned from this experience was to avoid assuming students have access to online software in school grounds, even if the software is designed for them and it is age appropriate. Schools set up their firewall system differently, with some schools being more restrictive with children's internet access than others. Finally, gaming technologies are not free from controversy and mixed agendas. Home-schooling parents were reluctant to let their children participate in this study because the games to be played were owned by a company that was involved in controversial issues. Given these controversial issues, parents were unwilling to let their children play Club Penguin™ even if the games in Club Penguin™ were designed to foster mathematical learning.

For future researchers planning to conduct similar research, I recommend submitting the research proposal with required documents at least six months prior to the implementation of study, especially if the research site is a school setting. With a six-month time frame, researchers can carefully plan and handle research logistics in advance. Future researchers should also consider contacting the school media specialist to verify students' Internet access. If students' Internet access is limited, researchers, in conjunction with school administrators, should discuss ways to authorize students' access to specific online software without jeopardizing students' safety.

REFERENCES

Aldrich, C. (2009). *Complete guide to simulations and serious games: How the most valuable content will be created in the age beyond Gutenberg to Google*. Hoboken, NJ: Pfeiffer. Retrieved from http://site.ebrary.com/lib/ugalib/Doc?id=10341735&ppg=65

Alessi, S., & Trollip, S. (2000). *Multimedia for learning: Methods and development* (3rd ed.). New York, NY: Allyn & Bacon.

Anderson, A. F., & Bavelier, D. (2011). Action game play as a tool to enhance perception, attention and cognition. In S. Tobias & J. D. Fletcher (Eds.), *Computer games and instruction* (pp. 307-330). Charlotte, NC: Information Age Publishing.

Anderson, J. R. (1993). Problem solving and learning. *American Psychologist*, *48*(1), 35–44.

Anderson, J. R. (2005). *Cognitive Psychology and Its Implications: Sixth Edition*. New York: Worth Publishing.

Barab, S., & Squire, K. D. (2004). Design-based research: Putting a stake in the ground. *Journal of the Learning Sciences*, *13*(1), 1-14.

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making Learning Fun: Quest Atlantis, A Game Without Guns. *Educational Technology Research and Development*, *53*(1), 86-108.

Barab, S., Arici, A., & Jackson, C. (2005). Eat Your Vegetables and Do Your Homework : A Design- Based Investigation of Enjoyment and Meaning in Learning. *Educational Technology*, *65*(1), 15–21.

Barab, S., Sandler, T., Heiselt, C., Hickey, D., & Zuiker, S. (2007). Relating narrative, inquiry, and inscriptions: Supporting consequential play. *Journal of Science Education & Technology*, *16*(1), 59-82.

Barab, S., Zuiker, S., Warren, S., & Hickey, D. (2007). Situationally embodied curriculum: Relating formalisms and contexts. *Science Education*. doi:10.1002/sce

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

Bell, M. W. (2008). Toward a definition of "virtual worlds". *Journal of Virtual World Research*, *1*(1), 2-5.

Bernard, H. R. (2006). *Research methods in anthropology: Qualitative and quantitative approaches* (4th ed.). Walnut Creek, CA: AltaMira Press.

Biesta, G.J.J., and Burbules, N.C. (2003). *Pragmatism and educational research.* NY: Rowman & Littlefield Publishers, Inc.

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research in education: An introduction to theory and methods* (5th ed.). Boston, MA: Allyn and Bacon.

Bredo, E. (1994). Reconstructing educational psychology: Situated cognition and Deweyian pragmatism. *Educational Psychologist*, *29(1),* 23-35.

Bruckman, A. (1999). Can Educational Be Fun? *Game Developer's Conference*, San Jose, CA (pp. 75-79). Retrieved from http://www.cc.gatech.edu/~asb/papers/conference/bruckman-gdc99.pdf.

Bruner, J. S. (1966). *Toward a theory of instruction*. Cambridge, MA: Belknap Press of Harvard University.

Bruner, J. S. (1962). *On knowing: Essays for the left hand*. Cambridge, MA: Belknap Press of Harvard University.

Burley, D. (2010). Penguin Life: A Case Study of One Tween's Experiences inside Club Penguin. *Journal Of Virtual Worlds Research, 3*(2). doi:10.4101/jvwr.v3i2.1894

Bryman, A. (2003). Triangulation. In M. S. Lewis-Beck, A. Bryman, & T. F. Liao (Eds.), *Encyclopedia of social science research methods*. London: Sage Publications. Retrieved from: http://www.sagepub.com/chambliss4e/study/chapter/encyc_pdfs/4.2_Triangulation.pdf

Castronova, E. (2005). *Synthetic worlds: The business and culture of online games*. Chicago, IL: University of Chicago Press.

Chang, K., Wu, L., Weng, S., & , & Sung, Y. (2012). Embedding game-based problem-solving phase into problem-posing system for mathematics learning. *Computers & Education, 58*, 775-786.

Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Sage Publications Ltd.

Chi, M. T. H., & Glaser, R. (1985). Problem-solving ability. In R. Sternberg (Ed.), *Human Abilities: An Information-Processing Approach* (pp. 227-257). San Francisco: W. H. Freeman & Co.

Cannon-Bowers, J. A., & Bowers, C. A. (2008). Synthetic learning environments. In J. M. Spector, M. D. Merrill, J. van Merriënboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed., pp. 317-327). New York, NY: Lawrence Erlbaum.

Corbin, J. M., & Strauss, A. L. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage.

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

Csikszentmihalyi, M. (1988). The flow experience and its significance for human psychology. In M. Csikszentmihalyi & I. S. Csikszentmihalyi (Eds.). *Optimal experience : psychological studies of flow in consciousness* (pp. 15-35). New York: Cambridge University Press.

de Freitas, S. I. (2006). Using games and simulations for supporting learning. *Learning, Media and Technology*, 31(4), 343-358.

Deterding, S., Dixon, D., Khaled, R. and Nacke, L. E. (2011). From game design elements to gamefulness: Defining “gamification”. In Lugmayr, A., Franssila, H., Safran, C., & Hammouda, I. (Eds.), *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments* (pp.9-15). New York: ACM Press.

DeWalt, K. M., & DeWalt, B. R. (2002). *Participant observation: A guide for fieldworkers*. Walnut Creek, CA: AltaMira Press.

