GAMHER: CREATING A GAME TO INCREASE GIRLS' INTEREST IN PROGRAMMING

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ABSTRACT

There is a serious shortage of women in the science, technology, engineering, and math (STEM) fields, and the decline of women in computer science (CS) is the most alarming. This dissertation describes a research study that involved the designing, developing, and evaluating of a gender-specific, 2D/3D educational game prototype to teach Java programming to help educate and influence girls' views on computer science.

Four categories of the research literature reviewed identified the gaps in research as well as game design elements that attract girls and game-based learning elements that make good educational games. A 2D game called *Array[7]* and a 3D virtual world named *Gamher World* was developed based on this study. This mixed method study was predominately a quantitative analysis with a secondary, qualitative analysis. A total of seventy-eight girls, ranging in ages between 13 and 17 years, participated in the research. Twenty-nine of the girls learned programming via a traditional method of lecture and exercises, whereas 49 girls learned it via the educational game developed; all the girls learned through the same curriculum.

The author collected data through pre-quiz–post-quiz and pre-survey–post-survey responses from research participants. The quantitative data collected was analyzed using a dependent t test and an analysis of covariance test. Although participants scored significantly different on the prequiz and postquiz, the focus and control groups' postexamination and postsurvey responses were not significantly different. The game was just as successful in teaching computer science as the instructor.

Key Words: *Computer Science, Game-Based Learning, Educational Games, STEM, Girls, Game Design, Game Design Elements, Educational Software, Gender Specific Game Design, ADDIE, Mixed Method, Instructional Game Design*

DEDICATION

I dedicate this dissertation to my husband and son, Bahram and Bahruz, for supporting me, encouraging me, and never losing faith in me.

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I would like to thank first and foremost my husband, Bahram, for the constant support and motivation he provided. He is the rock that helped me get through my studies. I would also like to thank my parents for constantly instilling in me the importance of education. I thank my sister, Dilnaz, for helping me find humor through the stress. I am thankful to my dissertation committee, especially Dr. Calongne, who tirelessly kept in contact with me and was always there to help me find resources and identify research giants. Finally, I thank all of the CTU colleagues, peers, and faculty I have met along my dissertation journey for their motivation and support.

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CHAPTER ONE

This research focused on addressing the decrease of women in computer science through the design, development and evaluation of an education game prototype to teach basic Java programming language skills to girls ages 13-17. The goal was to help educate and influence the girls' views on computer science.

The decline in the number of females in computer science and information technology degree programs led to the exploration of opportunities to interest young women in computer science. Educational games designed with specific goals and for a target population offered a great promise in several studies (Esper, Foster, & Griswold, 2013; Stewart-Gardiner, Carmichael, Latham, Lozano & Greene, 2013). Therefore, this study investigated the use of an educational game and how students used it to learn introductory Java programming skills. A qualitative surveying game evaluation instrument and a quantitative measure of computer science knowledge were used to evaluate the research participants' results against a control group to help assess the developed game.

The purpose of the study was to investigate whether the educational game would have an effect on participants' view and understanding of computer science within an introductory workshop. The data helped determine whether gender-specific game-based learning (GBL) and an educational game was useful as a learning tool and whether the game would change the girls' view of programming.

Topic Overview

The decline of female engineers and computer scientists is a nationwide problem (National Girls Collaborative Project, 2011). Women account for a minuscule percentage of the mathematical and computer science (CS) career fields (National Girls Collaborative Project, 2011). According to the US Department of Labor, women make up 46.5% of the workforce but only 25% of the mathematical and computer science jobs (National Girls Collaborative Project, 2011). Generally, women earn more degrees at the associate, bachelors, masters and doctoral level than men. However, women only received 17% of engineering and 18% of computer science bachelor's degrees in 2009-2010 (Marklein & Marinova, 2012). Statistics shows that in 2004 and 2007, only 12% of students studying computer science (CS) in college were female (College Entrance Examination Board, 2004; Stross, 2008). Following that same pattern, in 2012, female students studying CS have dropped from the previous year's numbers, 13.8% in 2011 to 11.7% in 2012 (Frieze & Quesenberry, 2013). In a 2014 survey done by AAUW (American Association of University Women), only 1% of women first-year college students intended to study computer science (Corbett & Hill, 2015).

Figure 1 illustrates the statistics on CS bachelor's degrees earned by women over several years (College Entrance Examination Board, 2004; Frieze & Quesenberry, 2013; Marklein & Marinova, 2012; National Girls Collaborative Project, 2011; Stross, 2008; Zweben, 2013).

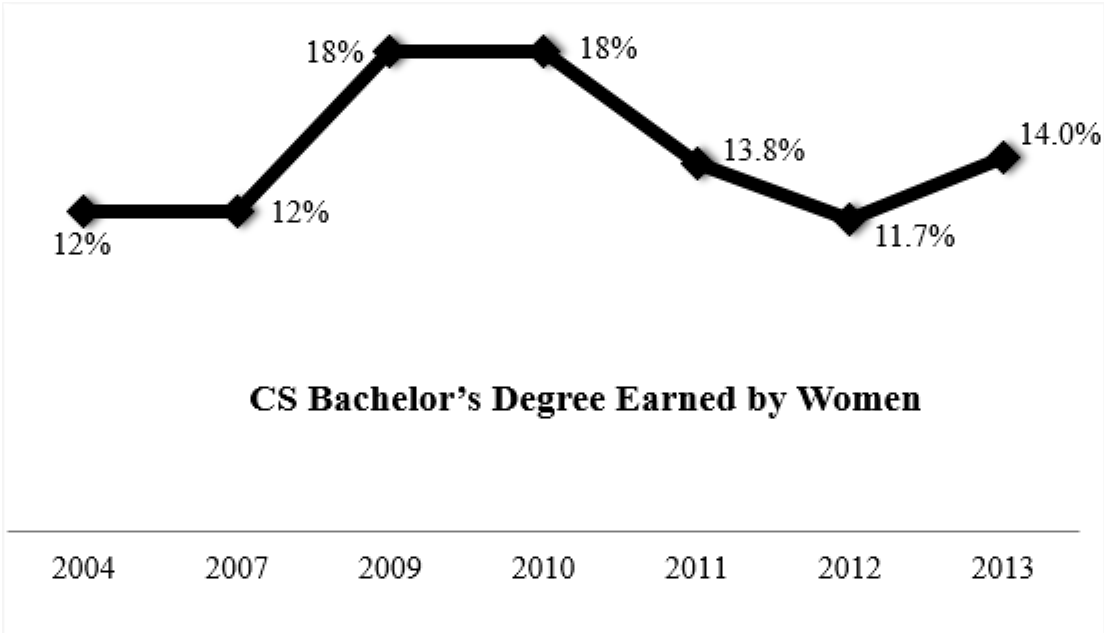

Figure 1. Statistics at a glance.

According to a survey done by the SAT exams, more than 60% of the 1.5 million students who reported not having computer coursework or experience were girls (NCWIT, 2012a). More than half of high school Advanced Placement (AP) exam takers are female (Teach, 2013). However, only 19% of students who took AP Computer Science were female in 2011 and only 15% in 2013 (NCWIT, 2012a, p.13; Teach, 2013). While girls are graduating high school with equal achievements in math and science they are pursuing computer science in lesser numbers (Corbett & Hill, 2015).