Dicheva D., Dichev C., Agre G., & Angelova G. (2015). Gamification in education: A systematic mapping study. *Journal of Educational Technology and Society*, *18* (3), 1-14.

Dickey, M. (2007). Game design and learning: a conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology and Research Development*, *55*, 253–273.

Dickey, M. D. (2011). World of Warcraft and the impact of game culture and play in an undergraduate game design course. *Computers & Education*, *56*, 200-209. doi:10.1016/j.compedu.2010.08005

Egenfeldt-nielsen, S. (2007). Third Generation Educational Use of Computer Games. *Journal of Educational Multimedia and Hypermedia*, *16*(3), 263-281.

Entertainment Software Association. (2011). 2011 Essential facts about the computer and video game industry. Retrieved from http://www.theesa.com/facts/pdfs/ESA_EF_2011.pdf

Feldon, D. F., & Kafai, Y. B. (2007). Mixed methods for mixed reality: understanding users' avatar activities in virtual worlds. *Educational Technology Research and Development, 56*, 575-593. doi: 10.1007/s11423-007-9081-2

Fields, D. A., & Kafai, Y. B. (2007). Tracing insider knowledge across time and spaces: A connective ethnography in a teen online game world. *Proceedings of the 8th international conference on Computer supported collaborative learning* (pp. 199–208). International Society of the Learning Sciences.

Fields, D. A, & Kafai, Y. B. (2010a). "Stealing from grandma" or generating cultural knowledge?: Contestations and effects of cheating in a tween virtual world. *Games and Culture*, *5*(1), 64-87. doi:10.1177/1555412009351262

Fields, D. A., & Kafai, Y. B. (2010b). Knowing and throwing mudballs, hearts, pies, and flowers: A connective ethnography of gaming practices. *Games and Culture*, *5*(1), 88-115. doi:10.1177/1555412009351263

Freeman, M., & Mathison, S. (2009). *Researching children's experiences*. New York, NY: Guilford Press.

Garris, R., Ahlers, R. & Driskell, J. E. (2002) Games, motivation, and learning: a research and practice model, *Simulation & Gaming, 33*, 441–467.

Gee, J. P. (2004). Learning by design: Games as learning machines. *Interactive Educational Multimedia*, (8), 15-23.

Gee, J. P. (2007). *What video games have to teach us about learning and literacy* (2nd ed.). New York: Palgrave.

Gredler, M. E. (1996). Educational games and simulations: A technology in search of a (research) paradigm. In D. H. Jonassen (Ed.), *Handbook of research for educational communications and technology* (pp. 521-540). New York, NY:Macmilliam.

Habgood, M. P. J., & Ainsworth, S. E. (2011). Motivating Children to Learn Effectively: Exploring the Value of Intrinsic Integration in Educational Games. *Journal of the Learning Sciences*, *20*(2), 169–206. doi:10.1080/10508406.2010.508029.

Holt, N. (2011). *Deep involvement in the world of warcraft: An elfnography*. (Unpublished doctoral dissertation). University of Georgia.

Hong, J. C., & Liu, M. C. (2003). A study on thinking strategy between experts and novices of computer games. *Computers in Human Behavior*, *19*(2), 245–258.

Ito, M. (2008). Education vs. entertainment: A cultural history of children's software. In K. Salen (Ed.), *The ecology of games: Connecting youth, games, and learning* (pp. 89-116). Cambridge, MA: The MIT Press.

Jordan, B., & Henderson, A. (1995). Interaction analysis: Foundations and practice. *The Journal of the Learning Sciences, 4*(1) (1995), 39-103.

Jonassen, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophical paradigm? *Educational Technology Research and Development, 39*(3), 5-14.

Juul, J. (2005). *Half-real: Video games between real rules and fictional worlds*. Cambridge, MA: MIT Press.

Kafai, Y. B. (2010). World of Whyville: An introduction to tween virtual life. *Games and Culture, 5*(1), 3-22. doi:10.1177/1555412009351264

Kafai, Y.B., Feldon, D., Fields, D., Giang, M., & Quintero, M. (2007). Life in the times of whypox: A virtual epidemic as a community event. In C. Steinfeld, B. Pentland, M. Ackermann, & N. Contractor (Eds.), *Proceedings of the Third International Conference on Communities and Technology*. New York: Springer.

Kafai, Y. B., Fields, D. A, & Cook, M. S. (2010). Your second selves: Player-designed avatars. *Games and Culture*, *5*(1), 23-42. doi:10.1177/1555412009351260.

Kafai, Y. B., Quintero, M., & Feldon, D. (2010). Investigating the "why" in whypox: Casual and systematic explorations of a virtual epidemic. *Games and Culture*, *5*(1), 116–135. doi:10.1177/1555412009351265.

Ke, F. (2008a). Computer games application within alternative classroom goal structures: Cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development, 56*(5), 539-556.

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

Kelly, R. V. (2004). *Massively multiplayer online role-playing games: The people, the addiction and the playing experience*. Jefferson, NC: McFarland & Co.

Kirschner, P.A., Sweller, J. & Clark, R.E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry based teaching. *Educational Psychologist*, *41*, 75-86.

Koster, R. (2005). *A theory of fun for game design*. Scottsdale, AZ: Paraglyph Press.

Lepper, M. R., & Malone, T. W. (1987). Intrinsic motivation and instructional effectiveness in computer-based education. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, learning, and instruction: III. Conative and affective process analysis* (pp. 255-286). Hillsdale, NJ: Erlbaum.

Linderoth, J., Lindström, B., & Alexandersson, M. (2004). Learning with computer games. In J. Goldstein, D. Buckingham & G. Brougére (Eds.), *Toys, games, and media* (pp. 157-176). Mahwah, NJ: Lawrence Erlbaum Associates.

Loh, C. S. (2011). Researching and developing serious games as interactive learning instructions. In R. E. Ferdig (Ed.), *Discoveries in gaming and computer-mediated simulations: New interdisciplinary applications* (pp. 263-282). Hershey, PA: IGI Global.

López, J. M. C., & Cáceres, M. J. M. (2010). Virtual games in social science education. *Computer & Education*, *55*, 1336-1345.

M2 Research (2010, August 18). Kids and Games: What Boys and Girls are Playing Today. Retrieved from http://www.m2research.com/kids-and-games-report-release.htm

Malone, T.W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive Science*, *4*, 333-370.

Marsh, J. (2011). Young children ’s literacy practices in a virtual world : Establishing an online interaction order. *Reading Research Quarterly*, *46*(2), 101–118.

Marsh, J. (2010). Young children’s play in online virtual worlds. *Journal of Early Childhood Research*, *8*(1), 23–39. doi:10.1177/1476718X09345406.

Marsick, V. J., & Watkins, K. E. (2001). Informal and incidental learning. *New Directions for Adult and Continuing Education,* (89), 25-34.

Michael, D., & Chen, S. (2005, October 19). Proof of learning: Assessment in serious games. *Gamasutra*. Retrieved from http://www.gamasutra.com/view/feature/2433/proof_of_learning_assessment_in_.php.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks: Sage.

Merriam, S.B. (1988). *Case study research in education: A qualitative approach*. San Francisco, CA: Jossey–Bass

Merriam, S. B., & Associates. (2002). *Qualitative research in practice: Examples for discussion and analysis*. San Francisco, CA: Jossey-Bass.

Meyers, E. (2009). Tip of the iceberg: Meaning, identity, and literacy in preteen virtual worlds. *Journal of Education for Library and Information Science*, *50*(4), 226–237.

Moline, T. (2010). Video games as digital learning resources: Implications for teacher-librarians and for researchers. *School Libraries Worldwide, 16*(2), 1-15.

Nelson, B. (2007). Exploring the use of individualized, reflective guidance in an educational multi-user virtual environment. *Journal of Science Education and Technology*, *16*(1), 83-97.

Newell, A. (1979). Reasoning, problem solving, and decision processes: The problem space as a fundamental category. *Technical Report*. Pittsburgh, PA: Department of Computer Science, Carnegie-Mellon University.

O'Neil, H. F. (1999). Perspectives on computer-based performance assessment of problem solving. *Computers in Human Behavior*, *15*(3-4), 255–268. doi:10.1016/S0747-5632(99)00022-9.

O'Neil, H. F., Mainess, R., & Baker, E. L. (2005). Classification of outcomes: Evidence from the computer games literature. *The Curriculum Journal*, *16*, 455-474.

Okan, Z. (2003). Edutainment: Is learning at risk? *British Journal of Educational Technology*, *34*(3), 255-264. doi:10.1111/1467-8535.00325.

Olson, C. K. (2010). Children's motivations for video game play in the context of normal development. *Review of General Psychology*, *14*(2), 180–187. doi:10.1037/a0018984.

Papert, S. (1998). Does easy do it? Children, games, and learning. *Game Developer*. Retrieved from http://www.papert.org/articles/Doeseasydoit.html.

Pareto, L., Haake, M., Lindström, P., Sjödén, B., & Gulz, A. (2012). A teachable-agent-based game affording collaboration and competition: Evaluating math comprehension and motivation. *Educational Technology Research and Development*, 1-29. doi: 10.1007/s11423-012-9246-5.

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. SAGE.

Piaget, J. (1962). *Play, dreams, and imitation in childhood*. (C. Gattegno & F. M. Hodgson, Trans.). New York: Norton (Original work published 1951).

Piaget, J. (1983). Piaget's theory. (G. Gellerier, Trans.). In P. Mussen (Ed.), *Handbook of Child Psychology* (4th ed., vol.1, pp. 103-128). New York: Wiley.

Piaget, J., & Inhelder, B. (2000). *The psychology of the child*. (H. Weaver, Trans.). New York: Basic Books (Original work published 1969).

Pinch, T. J., & Bijker, W. E. (1989). The social construction of facts and artifacts: Or how the sociology of science and the sociology of technology might benefit each other. In W. E. Bijker, T. P. Hughes, & T. Pinch (Eds.), *The social construction of technological* *systems: New directions in the sociology and history of technology* (pp. 17-50). Cambridge, MA: MIT Press.

Prensky, M. (2005). Computer games and learning: Digital game-based learning. *Handbook of computer game studies*, 97–122.

Randel, L. M., Morris B. A., C. D., & Whitehill, B. V. (1992). The effectiveness of games for educational purposes: A review of recent research. *Simulation and Gaming,* 23, 261-276.

Rideout, V., Foehr, U., & Roberts, D. (2010). Generation M2: Media in the lives of 8- to 18-year-olds. *The Henry J. Kaiser Family Foundation*. Retrieved from http://www.kff.org/entmedia/mh012010pkg.cfm

Rieber, L. P. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. *Educational Technology Research & Development*, *44*(2), 43-58.

Rieber, L. P., Davis, J. M., Matzko, M. J., & Grant, M. M. (2009). Children as critics of educational computer games designed by other children. In R. E. Ferdig (Ed.), *Handbook of research on effective electronic gaming in education* (pp. 1234- 1256). Hershey PA: IGI Global.

Rieber, L. P. (2014). Lloyd's video analysis tool (Version 4.0) [Software]. Available from http://www.nowhereroad.com/vat/.

Rigby, S., & Ryan, R. M. (2011). *Glued to games: How video games draw us in and hold us spellbound*. Santa Barbara, CA: Praeger.

Roulston, K. (2010). Reflective interviewing: A guide to theory and practice. Los Angeles, CA: Sage Publications.

Runco, M. A. (2007). *Creativity: Theories and themes: Research, development, and practice*. Boston, MA: Academic Press.

Saldaña, J. (2011). *Fundamentals of qualitative research*. New York : Oxford University Press.

Salen, K., & Zimmerman, E. (2004). *Rules of play: Game design fundamentals*. Cambridge, MA: The MIT Press.

Schell, J. (2006). *The art of game design: A book of lenses.* Burlington, MA: Morgan Kaufmann Publishers.

Schroeder, R. (2008). Defining virtual worlds and virtual environments. *Journal of Virtual Worlds Research, 1*(1). doi:10.4101/jvwr.v1i1.294

Shaffer, D. W., Squire, K.D., Halverson, R., & Gee, J.P. (2005). Video games and the future of learning. *Phi Delta Kappan*, *87*(2), 105-111.

Shelton, B. E., & Scoresby, J. (2011). Aligning game activity with educational goals: Following a constrained design approach to instructional computer games. *Educational Technology and Research Development*, *59*, 113–138.

Schuh, K. L. & Barab, S. A. (2008). Philosophical perspectives. In J. M. Spector, M. D. Merrill, J. J. G. van Merriënboer, & M. P. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed.) (pp. 67-82). Mahwah, NJ: Lawrence Erlbaum Associates.