At the industry level, 56% of women technologists in the industry quit at double the rate of men (Gammal & Simard, 2013). 15% of women computer scientists never enter the CS workforce, and 20% working initially in the field leave altogether (Gammal & Simard, 2013).

At the education level, factors that influence such statistics include lack of role models, peer influences, media and popular culture and formal and informal education (NCWIT, 2012a).

At the industry level, factors that affect women leaving the field are too many hours, lack of time with family, not liking the daily tasks and the work culture (Gammal & Simard, 2013).

Studies have shown that, in formal and informal education, the curriculum is uncomfortable for girls. Additionally, role models and equal opportunities are lacking for girls' early experiences in computing. Other factors influence girls' perceptions, interests, confidence, and future career decisions as well. Two examples are being the lone girl in a classroom and the media's portrayal of computing as masculine or "geeky" (NCWIT, 2012a).

Girls have math and computer anxiety (De Palma, 2001). As noted by Drobnis (2010) if girls' negative view of computer science is not addressed, women "limit their future options in a world that is surrounded by technology" (p. 2). Without female participation in the field, there is not enough diversity in computer science to generate new ideas (Drobnis, 2010).

> [The lack of women in Science Technology Engineering and Math (STEM)] is a serious problem in both social and economic terms. Many futurists have predicted a shortage of skilled specialists in professions involving math and science, a shortage that will be critical, as environmental and economic issues necessarily become the utmost importance over the next decade. […] Women are needed as engineers, scientists, and technologists. They are needed for their numbers; they are needed for the fresh outlook they may bring to these professions. (Inkpen, Upitis, Klawe, Lawry, Anderson, Ndunda, Sedighian, Leroux & Hsu, 1994, p. 2)

The lack of computer science courses offered in high school is another problem. The number of schools offering introductory computer science has decreased 17% since 2005, and AP computer science courses have decreased 35% (NCWIT, 2012a, p. 5). This drop in course offerings is a significant issue because studying computer science at the K-12 level can develop an early interest in students. The misunderstanding of the differences between computer science and computer literacy is the cause of the decline (NCWIT, 2012a). While computer literacy teaches the use of computers, computer science teaches the invention and development of new technologies. This lack of understanding has resulted in fewer computer science courses being offered due to computer literacy courses that are currently in place (NCWIT, 2012a). Software development is a creative process. To catch learners early and help them to develop strong logic and problem-solving skills helps to build interest in computer science careers and a can-do spirit (code.org, 2013).

The lack of women in programming extends beyond the United States. According to the Higher Educational Statistics Agency, in 2009 only 16% of all students studying CS in the United Kingdom were female (Shepherd, 2012). Professor Dame Wendy Hall, a renowned computer scientist, noted the perception of computing as ‘geeky’ and misunderstanding of computer science with computer literacy as reasons for the decline (Shepherd, 2012).

Google acknowledged the severity of the lack of women in technology stating that the gender skills gap should be addressed. According to a Google engineer, women hold less than one-third of the world’s engineering jobs (Clarke, 2012).

Maria Klawe, president of Harvey Mudd College, noted that women should study CS for the career possibilities, to create new technology and to acquire the skills. Klawe sites disinterest, lack of confidence and lack of attractiveness in studying computer programming as reasons why women are not interested in completing CS and information technology (IT) degrees (Woodruff, 2012).

Increasing the number of women in the computer field is important because of innovation. With a dramatic underrepresentation of women in the field, many of the technical decisions are based on the opinions and judgments of men (Corbett & Hill, 2015). Innovative ideas that are unique to women are overlooked (Corbett & Hill, 2015).

The importance of having girls study Science, Technology, Engineering and Mathematics (STEM) or Science, Technology, Engineering, Arts and Mathematics (STEAM) is recognized nationally (The White House, 2011). First Lady Michelle Obama spoke of supporting and retaining women and girls in STEM careers (The White House, 2011). The White House Council on Women and Girls and Office of Science and Technology Policy encouraged the interest of young women in grades 6-12 in STEM (The White House, 2011). Correspondence between the White House and the National Science Foundation endorsed independent organizations and academic associations to encourage interest in STEM topics among young women.

Several organizations have pledged their support:

- the National Alliance for Partnerships in Equity
- the Association for Women in Science
- the National Girls Collaborative Project
- the American Association of University Women
- the Association of American Universities
- the Association of Public Land-Grant Universities (White House, 2011).

After identifying the problem of the lack of women in CS, a proposed solution was to design an educational game prototype to evaluate basic Java programming skills and interest in computer science among adolescent girls.

Problem Opportunity Statement

Responding to a national call for organizations to promote STEM, an allocation of $450 million led to an increase in qualified educators and the development of new programs (O'Leary, 2013). $3.1 billion dollars were spent to improve STEM education (O'Leary, 2013). The number of states requiring technology proficiency from their teachers has increased (Mims-Word, 2012). Thirteen states require teachers/administrators to complete technology-related coursework while nine states require them to pass technology-related assessments for initial licensure (Mims-Word, 2012).

Although organizations have funded various groups and individuals to advance girls in STEM, women are still underrepresented in these fields (Fidan, 2011; Kurtzleben, 2013; Tett 2013; Toglia, 2013). The gap between women and men in the industry is evident (Frieze & Quesenberry, 2013). Even with the amount of effort the gender divide has not narrowed and "years of attention and funding applied to women in computing issues have not paid off" (Frieze & Quesenberry, 2013, p.5).

Projects such as the FabFems Project, Guides, National Girls Collaborative Project, Pacific Northwest Girls Collaborative Project, Science Journalism, SciGirls, TechREACH, and WaterBotics promote STEM (EdLab Group, 2011). These projects range from providing role models for girls in the 6-12th grades, television shows engaging girls in STEM and robot building workshops (EdLab Group, 2011). The attempts to increase girls' interest in computer science have been through engagement, encouragement, targeted recruiting and collaborative learning. Projects that involve educational games include the design and development of animated stories and games by the girls rather than the actual playing of one.

G.A.M.E.S or Girls Advancing in Math, Engineering, and Science, a national project for the advancement of girls in STEM, is a new collaborative effort between university partners and gaming companies in Seattle. The focus of this partnership is to develop educational games solely for girls by professionals and researchers who study game science (Collette, 2013). The objective of this organization is to develop at least 20 test games by 2017 (Long, 2013). However, none of the 20 games is listed as computer science teaching games.

There are no explicit projects funded where an educational game for girls is developed to teach computer science. One current project by Stewart-Gardiner, Carmichael, Latham, Lozano, and Greene (2013) involves the development of a puzzle-solving game called *Gram's House*, which teaches computer science concepts to middle school aged girls. However, this game covers programming logic and not a programming language. The Stewart-Gardiner et al. study did not include thorough background research on girls' preferred game design elements.

CodeSpells is a Java language teaching educational game developed by Ph.D. researchers at UC San Diego (Esper et al., 2013). The academics have used a Kickstarter campaign to develop the game and offer it via codespells.org (Esper et al., 2013). However, this game is not gender specific, and the research involved girls ages 10–12, which is a different age group than this research.

The literature review conducted will show that other dissertation and research studies also do not focus on creating an educational computer science video game to the identified demographic.