Simon, H., & Newell, A. (1971). Human problem solving: The state of the theory in 1970. *American Psychologist*, *26*(2), 145–159.

Simon, H. (1995). The information-processing theory of mind. *American Psychologist*, *50*(7), 507–508.

Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology, 64*(2), 489-528. doi: 10.1111/j.1744-6570.2011.01190.x

Siyahhan, S., Barab, S. A., & Downton, M. P. (2010). Using activity theory to understand intergenerational play: The case of family quest. *Computer-Supported Collaborative Learning, 5*(4), 415-432.

Spradley J. (1980). *Participant Observation*. New York: Holt, Rinehart, and Winston.

Squire, K. D. (2003). Video games in education. *International Journal of Intelligent Simulations and Gaming, 1*(2).

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage Publications.

Steinkuehler, C. A. (2004). Learning in massively multiplayer online games. In Y. B. Kafai, W. A. Sandoval, N. Enyedy, A. S. Nixon, & F. Herrera (Eds.), *Proceedings of the Sixth International Conference of the Learning Sciences* (pp. 521–528). Mahwah, NJ: Erlbaum.

Steinkuehler, C. A. (2006). Massively multiplayer online videogaming as participation in a Discourse. *Mind, Culture, & Activity, 13*(1), 38-52.

Tobias, S., & Fletcher, J.D. (2007). What research has to say about designing computer games for learning. *Educational Technology*, *47*(5), 20-29.

Tobias, S., & Fletcher, J. D. (2011). *Computer games and instruction,* (Eds.). Charlotte, NC: Information Age Publishing.

van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (2006). *Educational design research*. London: Routledge.

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

Van Eck, R. (2006). Digital game-based learning: It's not just the digital natives who are restless…. *Educause Review*, *41*(2).

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis [Article]. *Journal of Educational Computing Research, 34*(3), 229-243.

Wang, F., Kinzie, M. B., McGuire, P., & Pan, E. (2010). Applying Technology to Inquiry-Based Learning in Early Childhood Education. *Early Childhood Education Journal*, *37*(5), 381-389. Retrieved from EBSCO*host*.

Yin, R. K. (2014). *Case study research: Design and methods*. Los Angeles, CA: Sage Publications.

Appendix A

IRB Approval of Protocol

Phone 706-542-3199

The University of Georgia®

Institutional Review Board

Fax 706-542-3660 Office of the Vice President for Research

APPROVAL OF PROTOCOL

December 18, 2013

Dear Michael Orey: On 12/18/2013, the IRB reviewed the following submission:

Type of Review:	Modification
Title of Study:	Playing and Learning: A Study of Children's Experiences with "Serious Games" in a Virtual World
Investigator:	Michael Orey
IRB ID:	MOD00000411
Funding:	None
Grant ID:	None

The IRB approved the protocol from 12/18/2013 to 4/16/2014 inclusive. Before 4/16/2014 or within 30 days of study closure, whichever is earlier, you are to submit a continuing review with required explanations. You can submit a continuing review by navigating to the active study and clicking Create Modification / CR.

If continuing review approval is not granted before the expiration date of 4/16/2014, approval of this study expires on that date.

In conducting this study, you are required to follow the requirements listed in the Investigator Manual (HRP-103).

Sincerely,

Larry Nackerud, Ph.D. University of Georgia Institutional Review Board Chairperson

629 Boyd Graduate Studies Research Center ◆ Athens, Georgia 30602-7411 An Equal Opportunity/Affirmative Action Institution

Appendix B

Recruitment Letter

Dear Families of _________________:

Given that ______________ is situated near a major university, it is not uncommon for our school's administration to receive requests each year from researchers looking to conduct educational studies or observations involving teachers and/or students. Given our commitment to academic excellence and maximizing instructional time, we often cannot grant such requests. However, certain opportunities do arise which enable us to make progress toward our own educational goals without interrupting the flow of the curriculum or taking students out of class.

Earlier this year, the administration was approached by Daisyane Barreto, a graduate student in the Learning, Design and Technology at UGA, who is interested in studying children's understanding of and engagement with computer-based educational games during a voluntary after-school program. The results of this study could prove invaluable not only to the Athens Academy community, but also to other researchers in her field. She is presently conducting her Ph. D. dissertation project and hopes to invite children in Grades 1-4 from the ____________ Extended Day program to participate in the project. In general, she intends to study children's experiences with computer educational games and to identify the learning outcomes from playing these games. Overall, it is relevant to explore children's experiences and understanding of game technologies because they may perceive games differently from adults, as children are still developing their cognitive thinking. In addition, children's engagement with these technologies should also be investigated because of the purpose of educational games, which is to motivate children to learn by playing. Moreover, using games to support and promote learning is one step to expose, encourage and stimulate children to learn about topics that they may not enjoy. In this case, two computer educational games were chosen for this study because of their focus on mathematics. Upon completion of the project, Mr. Barreto's hope is to identify children's learning experiences and engagement with these games.

In this study, children will be asked to complete computer-based math assessments a week before and after the after-school program to determine their knowledge in basic arithmetic and geometric concepts. During the program, children will play computer educational games while researchers observe their interactions with these games. Children may also be invited to talk about his/her experience with the computer games. These conversations will be audio recorded. Children's interactions with the computer games might also be audio and computer screen recorded.
To participate in the study, children (ages 6 to 9) who regularly attend the afterschool program will need to participate in 10 sessions over four weeks. Each session lasts about 45-60 minutes. Children will complete the sessions in groups or individually. Children will also receive one-month paid-membership to Club Penguin™ (http://www.clubpenguin.com/) as an incentive to participate in this study. Before enrolling their child(ren) in the study, parents must sign and return the attached permission form (and keep the second copy for their records). Ms. Barreto may be reached by phone (706-621-1150) or by email (daisyane@uga.edu). Moreover, we are always available to answer questions as well at the numbers listed below. Some additional points of emphasis are listed below:

- Students have the ability to opt out of the study at any point.
- All researchers and assistants involved in the study will have completed a criminal background check required by ___________________ of all school personnel.
- Given the visibility provided by the glass walls throughout the School, where the activities will take place, parents are welcome to observe the study in progress.
- In scheduling the individual sessions, administrators and researchers will make every attempt to avoid conflicts with regularly scheduled after-school enrichment opportunities.
- Results of the study will be made available to interested parents and students upon completion of the project.

Thank you for considering this opportunity to collaborate with researchers in an effort which has the potential to yield very constructive and affirming results for _____________ in terms of its ongoing commitment to intellectual and physical wellness.

Sincerely,
School Administration

Appendix C

Parental Permission Package

I agree to allow my child, ____________________, to take part in a research study titled, "Playing and learning: A study of children's experiences with "serious games"**,** which is being conducted by Daisyane Barreto (706-621-1150) investigator, from the Department of Career and Information Studies at the University of Georgia under the direction of Dr. Michael Orey, Professor in the Department of Career and Information Studies (706 542-4028). I do not have to allow my child to be in this study if I do not want to. My child can refuse to participate or stop taking part at any time without giving any reason, and without penalty or loss of benefits to which she/he is otherwise entitled. If I decide to withdraw my child from the study, the information that can be identified as my child will be kept as part of the study and may continue to be analyzed, unless I make a written request to remove, return or destroy information.

The reason for the study is to examine children's experiences with computer educational games and to identify the learning outcomes from playing these games. If my child takes part of this research, she/he will be exposed and encouraged to learn about topics that she/he may not enjoy, such as mathematics, through play. My child will also have a venue to voice opinions about gaming experience, mastering strategic and logical thinking from playing these games. My child will also reflect on her/his own learning experience with these games, which may improve her/his understanding of mathematical content in the games.

By participating in this research, my child will receive one-month paid-membership to Club Penguin, which is a popular online gaming environment for children, as an incentive to participate in this study. In order to play the educational games in the intervention, my child will need a penguin account, which involves creating a username and password with Club Penguin website (http://www.clubpenguin.com/). I can either create my child's penguin account at home or have researchers help my child creating her/his penguin account (please indicate your preference at the bottom of this form). In either case, I will have to grant permission to my child to play this game by activating her/his penguin account via my email address [please see attached instructions on how to create and activate your child's penguin account].

If I allow my child to take part in this study, my child will be asked to take part in a math intervention playing computer games. During the intervention:

1. My child will be invited to play computer educational games for about 60 minutes three days per week during seven weeks. While my child plays these games, the researchers will watch and take notes. My child's interactions with these computer games will be observed to identify whether she/he is engaged (e.g., positive comments, time on task, perceived enjoyment such as joyful facial expressions) with the games.
2. If my child is identified as an engaged player, researchers will verbally ask my child's permission to record her/his audio and to capture on screen video of her/his game play via an audio and screen recording software in her/his computer station. The audio and screen capture recordings of my child will occur every other day during the intervention and should be no longer than 30 minutes.
3. My child will also be invited to talk about her/his experiences with these games in during 30-minute focus group interviews where my child will share her/his experiences about games with other children. These focus group interviews will be audio-recorded. These interviews will take 30 minutes out of the 60 minutes of game play and will occur once a week.
4. If my child has particularly strong communication skills during the focus groups, he/she might also be selected as a *key informant* for up to 3 30-minute follow-up individual interviews about his/her own learning experience(s).
5. The researchers will also ask my child to complete two computer-based math assessments while the researchers watch a week before the intervention starts and a week after the end of intervention. Each assessment will take approximately 45 minutes of my child's time. The results of my child's assessments

will be compared to a group of children who serviced as a control group and did not play computer games as an intervention.

All of the research activities will take place during my child's free time while she/he is waiting for the school bus for one month. If I do not want my child to take part then she/he will be allowed to participate on other regularly occurring school activities.

The research is not expected to cause any discomfort or risk. My child can quit at any time. My child's grade will not be affected if my child decides not to participate or to stop taking part.

Even though the investigator will emphasize to all participants that comments made during the focus group session should be kept confidential, it is possible that participants may repeat comments outside of the group, which the researchers have no control of. Additionally, internet communications are insecure and there is a limit to the confidentiality that can be guaranteed due to the technology itself. However once the materials are received by the researcher, standard confidentiality procedures will be employed and the researchers will remove my child's name and identifying information from the research record 6 months after data collection has been completed. Additionally, the researchers will destroy any audio-recordings of my child 6 months after data collection has been completed. The researchers will not disclose any individually identifiable information collected about my child to anyone outside of the research team, unless otherwise by law.

The researchers will answer any questions about the research, now or during the course of the project. Daisyane Barreto can be reached by telephone at (706) 621-1150 and Dr. Orey can be reached at (706) 542-4028.

I understand the study procedures described above. My questions have been answered to my satisfaction, and I agree to allow my child to take part in all of the above-described study procedures. I have been given a copy of this form to keep.

_______ I prefer to create my child's penguin account at my home during my free time.
_______ I prefer to have researchers help my child creating her/his penguin account during her/his free time at school. [Please provide your email here______________________ so your child can create her/his penguin account].

____________________ ________________________ __________

Daisyane Barreto Signature Date
Telephone: 706-6211150
Email: daisyane@uga.edu

__________________________ ________________________ __________

Name of Parent or Guardian Signature Date

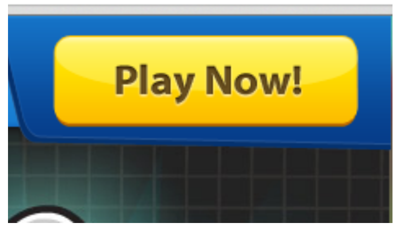
Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding my child's rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu

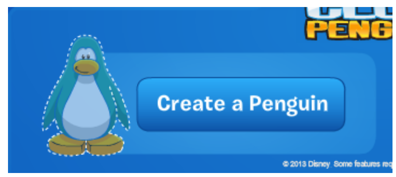
Instructions on how to set up your child's club penguin account:

1st Step. Type the following URL (http://www.clubpenguin.com/?country=US) to your web browser (i.e., Internet Explorer, Firefox, etc.)