Purpose Statement

Engaging ways to introduce girls to computing involves the use of Educational Software (ES) in the classroom; however some educational software still includes gender stereotypes. When using ES in the classroom the content, appearance and structure of the software needs to be considered (NCWIT.org, 2008a). The focus of this study is to attract women to the field of computer science via GBL. Games were successful tools for teaching since the 1990s (Steiner, Kickmeier-Rust & Albert, 2009). Young children spend more time watching television and using the computer than reading; therefore, this type of technology is an effective teaching tool (Steiner, Kickmeier-Rust & Albert, 2009).

In this research, a game is defined as an interactive form of entertainment with goals, rules and challenges combined with problem-solving activities (Novak, 2012; Schell, 2008, p. 37). Educational games are any games designed for the particular use in achieving a curricular goal in school subjects (Gee, 2003). In this research, educational game is therefore defined as, an interactive form of entertainment with a set of goals, rules and problem-solving challenges with the purposes of instructing a subject matter.

GBL is useful because it incorporates three learning theories: situated learning theory, active learning theory and mastery learning theory (Why does GBL work? 2012). Situated learning theory is the theory of applying the subject being discovered in the right context. Active learning theory is the theory that supports hands-on learning activities over other methods (Why does GBL work? 2012). Mastery learning theory involves the mastering of materials at one level before moving on to the next (Why does GBL work? 2012). All three methods apply to GBL, making it encouraging in skill and knowledge development.

GBL produces positive results because it promotes familiarity, engagement, rich content, quest based learning, flexibility and grasp student interest (Ten Reasons why Game Based Learning Works in Education, 2012).

In this research, a 2D game *Array[7]* and a 3D virtual world companion space called *Gamher World* was designed and developed as a gender-specific educational game prototype. The game aims to teach computer science to adolescent girls in hopes of increasing their knowledge of and influencing their views on the subject.

Two forms of workshops were held to evaluate the game's ability to change girls' view and knowledge of CS. One class used traditional methods of lecture and exercise (control group), and the other used the game developed (focus group). The evaluation phase involved the surveying and quizzing of the video game workshop participants and the non-video game participants, followed by a comparison of the results between the two groups. A survey instrument and a quiz were created to compare results.

Research Questions

Quantitative

1. How does the participant's pre-quiz score compare to her post-quiz score?
2. How does the focus group's post course quiz score compare to that of the control group?
3. How does the focus group's post survey response view of computer science compare to that of the control group?

Qualitative

1. What components of the game obtained participant interest? Why?
    - Graphics/Colors? Why?
    - Gameplay Elements? Why?
    - Characters used, interface, music, sound, other content? Why?
2. What can be done to improve the game?
    - What are some suggestions for making the game better in terms of fun level and educational level? Are there any other additional suggestions?

Hypotheses

Null Hypothesis (H0): There is no difference between the response and quiz scores of the focus and the control group.

Research Hypothesis (H1): The focus group will score higher and, or respond more positively to the computer science course than the control group.

Conceptual Framework

This exploratory research used the hypotheses listed as the conceptual framework. The development of the educational game followed an instructional systems design model. Instructional design involves the designing of any material for educational purposes (Kadlec, 2013). The ADDIE model, or the Analysis, Design, Develop, Implement, Evaluate model, is often used when designing a system (Kadlec, 2013). Figure 2 showcases this model.

Figure 2. ADDIE model.

The literature review was conducted first as part of the analysis stage. The literature review serves to ground the research; it shows the lack of study on the topic and more importantly helped identify established instructional game design elements used in the past. Game design elements are parts that make up the game. These include the genre, game story, number of players and identifying what the interactive components of the game should be (Novak, 2012).

Games come in many forms. According to Jesse Schell, a well-known game designer, a game is a “problem-solving activity, approached with a playful attitude” (Schell, 2008, p. 37). Schell identifies four essential elements of game design as shown in Figure 3.

Figure 3. Four elements of game design. From *The Art of Game Design: A Book of Lenses* (p. 39), by J. Schell, 2008, Burlington, MA: Morgan Kaufmann. Copyright 2008 by Morgan Kaufmann. Reprinted with permission.

Aesthetics is the unique and exciting way that the game uses art; for example, realistic graphics versus cartoon graphics, colors used, text, audio, and so forth. It is not mainly to make a game look like a game. The aesthetics is related to the type of game being developed and should enhance and work with the gameplay. The story is a game design element sometimes overlooked, however, a story is crucial to a game and is the reason one would play a game. The story runs the game. Mechanics (also referred to as gameplay), includes the win conditions, scoring, achievements, levels in the game, and so forth. The technology answers the question how is the game played? Console versus Computer versus Mobile? The technology used has to help enhance the game and allow for active participation of the players (Schell, 2008).

By studying what others have done during the analysis stage, the literature review helped identify these four key design elements; which in turn helped in developing the educational game for adolescent girls. The information gathered helped determine user characteristics including general learning preferences and gameplay mechanics that have previously worked or are popular among the female demographic.

The design stage of the ADDIE model involved the actual planning of the game. In this stage, the idea for the proposed game was developed. The goals, rules, and challenges within the game were mapped out in a completed game design document.

In the develop phase, the actual playable game was created using various software and tools available to game developers.

The implementation and evaluation phase involved the targeted demographic playing the game. Therefore, during these stages, a computer science learning workshop was conducted, where several female participants played the game while another group learned Java programming via a traditional mode of course delivery.

Biases

It is impossible to guarantee that a researcher will be completely unbiased and without preconceived notions. Because the game and the evaluation is developed and conducted by the same researcher, there were personal feelings involved in the game designed. There might be preconceived assumptions that the game is successful or is a failure. Also, because the researcher taught the workshops, the participants might have felt embarrassed to evaluate the course negatively in front of the evaluator. The participants in the research were self-selected. The students signed up for the workshops once the dates were advertised. Because the students selected to attend the workshops, there is the bias of participants already having an interest in learning computer science or having a positive view of programming. Unknowingly the researcher might have influenced the evaluation results. To stay neutral and to avoid some of the biases, a workshop curriculum was developed prior to the evaluation. Both workshops used the same curriculum. To avoid the participant fear of evaluating a game in front of the developer, the researcher assured them that negative comments/feedback were welcomed. Besides helping with technical issues or answering questions, the researcher did not communicate or in any way influenced the participants as they played the game. The survey instrument questions formed with the biases in mind, and there were no questions that evaluated the workshop instructor. A computer science quiz that examined the basic knowledge of programming concepts was developed and administered in both workshops and graded objectively.

Significance of the Study

There were two significant deliverables as a result of this research.

A Game Design Guide

Through a lengthy research into articles, dissertations, and current educational and entertainment games, a result of this thesis is a well-defined game design guide. The game design guide consists of game elements that make an educational game successful and attractive to the female demographic. It is unique and was used to create a gender inclusive game to teach computer science.

Other game designers and game developers can use this guide to create even more educational games to promote STEM.

An Educational Game

Another deliverable of this research was the final application itself: the game (prototype). The prototype of the GBL application provides another method for introducing computer science to girls. Individuals, as well as educational institutions, can use the game in their classrooms to promote, learn, or teach computer science.

Delimitations

To keep the scope of the study to a manageable level, this study focused solely on developing a single computer science educational game prototype (a playable demonstration - not a complete game). Easy to use game development software was used to keep the development phase as short as possible. The workshop lessons followed the curriculum already developed by the Computer Science Teachers Association. Basic programming questions were written up for the quizzes based on the curriculum. Survey instruments found during the literature review were used, with modifications, as the questionnaires for the research. Only five short four-hour workshops were offered free to local Northern Virginia/District of Columbia/Maryland area girls. Two of the workshops did not utilize the game, and three did. The comparison study only compared a programming course taught by the use of the game versus a course taught in a traditional way with lecture and exercise. No comparison was done to see the results of using the game developed versus established programming teaching software such as *Alice*, *Scratch*, and others.