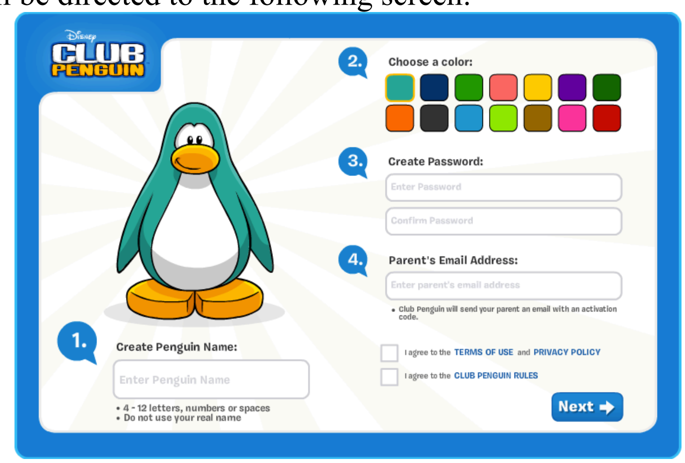
2nd Step. Once the club penguin page loads on your computer screen, click on the button "Play Now!" on the top left corner of your screen.



3rd Step. After that, click on the button "Create a Penguin" at the bottom of your computer screen.

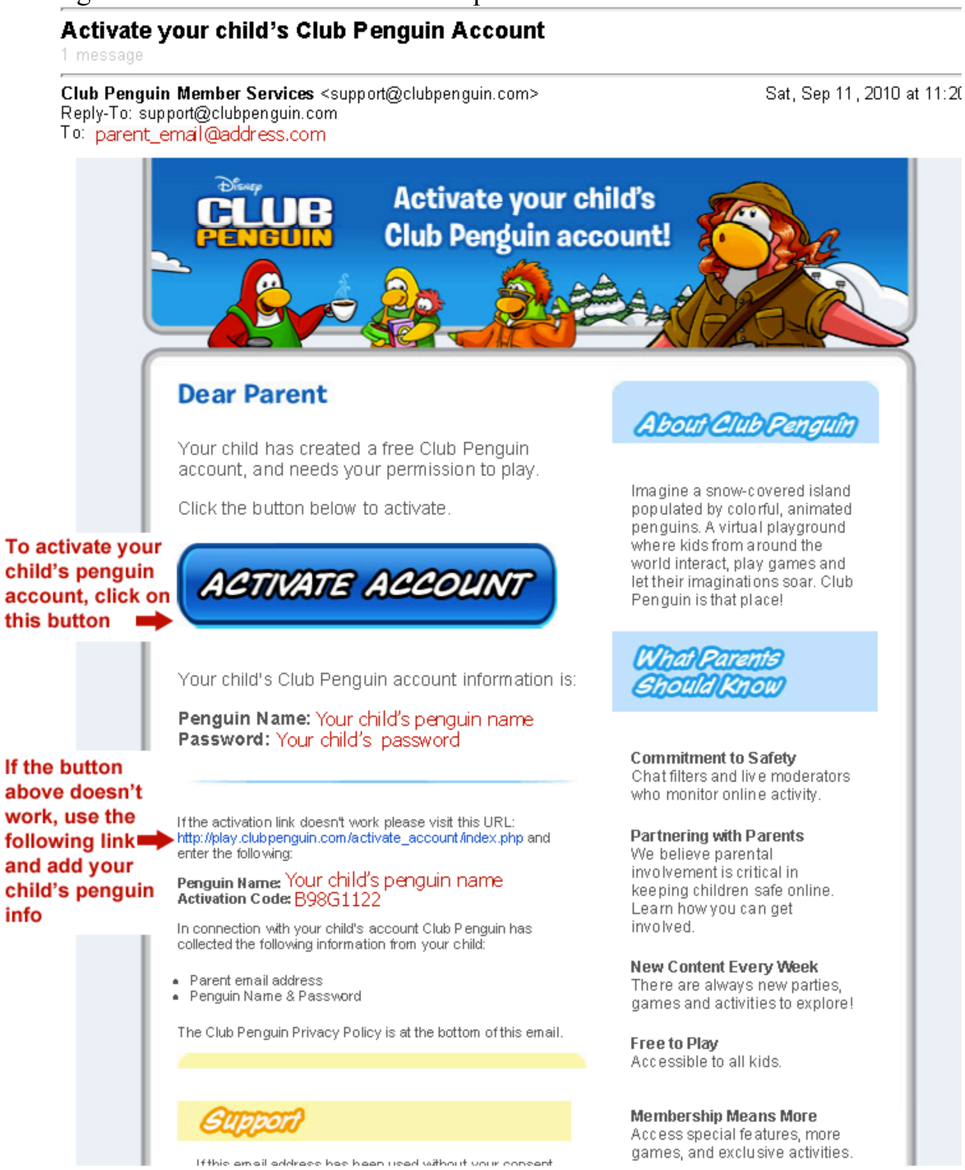


4th Step. You will be directed to the following screen:



1. Create or let your child create a penguin name. The penguin name can have 4-12 characters including letters, numbers or spaces. You might want to write this information on a piece of paper in case your child forgets it.
2. Select or let your child select the color of her/his penguin character.
3. Create or let your child create a password that she/he can easily remember. For example, the password could be her/his pet name or unique information that she/he knows well. You might want to write this information on a piece of paper in case your child forgets it.
4. Provide your email address so Club Penguin can send you an activation code to authorize your child's Club Penguin account.
5. Read and check the boxes of ***terms of use*** and ***privacy*** as well as the ***club penguin rules*** before clicking on the "Next" button.

5th Step. Check your email account and look for an email from Club Penguin Member Services. Open that email and follow the procedures to activate your child's account. A sample of the message and additional instructions are provided below.



Activate your child's Club Penguin Account

1 message

Club Penguin Member Services <support@clubpenguin.com> Sat, Sep 11, 2010 at 11:2
Reply-To: support@clubpenguin.com
To: parent_email@address.com

Dear Parent

Your child has created a free Club Penguin account, and needs your permission to play.

Click the button below to activate.

To activate your child's penguin account, click on this button

ACTIVATE ACCOUNT

Your child's Club Penguin account information is:

Penguin Name: Your child's penguin name
Password: Your child's password

If the button above doesn't work, use the following link and add your child's penguin info

If the activation link doesn't work please visit this URL: http://play.clubpenguin.com/activate_account/index.php and enter the following:

Penguin Name: Your child's penguin name
Activation Code: B98G1122

In connection with your child's account Club Penguin has collected the following information from your child:

- Parent email address
- Penguin Name & Password

The Club Penguin Privacy Policy is at the bottom of this email.

Support

About Club Penguin

Imagine a snow-covered island populated by colorful, animated penguins. A virtual playground where kids from around the world interact, play games and let their imaginations soar. Club Penguin is that place!

What Parents Should Know

Commitment to Safety
Chat filters and live moderators who monitor online activity.

Partnering with Parents
We believe parental involvement is critical in keeping children safe online. Learn how you can get involved.

New Content Every Week
There are always new parties, games and activities to explore!

Free to Play
Accessible to all kids.

Membership Means More
Access special features, more games, and exclusive activities.

Appendix D

Minor Assent Form

Dear Student,

You are invited to participate in my research project titled, "Playing and learning: A study of children's experiences with "serious games". Through this project I am learning about children's experiences with computer educational games.

If you decide to be part of this project, you will be asked to complete two computer-based math exercises, which will tell us how good you are in math. You will also be invited to participate in intervention where you can play fun computer games for about an hour, twice a week, for about a month. This program will happen during your free time at school while you are waiting for the school bus. In this program, we will watch you play computer games and ask you to play specific games for some time. You may also be invited to talk to us about your experiences with these games. These conversations will be audio recorded. We may also ask if we can record the audio and computer screen while you play these games.

There are no discomforts from being in our research. Your participation in this project will not affect your grades in school. I will not use your name on any papers that I write about this project. Our research activities may feel like other activities you do in school or in home. We hope that the things we do for this research will help you learn school content through play. We also hope that you can share your experiences and learn from thinking about these experiences.

If you want to stop participating in this project, you are free to do so at any time. You can also choose not to answer questions that you don't want to answer.

If you have any questions or concerns you can always ask me or call my teacher, Dr. Michael Orey at the following number: 706 542-4028.

Thank you!

Daisyane Barreto
Department Career and Information Studies
University of Georgia
706-6211150
daisyane@uga.edu

I understand the research described above and I agree to participate. I have received a copy to keep of this form.

______________________________________ ______________________
Your Signature Date

______________________________________ ______________________
Daisyane Barreto Date
Department Career and Information Studies
University of Georgia
706-6211150
daisyane@uga.edu

Please sign both copies, keep one and return one to the researcher.

Additional questions or problems regarding your rights as a research participant should be addressed to The Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail AddressIRB@uga.edu

Appendix E

Pretest and Posttest Assessment

Student Name: ________________________________Age: _____ Date:________
School:____Grade:_____________

Thank you for completing this worksheet! Follow the instructions below:

- Make sure to answer the questions based on what you know.
- Try *NOT* to spend too much time on any single question.
- Avoid guessing. If you do not know the answer just leave it blank.

Section I

1. Susan likes to play a game called *Bits and Bolts*. Susan wants to build the number 6 with equal amounts of bolts. How will Susan do it?

   A. 

   B. 

   C. 

   D. 

2. Now, Susan has to build the number 8, but she has to use bolts that come in twos. How will Susan do it?

   A. 

   B. 

   C. 

   D. 

3. Alex plays Bits and Bolts for the first time. Alex has to build the number 9, but he has to use bolts that come in threes. How will Alex do it?

   A. 

   B. 

C. 

D. 

4. Now, Alex has to build the number 10. Alex has to use <u>only odd</u> number of bolts to build the number 10. How will Alex do it?

   A. 

   B. 

   C. 

   D. 

5. How many different ways can you break the number 12 apart so that all parts have equal amounts? Check **ALL** the possible answers:

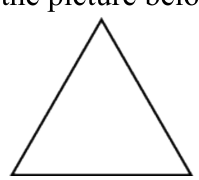
   ☐ 　☐ 

   ☐ 　☐ 

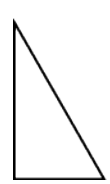
   ☐ 　☐ 

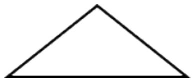
Section II [Pretest: This section will be presented to participants as it is here. Posttest: Items, as well as answer choices, will be randomized. These items will be presented to participants until they are able to answer three items in a row correctly].

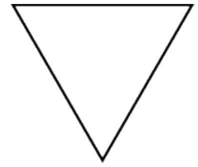
6. Look at the picture below:



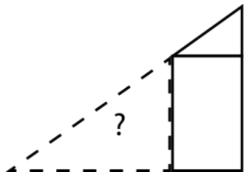
Which of the answers below has the same <u>size</u> and <u>shape</u>?

A. 　C. 

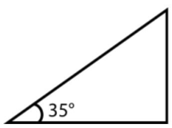
B. 

D. 

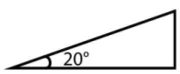
7. Look at the picture below:

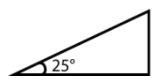


Kyle wants to build a bike ramp, but one piece is missing. Which of the pieces below will fit his ramp?

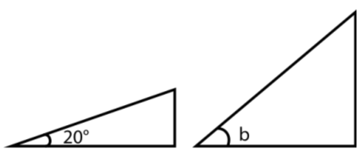
A. 

C. 

B. 

D. 

8. Look at the picture below:

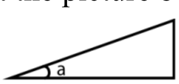


triangle1 triangle 2

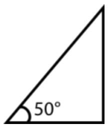
The degree measure of the angle **b** in triangle 2 is 2 times the measure of the angle in triangle 1.What is the degree measure of the angle **b**?

A. 40º
B. 60º
C. 30º
D. 50º

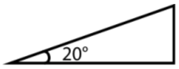
9. Look at the picture below:

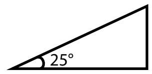


Which of the shapes below match the picture above?

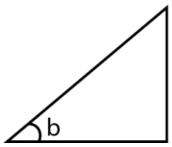
A. 

C. 

B. 

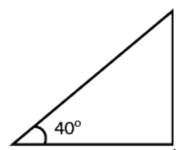
D. 

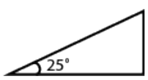
10. Look at the picture below:

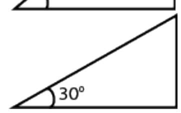


Which of the shapes below match the picture above? ?

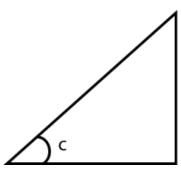
A. 

C. 

B. 

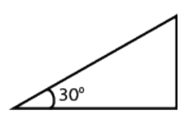
D. 

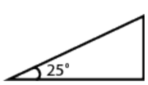
11. Look at the picture below:

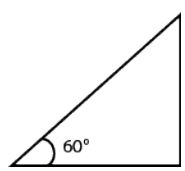


Which of the shapes below match the picture above?

A. 

C. 

B. 

D. 