Limitations

GameMaker, a software development kit and game engine; and OpenSim, an online multiplayer virtual world, were the tools used to develop the game. Thus, the development of the game was limited to what the tools offer. The game art, music, and sound effects were either created by the researcher or borrowed from free libraries. Except for some assistance, a game developed by one person will not be the same as games developed by the various game companies in the industry. Other limitations of the research include the use of free software to create the game assets; some free software is not as advanced as expensive software and thus limited the creation level of the game items. The game was designed and created by one person, which limited how extensive the game can be. There was a constraint on the building timeline, which hindered the complexities of the game. Once complete, the target audience evaluated the game. There were limitations to this as it was difficult to round up many partakers within the target age group. Budget and lack of collaboration were other hindrances. To overcome these limitations, the researcher used game development skills acquired from industry experience to develop the game and reached out to collaborate with non-profit organizations to help in offering the workshops.

Abbreviations

STEM: Science Technology Engineering Mathematics

STEAM: Science Technology Engineering Arts and Mathematics

NCWIT - National Center for Women and Information Technology

GDD: Game Design Document

MOOC: Massive Open Online Course

CS: Computer Science

GCG: Girls Creating Games

SL: Second Life

NGCP: National Girls Collaborative Project

NSF: National Science Foundation

RPG: Role Playing Game

MMOG (MMO)/MMORPG: Mass Multiplayer Online Game, Role Playing Game

FPS: First Person Shooter

NPC: Non-Playable Character

AI: Artificial Intelligence

IT: Information Technology

CT: Computational Thinking

ES: Educational Software

GBL: Game Based Learning

ESA: Entertainment Software Association

PLE: Personal Learning Environments

ANCOVA: Analysis of Covariance

Definitions

Active learning theory: the theory that supports hands-on learning activities over other learning methods (Why does GBL work? 2012).

Affinity space: Part of a meta-game, provides an online space for game players (Gee, 2012).

Computational Thinking (CT): logical thinking (NCWIT, 2012a).

Computer literacy: the knowledge of how to use a computer (NCWIT, 2012a).

Computing: the act of designing, developing, studying computer software and, or hardware (NCWIT, 2012a).

Constructivist: the idea that students learn from designing and building games (Hayes & Games, 2008).

Educational games: Educational games are any games designed for achieving a curricular goal in school subjects (Gee, 2003).

Educational software (ES): software designed for educational purposes (NCWIT.org, 2008a).

Game: an interactive form of entertainment with a set of goals, rules, challenges and problem-solving activities (Novak, 2011; Schell, 2008, p. 37).

GameMaker: game development software, yoyogames.com/studio

Game-based learning (GBL): using games as a learning tool (Why does GBL work? 2012).

Game elements: parts of a game that makes up the game such as game story, genre, and gameplay, and so forth (Novak, 2011).

Gameplay or Gameplay mechanics: the type of interactivity the game offers such as puzzle, seeking, gathering, shooting, racing, and so forth (Novak, 2011).

Gender inclusive: keeping gender differences in mind, being sensitive to gender differences (Ibrahim, 2011).

Instructivist: the idea that students learn from playing games (Hayes & Games, 2008).

Mastery learning: the mastering of materials at one level before moving on to the next (Why does GBL work? 2012).

Meta-game: An educational game that promotes player interaction inside and outside the game (Gee, 2012).

OpenSim: mass multiplayer virtual world, opensimulator.org/wiki/Main_Page

Otome: genre/category of a game—dating simulation game—“young woman” in Japanese (Lee, 2012).

Prototype: a demo version of software/a playable version of a game (Novak, 2011).

Situated learning theory: the theory of applying the subject being learned in the right context (Why does GBL work? 2012).

Technology or technical: tools, machines, utensils, weapons, instruments, housing, clothing, communicating and transporting devices; and the skills applied (Technology, n.d.).

Virtual world: Online 3D Virtual Reality Worlds (Hayes & Games, 2008).

General Overview of the Research Design

This research used a mixed method sequential exploratory design consisting of two phases, quantitative priority and qualitative secondary. This study involved the offering of five free Java programming workshops to girls 13 to 17 years of age, with the goal for a large number of participants. The research design involved instructing one group using a traditional lecture method and another group using the game developed. Both groups were given a numeric ratings based pre and post survey that asked their views, understanding and evaluation of computer science. Both groups got quizzed in the beginning and the conclusion of the course to determine their knowledge acquired. Figure 4 illustrates the research process.

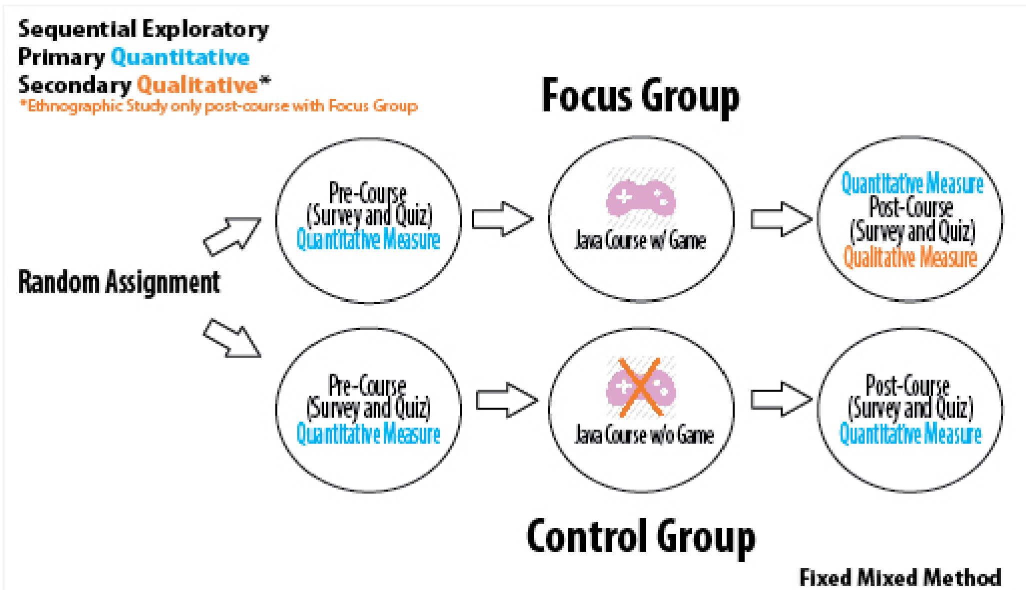

Figure 4. Research design.

The qualitative phase only involved the focus group. In this phase, an ethnographic study was conducted using a survey and observation. Some of the points looked at where what elements of the video game made the game appealing and what can be done to make it better.