Appendix F

Interview Guide

Hi, my name is Daisyane Barreto. I am student at The University of Georgia and as part of my schoolwork, I have to write an essay project about children's understanding about games, specifically the ones you played today. As you can see, I have this digital recorder here, which will record what we say. I am using this recorder so I remember what we said. Our conversation should take about 30 minutes. And if you feel uncomfortable any time during our talk, you can stop participating. If there are any questions you don't want to answer, feel free to skip them. Any questions before we start our conversation about games? So let's start.

Engagement with the games:

1. What games did you play in Club Penguin today?
    a. Did you play Bits & Bolts/Pufflescape?
2. Which of these games did you like the most? Can you tell why?
    a. What did this game have it that you enjoyed so much?
3. Which of these games did you like the least? Can you tell why?
    a. What did this game have it that you didn't enjoy so much?
    b. If you were to change this game to make it more enjoyable (fun), what would you do?

Understanding of games:

Now, we will pretend that we are playing Bits & Bolts/Pufflescape together. Here is the initial screen of game [show the print screen of the game]. What do I have to do first? Do I need to click on some place special?

- So once I click here, I go to this scene here [show a print screen of the first level], what do I have to do here?
    - Where should I click?
    - What are these things/objects here? What do they do? What do they mean?
    - Do you know why I need this information/object?
    - What should I do to win this game?

After playing Bits & Bolts/Pufflescape**:**

1. Can you tell me what it is about?
    a. Do you think this game is similar to other games you have played before? If so, which one?

2. How far have you gone in this game?
3. Did you make any mistakes while you were playing this game? Could tell me one?
    a. What did you do after that mistake?
4. Did you use any special tricks or secrets to pass a level? Could you share with me some of these tricks or secrets?
5. What do I need to do to be good at this game?

Understanding of math content

Now, let's relate Bits & Bolts/Pufflescape to what you are doing at school:

- How is this game similar to any topic you are studying at school?
    - Do you think this game remind you of any topic that you are studying at school? If so, which one?
- How is this game different from your schoolwork or things that you are doing at school?
    - What do you have to do in the game that is different from your schoolwork?
- What skills from this game do you think you could use at school?
    - Do you think that the skills you are learning in this game could be useful at school? Which ones?

Appendix G

Log of Field Visits

Log of Time in Field Researcher: Daisyane Barreto Topic: Children's learning experiences and engagement with serious games				
Participant(s)	**Date**	**Day of Week**	**Time**	**Serious Game(s)**
Ingrid (Home)	02/01/2014	Saturday	1:30-2:30 PM	Bits & Bolts and Pufflescape
Ingrid (Home)	02/08/2014	Saturday	3:40-4:40 PM	Bits & Bolts
Ingrid (Home)	02/15/2014	Saturday	2:00-3:00 PM	Pufflescape
Elizabeth, Ben & Rachel (School)	02/18/2014	Tuesday	3:20-4:10 PM	Bits & Bolts
Susie (School)			4:20-5:10 PM	
Emma (School)	02/19/2014	Wednesday	3:20-4:10 PM	--
Ingrid (Home)	02/23/2014	Sunday	2:00-3:00 PM	Bits & Bolts
Elizabeth, Ben & Rachel (School)	02/25/2014	Tuesday	3:20-4:10 PM	Pufflescape
Susie (School)			4:20-5:10 PM	
Elizabeth, Clara & Rachel (School)	02/27/2014	Thursday	3:20-4:10 PM	--
Susie (School)			4:20-5:10 PM	
Ben (School)	02/28/2014	Friday	3:20-4:10 PM	--
Ingrid (Home)	03/01/2014	Saturday	2:00-3:00 PM	Bits & Bolts and Pufflescape
Elizabeth, Ben & Rachel (School)	03/04/2014	Tuesday	3:20-4:10 PM	Bits & Bolts
Susie (School)			4:20-5:10 PM	
Emma & Clara (School)	03/05/2014	Wednesday	3:20-4:10 PM	Bits & Bolts
Elizabeth, Clara & Rachel (School)	03/06/2014	Thursday	3:20-4:10 PM	Pufflescape
Susie (School)			4:20-5:10 PM	
Ben (School)	03/07/2014	Friday	3:20-4:10 PM	Pufflescape
Ingrid (Home)	03/09/2014	Sunday	2:00-3:00 PM	Pufflescape
Ingrid (Home)	03/15/2014	Saturday	2:00-3:00 PM	Bits & Bolts and Pufflescape
Elizabeth, Ben & Rachel (School)	03/18/2014	Tuesday	3:20-4:10 PM	--
Susie			4:20-5:10 PM	
Emma & Clara (School)	03/19/2014	Wednesday	3:20-4:10 PM	Pufflescape
Elizabeth, Clara & Rachel (School)	03/20/2014	Thursday	3:20-4:10 PM	Pufflescape
Susie (School)			4:20-5:10 PM	
Ben (School)	03/21/2014	Friday	3:20-4:10 PM	Bits & Bolts
Ingrid (Home)	03/22/2014	Saturday	2:00-3:00 PM	Pufflescape
Elizabeth, Ben & Rachel (School)	03/25/2014	Tuesday	3:20-4:10 PM	Bits & Bolts
Susie (School)			4:20-5:10 PM	
Emma & Clara (School)	03/26/2014	Wednesday	3:20-4:10 PM	Bits & Bolts

Elizabeth, Clara & Rachel (School)	03/27/2014	Thursday	3:20-4:10 PM	Pufflescape
Susie (School)			4:20-5:10 PM	
Ben (School)	03/28/2014	Friday	3:20-4:10 PM	Pufflescape
Ingrid (Home)	03/30/2014	Sunday	2:00-3:00 PM	Bits & Bolts and Pufflescape
Elizabeth, Ben & Rachel (School)	04/01/2014	Tuesday	3:20-4:10 PM	Bits & Bolts and Pufflescape
Susie (School)			4:20-5:10 PM	Bits and Bolts
Emma & Clara (School)	04/02/2014	Wednesday	3:20-4:10 PM	Pufflescape
Elizabeth, Clara, Emma & Rachel (School)	04/03/2014	Thursday	3:20-4:10 PM	Bits & Bolts and Pufflescape
Susie (School)			4:20-5:10 PM	
Emma & Clara (School)	04/09/2014	Wednesday	3:20-4:10 PM	Bits & Bolts and Pufflescape
Clara (School)	04/10/2014	Thursday	3:20-4:10 PM	--