Summary of Chapter One

There is a lack of female computer programmers. If this trend continues, women will limit their future. Educational games are useful motivational teaching tools. However, no educational games that teach computer science specifically to the adolescent girl demographic currently exist. This research attempted to change the number of women in the CS industry by targeting girls at a young age and exposing them to computing through developing an educational game geared specifically towards girls. The analysis of literature showed that there is a research gap in this field and helped identify game elements that best suit female gamers and educational games. A 2D game with a 3D affinity space was designed, developed and implemented. This research consisted of a quantitative experiment comparing knowledge acquired by girls in a focus group versus a control group. The focus group was asked qualitative questions such as elements of games that were most appealing and suggestions to better the game, which helped in evaluating the game developed.

Organization of Dissertation

To meet the above objectives, in chapter 2 four categories are explored: current studies on attracting women to STEM, research on using games for STEM education, developing and designing games for girls and educational games. Findings of the literature review include a game design guide to developing educational games for girls. The research result was used to create a game design document that details the prototype. Chapter 3, the methodology section of this paper, explains in detail the evaluation phase of the research framework. Chapter 4 describes the development phase of the game. Chapter 5 explores data analysis and findings. Chapter 6 is the discussion of findings, limitations, implications, and summarizes the research.

CHAPTER TWO

This literature review looked broadly at the following four categories: studies on attracting women to STEM fields, using games for STEM education, developing and designing games for girls and educational games. This literature review looked at girls and women of all ages and all subject matters of STEM with a focus on computing.

The keywords used to search articles were: *gender inclusive*, *computer science*, *girls*, *women*, *feminism*, *mathematics*, *STEM*, *computer games*, *video games*, *motivations*, *game design*, *technology*, and *women*. The search was conducted using, Google Scholar, Academic Search Complete Database, ACM, IEEE, ProQuest, SAGE, and Science Direct. The study examined abstracts from 1990 to 2015.

Relevant articles were selected, and further research was conducted to narrow down the studies found. On selected papers, an annotated bibliography listed keywords, importance, research methodology, findings, significant quotes, themes, limitations, logical next steps and how the material applied to this study.

The four categories for review were selected based on the research topic of developing an educational Computer Science (CS) teaching video game for adolescent girls to encourage the study of CS. The review of the literature helped in identifying: the gap in existing research, the game design elements needed and study objectives and research questions.

Review and Discussion of the Literature

Category 1: Studies on Attracting Women to STEM

There is a severe shortage of women in the science, technology, engineering and math fields with the decline of women in computer science (CS) being most alarming. The growing gender divide in computer science is a perplexing phenomenon on college campuses today (Cohoon & Tillberg, 2005, p.127). This research looked at why women avoid computer science (CS) and how to attract women to the computer science major and other STEM subject areas.

There are many reasons and recommendations given in terms of why women find computer science unattractive.

Cheryan, Master and Meltzoff (2015) believe that two types of stereotypes deter women from studying computer programming: stereotypes about the culture and ability. Stereotypes about the culture include the view of the types of people who are computer scientists, view of the workplace as not collaborative and the view of CS values as masculine. This view combined with the stereotypical view of lesser ability in girls than boys in these subjects, contribute to the negative view of computer programming by women.

O'Conner (2014) found that while sponsorship and personal motivation had positive impacts on matriculation of female undergraduate CS majors; women faced gender expectations in the workplace that negatively affected their continuation in the industry. Cheryan, Drury and Vichayapai (2012) found that the stereotypical depiction of CS professionals had enduring adverse effects on women's interest in CS regardless of whether the stereotype was of a male or a female. Roy (2014) found that women who graduated with CS degrees did not continue to pursue IT jobs due to wanting a more engaging work and due to influences from family, as well as mentors.

Pohl and Lanzenberger (2008) suggest that it is far too complex to identify the many reasons behind the gender divide in CS. Carlson (2006) suggest that it is the view of the computer as a male tool, the lack of role models in the field and different social factors that influence men and women. Math anxiety, violent computer games, lack of mentors, female preference for relational work are some of the reasons suggested by yet another research (De Palma, 2001).

A study conducted by Lisa Damour (2009) asks, why aren't girls choosing to enter these critical fields of the future when girls are outpacing their male peers in most subjects? (para. 3). She answers her question by listing the reasons. Damour (2009) cites the lack of role models, lack of encouragement in tinkering, and not wanting to work in an isolated environment as reasons for the decline of women in CS. Damour (2009) states that women prefer to help others in their chosen careers.

Cohoon and Tillberg (2005) concluded that women found the CS major interesting only when they saw it as a form of communication, for self-expression or as a helping occupation. The overall consensus of these researchers is that there is no one reason for the lack of women in CS, but many reasons exist.

Researchers recommend ways to encourage women to study computer science. New approaches are being identified and used to introduce programming to girls in hopes of increasing their computer science interests. One method is using App Inventor (a mobile development application) in the classroom (Ahmad, 2012). Another method is creating a fun magazine called *cs4fn* (Myketiak, Curzon, Black, McOwan & Meagher, 2012). A third method is developing an online environment that connects fifth- and sixth-grade girls to female mentors

(Scott, 2013). A fourth method is having girls design and develop computer games (Denner, Werner & Ortiz, 2012; Webb, Repenning & Koh, 2012).

Some researchers believe designing and developing games to learn programming is not enough, they suggest other tactics. Kafai and Burke (2014) suggest creating a supportive community and applying cultural practices. Gardner (2013) suggests recruiting earlier, and explaining what Computer Science is in more detail. Gardner(2013) advise taking out the complex math requirements at the college level and offering a preintroductory course. Finally, Gardner (2013) recommends providing more hands-on activities in the classroom.

According to the National Center for Women and Information Technology (2011a) and their compilation of resources, there have been many studies on increasing girls' interest in computer science and computing. Some of the main approaches have been through encouragement, introducing computing in an engaging way, targeted recruiting, exploring the physical environment in which students learn CS and collaborative learning.

Suggestions made by other researchers for increasing women's interest in STEM include rebranding computing as "female," shifting the mindset of young women, mentoring programs, recruitment programs, guidance, and counseling. Additional recommendations include exposing girls to STEM early, providing them with peer and institutional support, and changing curriculum. Finally, girls can learn the creative aspect of computer science through designing and creating games (Kurtzleben, 2013; Mbera, 2013; Tett, 2013; Thilmany, 2011; Toglia, 2013).

Researchers have also cited group work, extrinsic motivation, hands-on activities, engagement and early support as ways to increase interest in STEM (Koester, 2013; Rowan-Kenyon, Swan & Creager, 2012).

Examples of engaging hands-on activities that researchers have used to promote computer science to middle school-age girls include holding week-long residential or daytime only summer camps and workshops. Different researchers used different activities. One activity was creating paper prototypes of a chat application (Robinson & Perez-Quinones, 2014). Another activity was exploring an online multiplayer virtual world called Curiosity Grid (Hulsey, Pence & Hodges, 2014). A third activity was designing jewelry using CAD and seeing it come to life through 3D printing (Starret, Doman, Garrison & Sleigh, 2015). All approaches tailored positive results.

Encouragement involves instructors and role models not having biases on the female students and persuading them to keep trying despite the stereotypical views that computing is masculine. Building confidence in students using real-world and motivating assignments has helped (NCWIT, 2011a).

When it comes to active recruiting, schools that actively recruited girls and minority students to their computing courses increased the number of female students in their classes. Some activities involved recruiting girls from high school student government, National Honor Society and Yearbook (NCWIT, 2010). Girls Exploring Science, Engineering and Technology (GESET), an event, started in 2006 in Denver, Colorado, actively recruited girls to STEM education with positive results (NCWIT, 2006).

Other programs such as the Georgia Tech Media Computation approach focused on introducing a curriculum that taught computing in an exciting way. The results of this curriculum were positive in that due to the program, 51% of the students in the introductory course at Georgia Tech were female (NCWIT, 2005a). Carnegie Mellon University increased their female CS students from 7% to 42% by using various approaches (Lin, 2013). These approaches included reaching out to high school teachers and students and developing a support program through which upper-class women helped freshmen women. The school also encouraged professors to relate course work to societal issues. Additionally, the school removed the programming experience requirement for admission (Lin, 2013).

The study of the physical environment in which students learn computer science also resulted in some interesting outcomes. Some images used in room decor made female students uncomfortable. Items such as *Star Trek* and *Star Wars* pictures, video game boxes, electronics, and computing-parts lessened the sense of belonging to the female students. Gender neutral ambiance was necessary to retain the female students (NCWIT, 2011b).

The Girl Scouts ran the *Girls are I.T* program sponsored by the National Science Foundation (NCWIT, 2007a). This program involved driving a bus with computing equipment to bring the technology to the girls. The bus reached 5200 girls, many in locations with limited tech resources (NCWIT, 2007a).

CS Unplugged is a form of activity used in the computer science curriculum. This teaching method introduces the computer science concepts without the use of the computer. Girls have responded positively to the activities involved in the CS Unplugged curriculum (NCWIT, 2007b).

When it comes to the collaborative method, University of California–Santa Cruz (UCSC) used pair programming team-based assignments to increase girls' interest in computing. This research increased the number of women who declared a computer science major at the University (NCWIT, 2005c). Peer-Led-Team-Learning was another collaborative approach applied which resulted in lower course drop rates and higher grades (NCWIT, 2007c).

Forty percent of the computer science majors at Harvey Mudd College are female, far more than the national average, due to President Maria Klawe's leadership (Kaufman, 2013). Klawe has achieved this through making computer science attractive to women and making introductory computer science mandatory to all majors (Kaufman, 2013). Klawe also encouraged the empowering of women to believe they can succeed and making them see that they can make a difference in the world (Kaufman, 2013). Klawe is working on developing a Game MOOC (massive open online course) for 10^{th} graders to get more women interested in computing (Kaufman, 2013).

De Palma (2001), Lagesen (2007) and Sackrowitz and Parelius (1996) all suggest the need for curriculum redevelopment at the college level to retain female students in CS classes. Sackrowitz and Parelius (1996) conducted their study in two well-known universities and looked at the retention rate of female students in introductory computer science courses. The conclusion of the study indicated that for female student retention, it was necessary to redesign the introductory courses. Lagesen (2007) looked at different methods to recruit women to CS. Her methods include reaching out to women, helping them understand the computer science field and changing their initial perception of the program.

De Palma (2001) suggests five ways to help attract women to computer science. He concludes that there is no lack of women in mathematics, only computer science. His recommendations are, making computer science more like mathematics and minimizing programming to pure logic. He also suggested reducing the introduction to hardware, keeping the program short and teaching one programming language at a time (De Palma, 2001).

Cohoon and Tillberg (2005), Damour (2009) and Drobnis (2010) suggest alternative ways to improve the numbers of female CS graduates. Damour (2009) proposes inspiring girls to tinker with computers at an earlier age as the way to promote CS. Damour (2009) states that when helping girls to tinker, realize that it will take time and space, and girls will not tinker alone and will like meaningful reasons for tinkering. Drobnis' (2010) study looked at the use of an all-girl computer science classroom in a high school to encourage CS. In the study, two computer science classes were offered to high school girls, one all-girl class and one mixed-gender class (Drobnis, 2010). The study concluded that girls from the all-girls' computer science class scored better than the girls from a mixed-gender CS class (Drobnis, 2010). Not only did the scores increase, but the girls in the all-girls class showed a growing interest in pursuing careers in CS in the future (Drobnis, 2010).

Cohoon and Tillberg (2005) found that women studied CS or math based on their initial experience with computing via their teachers, peers, the curriculum in school, or playing computer games. Cohoon and Tillberg (2005) suggest that supporting women *before* college in experience, support, skill and confidence will give them equal computing expertise as men.

All the researchers listed above have a mixture of reasons for the lack of women in CS. However, when it comes to how to increase their interest, there are two suggestions. Either a curriculum change at the college level is necessary or it is important to have precollege encouragement and exposure to computing. An additional study on precollege exposure to computing revealed that although there are numerous influences to women's disinterest in computer science, there is a common one.

Agosto (2002); Busch (1995); Cherney (2008); Denner, Werner, Bean, and Campe (2005); Gorriz and Medina (2000); Inkpen et al. (1994); and Li (2008) all agree that video games strongly impact the decline of female CS undergraduates. Inkpen et al. (1994) conclude that since boys outnumber girls by a ratio of 8 to 1 in playing video games, boys are more inclined to study computers in their future (1994). Inkpen et al. (1994) suggest that since the traditional school setting emphasizes on the individual, it caters more to men; therefore electronic games should be incorporated into the classroom setting.

Busch (1995) used 147 college students to determine whether attitudes towards computer use can affect computing. The researcher discovered that female students felt less confident about computing due to lack of computer experience and video gaming experience. Female students were less likely to be encouraged in computing and have less access to computers at home. The key to female success in computing is experience with computers, encouragement, and computer games. Nineteen years later, a 2014 study findings still supports Busch's 1995 results regarding computing confidence. Beyer's (2014) report suggests that students with higher computer self-efficacy were more likely to take computer science courses.

Agosto (2002) also suggests that early gaming experience can motivate students to study computer programming (para. 15). She concludes children who play games are more likely to study computer science and enter computer–related careers (Agosto, 2002, para. 15). Because boys play more computer games than girls, and because girls lose interest in games around age 13, female CS students are less knowledgeable about and less comfortable with computers (Agosto, 2002). Agosto (2002) predicts confidence in computer games can affect girls' success in problem-solving (para. 16).

Denner et al. (2005) write that computer games are considered a gateway to a more active use of technology (p. 90). The study suggests that not playing games equates to lack of computer knowledge, spatial skills, and problem-solving skills (Denner et al., 2005). In this study, an afterschool program called Girls Creating Games (GCG) was created for sixth through eighth graders (Denner et al., 2005). The study was a success for the 62 girls who participated and students felt more tech-savvy at the end of the program (Denner et al., 2005).

Cherney (2008) found that while women did better in verbal exams, men did better in spatial perception. Increased spatial perception meant men learned physical sciences, science and mathematics easier than women (Cherney, 2008). This study found that exposing women to computer games increased female spatial awareness level to that of the men, which can influence women's interest in STEM careers (Cherney, 2008).

Li (2008) looks at current technology used in education and the gap between male and female students. Li's (2008) study suggests the use of video games as the method to bridge the gap.

Gorriz and Medina (2000) states a growing concern is that girls are losing interest in computers, and thus, computer science, very early in the pipeline (p. 45). Gorriz and Medina (2000) conclude that the lack of interest in computer games implies lack of interest in computers and computer science (p.46).

Several studies have focused on using computers and computer games to influence girls' STEM education. Kelleher and Pausch (2007) focuses on using a game called *Storytelling Alice* to increase girls' interest in programming. The study included 23 girls from seven Pittsburgh Girl Scout troops playing with the *Alice* program and assessing how much of object-oriented programming methods they applied to their game. The result showed that girls using *Storytelling Alice* were more motivated to program and showed a stronger interest in taking a future *Alice* course (Kelleher & Pausch, 2007). The storytelling aspect of the game encouraged self-expression and allowed the girls to share stories with their friends and classmates (Kelleher & Pausch, 2007).

In the early 90s, games such as *MOOSE Crossing*, a text-based virtual world, and *StarLogo TNG* were created to motivate novice programmers (Hayes & Games, 2008). The National Science Foundation funds over hundreds of projects supporting STEM education, two projects that helped gaming and girls were *Rapunsel* and Girls Creating Games (GCG) (Hayes & Games, 2008). *Rapunsel* was a girl-friendly game environment, funded from 2003 to 2006, used to help teach programming concepts (Hayes & Games, 2008). Players of *Rapunsel* could participate in dance competitions, decorate their homes, create music and get rewarded for their completed lessons; the game taught Java programming (Hayes & Games, 2008). However, this world is not currently in use.

GCG ran from 2002 to 2005 and involved the programming of interactive stories to encourage girls' confidence in technology, similar to *Storytelling Alice* (Hayes & Games, 2008). Hayes and Games (2008) surveyed one hundred twenty-six middle school aged girls, and the results indicate that there were significant changes in perceptions of computer knowledge and computer skill level.

Recent studies list various hardware and software used to increase girls' interest in computing. One method is applying social learning theory through Facebook (Ku, Lin & Tsai, 2012). Another method is using a hardware device called Raspberry Pi (Sansing, 2013). A third method is creating interactive edutainment systems (Karime, Anwar, Rahman, Mahfujur, Wail, et al., 2012). Other methods include using rapid prototyping technology, organizing hackathons, and using motivating and engaging virtual environments (Beheshti, 2012; Fidan, 2011; Lipinski, 2011).

The University of Alberta has used *ScriptEase*, a visual tool used to developing games, to increase girls' interest in computing (Thilmany, 2011).

Girls Inc. and Discovery Education have developed a program specific to increasing girls' interest in computing entitled Discovery Education STEM Camp, which includes free curricula that involve hands-on labs and more (Peckham, 2013).

Globaloria, created in 2006 by the World Wide Workshop, allow collaborative teams to create video games around important educational and social issues. Using *Globaloria* has demonstrated successes when it comes to girls and computing courses. Female enrollment in *Globaloria* elective courses reached 33% in 2010-2011 and 37% in 2011-2012, exceeding the national average (NCWIT, 2012b).

AgentSheets is software that allows students to create games and simulations. In a summer elective course, 36 middle school boys and girls used *AgentSheets* to experiment with programming concepts. The initial results showed increased interest in both male and female students. *AgentCubes*, a 3D simulation and programming tool also developed by AgentSheets, revealed that students found the tool engaging (NCWIT, 2008a).

Scratch, developed by the MIT Media Lab targeted to both K-12 and Undergraduate students, is another programming environment used to teach computational thinking. Initial uses of *Scratch* in the classroom have also shown success (NCWIT, 2008b).

Another study used LEGO bricks to teach programming and other computing concepts to students in middle school, high school, and to undergraduate freshmen. 75% of the participants had positive comments on doing the LEGO exercise (NCWIT, 2005b).

Also, there are many non-profit organizations and associations that all promote STEM and more specifically computer science. Many organizations, foundations and schools that focus solely on increasing girls' and women's interest in STEM exist. Four such coding schools are, Girls Who Code, Girl Develop It, Black Girls Code, Girls Learning Code, and Ladies Learning

Code (Four Programs just for Aspiring Female Programmers, 2013). Code.org has developed *Hour of Code*, found at http://csedweek.org/, whose sole purpose is to introduce computer programming to everyone. Figure 5 is a list of such organizations and associations.

Programs that Teach or Inspire Women and Girls in Computing

COMPUGIRLS	[sst.clas.asu.edu/about/compugirls]
Black Girls Code	[blackgirlscode.com]
Girls Learning Code	[girlslearningcode.com]
DigitGirlz High Tech Camp (Microsoft)	[Microsoft.com/en-us/diversity/programs/digigirlz/hightechcamp.aspx]
Georgia Computers!	[gacomputes.css.gatech.edu]
Girls Creating Games (GCG)	[no longer running]
Computer Science Equity Alliance	[ucla.edu]
Geekchicpro	[geekchicprogramming.com]
Girl Develop It	[girldvelopit.com]
Femgineer	[femgineer.com]
She++	[sheplusplus.stanford.edu]
STEMinist	[steminist.com]
Women 2.0	[women2.com]
Girls Exploring Science Engineering and Technology (GESET)	[no longer running]
Mobile Technology Classroom	[girlsareit.org]
Aspire	[aspire.swe.org]
Technovation	[iridescentlearning.org/programs]
Code Liberation Foundation	[codeliberation.org]

Non-Profits/Organizations for Girls/Women in Computing

Women Gamers	[womengamers.com - no longer running]
Women in Games International	[womeningamesinternational.org]
GirlGamer	[girlgamer.com]
Girls Who Code	[girlswhocode.com]
The National Center for Women & Information Technology	[ncwit.org]
Ladies Learning Code	[ladieslearningcode.com]
Girls in Tech	[girlsintechnyc.com/girlsintechla.com]
She's Geeky	[shesgeeky.org]
Anita Borg Institute	[anitaborg.org]
Women in Technology Education Foundation	[womenintechnology.org]
Girlstart	[girlstart.org]
TechGirlz	[techgirlz.org]
National Girls Collaborative Project [NGCP]	[ngcproject.org]
Girl Scouts Hornet's Nest Council in North Carolina	[hngirlscouts.org]
Girl Geeks	[girlgeeks.org]
Society of Women Engineers	[swe.org]
Women In Technology	[womenintechnology.org]

STEM/Computer Science Based Organizations/Associations/Foundations/Programs

The Association for Women in Science	[awis.org]
The American Association of University Women	[aauw.org]
The Association of American Universities	[aau.edu]
Association of public land-grant universities	[aplu.org]
Computer Science Teachers Association	[csta.acm.org]
The Tapestry Workshop	[cs.virginia.edu/tapestry]
Creative Academies	[creativeacademies.net]
TeachingSTEM	[facebook.com/TeachingSTEM]
Code	[code.org]
National Science Foundation [NSF]	[nsf.gov]
MacArthur Foundation	[macfound.org]
STEMconnector	[stemconnector.org]
New Media Consortium (NMC)	[nmc.org]
The National Alliance for Partnerships in Equity	[napequity.org]
Exploring CS	[exploringcs.org]
National STEM Video Game Challenge (Pres. Obama's Initiative)	[stemchallenge.org]
The White House Council of Women and Girls in STEM Careers	[whitehouse.gov/administration/eop/ostp/women]
Women in ACM	[women.acm.org]
Technology Student Association	[tsaweb.org]
The Center for Excellence in STEM Education	[centerforstem.pages/tcnj.edu]
IEEE-USA STEM Literacy Committee	[ieeeusa.org]
MdBio Foundation	[techcouncilmd.com/mdbio/mdbio_foundation]
Exploring Computer Science	[exploringcs.org]
Women @ SCS	[women.cs.cmu.edu]

Figure 5. STEM organizations/associations/groups/programs

Although researchers have looked to identify the reasons behind the lack of women in CS, the main repeating cause is the lack of early exposure to computer games. Computer games are an influential factor to women's success in computer programming as well as obtaining a degree and working in the CS industry. Of the few games created for such purposes, *Rapunsel* is no longer active, and GCG is also no longer running. The *Storytelling Alice* game focuses more on creating animations and games rather than interactive gameplay. Other software like *AgentSheets, Scratch, Globaloria,* and non-software methods such as using LEGOs also do not focus on interactive gameplay.

The software or game design based programs used to increase girls' interest in CS follows the constructivist approach (having the girls create and make the video games). Not many games use the instructivist approach (having the girls play a game). Organizations that promote STEM and computer programming are not approaching it with an educational computer science game nor do they focus solely on the 13- to 17-year-old female demographic. There is a need for a research approach that focuses on using an educational CS game to teach programming to adolescent girls.

Category 2: Studies on Using Games for STEM Education

A PEW survey of 1,102 teens shows that virtually all kids play digital games and that half play games on a given day (Lenhart et al., 2008; Li, 2008). Numerous studies suggest that the enormous appeal of digital games makes educational games an effective learning tool (Anderson, 2008; Devlin, 2011; Dorman, 1997; Gredler, 1994; Gros, 2007; Hayes & Games, 2008; Kafai, 1996; Ke, 2009; Klopfer et al., 2009; Moline, 2010; Peppler & Kafai, 2007; Schwartzman, 1997; Tzeng, 1999).

Researchers see computer games as the future of STEM education. Computer games in the classroom are an excellent motivational strategy (Tzeng, 1999). Educational games appeal to children and help them better their skills (Dorman, 1997; Gredler, 1994; Schwartzman, 1997). Students' learning process is influenced by interacting with computer programs and games (Kafai, 1996). Games can engage learning and teachers can leverage the knowledge without disrupting the traditional school setting (Klopfer et al., 2009).

Many government agencies are making video games; the MacArthur Foundation is supporting two public schools entirely based on GBL (Miller, 2013).

The use of virtual worlds as an effective learning environment is encouraged to teach anything from Information Technology to English, Art, Music and Science (Rockcliffe University Consortium, 2012, pp. 16–29). Virtual world and virtual environments provide entertainment and social networking (OECD, 2011). Virtual environments provide repeated practices, reward for persistence and achieving goals (Behesthi, 2012).

According to Johnson, Adams, and Cummins (2012), K–12 schools will adopt GBL within the next 2 to 3 years (pg. 1). Johnson et al. (2012) support the idea that, when used correctly, video games can tap into students' natural passion for playing video games and can be a powerful educational tool. GBL is successful because it provides the students a safe place to learn from their failures (Johnson et al., 2012). Online game-like courses called Massively Open Online Courses (MOOC) fill a large gap for many who prefer customized learning environments (Johnson, Adams, Cummins, & Estrada, 2012).

Ke (2009) states, computer games have been anticipated as a potential learning tool with great motivational appeal and represent an interesting development in the field of education (p. 6). Ke's (2009) research shows that the simulated visualization, authentic problem-solving and instant feedback of computer games makes video games perfect for active learning.

Tillmann, Moskal, De Halleux, Fahndrich, Bishop, Samuel and Xie (2012) believe the future in teaching computer programming is in mobile games. Tillmann et al. (2012) used mobile devices instead of computers to promote STEM. Their approach suggests that in the future, powerful smartphones will be the computing device everyone will own and use for purposes of teaching and learning (Tillmann et al., 2012). Johnson et al. (2012) found that most games at the K-12 level come in mobile/tablet App form.

While a lot of these researchers focused on computer games or mobile games in the classroom, Moline (2010) suggests that children learn through video games out-of-school or in informal learning settings. Moline (2010) also summarizes that good video games are great instruments for engaged learning.

Gros (2007) finds that games provide complex learning environments appropriate for the acquisition of knowledge (p. 26). As Anderson (2008), Ke (2009) and Tzeng (1999) state, educational games improve student motivation. Devlin (2011) reveals that video games were ideal to teach middle-school math.

Some researchers look at educational games in the classroom, and some look at games outside the classroom; the consensus is educational games are useful tools for learning.

Educational games can teach a subject material because it provides great motivation, active learning and is fun for the students. Aside from research showing the effectiveness of educational games in the classroom, this review also explored researchers that developed educational games or used existing educational games in their study.

Hayes and Games (2008) identify that there are two ways to teach via video games: the instructivist approach and the constructivist approach. In the instructivist approach, a game is played to learn a subject; while, in the constructivist approach, students design and develop software to learn a subject. Both approaches have favorable findings (Hayes & Games, 2008). The research focused on studies that followed the instructivist approach first then the constructivist approach. Several researchers have looked at the instructivist approach.

Moskal, Lurie and Stephen (2004) focused on improving the retention rate of undergraduate students using *Alice*. Their studies showed that students who took the *Alice* course had the highest retention rate of 88%. Although *Alice* uses the instructivist approach, students who use Alice create an animated story as supposed to playing a computer game.

Steinkuehler and King (2009) focused on at-risk boys failing in high school and created an after school program that used online games for learning. Their study spanned a full year, and the findings showed success in teaching the adolescent boys (Steinkuehler & King, 2009).

Blasi and Alfonso (2006) created a virtual simulated electronic microscope and found that using that virtual instrument was an effective way to engage learners in High School.

Couceiro, Papasterogiou, Kordaki and Veloso (2013) found that using an instructional game was significantly effective in teaching Information and Communications Technologies when compared to traditional learning.

Sheehy (2012) used a virtual world called *Teen Second Life* to teach middle school classes. She focused on a year of teaching in Second Life and collected information from various teachers (Sheehy, 2012). The study showed that conducting class in a virtual environment while still meeting the curriculum requirements was a successful way to get students to be interested in the subject matter taught (Sheehy, 2012). The virtual world environment provided a more collaborative and inclusive learning space, and students were more engaged and responsible towards their education (Sheehy, 2012).

Leonard, Mangrum, Holmes, Squire, DeVane and Durga (2009) used a game called *Dr. Friction Multiplayer Educational Gaming Application* on 70 fourth and fifth-grade students, 31 male, and 43 female. As a result of playing this game, it was found that there were significant gains in learning in both genders (Leonard et al., 2009).

Squire et al. (2008) used *Civilization III* to teach world history to twelve fifth and sixth graders over a one-year period. There was a significant increase in knowledge where participants went from being newbies to systemic experts over the hours of play (Squire et al., 2008). Clem and Simpson (2008) used a game called *Crazy Machines* to teach fourth and fifth-grade science and a game called *Zoo Tycoon* to teach eighth and ninth grade science. Their research showed that simulation environments provided rich learning opportunities, and the students felt comfortable and capable in them (Clem & Simpson, 2008).

Steiner, Kickmeier-Rust, and Albert (2009) conducted a qualitative study on gender-based adaptation in educational games. The study concludes that computer games are an excellent tool for educating students in the classroom (Steiner et al., 2009). Steiner et. al. (2009) used an existing educational game on geography to conduct the research and found that students enjoyed GBL. The study also found that gender-sensitive games were more influential among the students (Steiner et al., 2009). Gender and game design aspects influenced by gender was developed as a result of Steiner et al.'s (2009) study. While Steiner et al. (2009) concluded that gender-sensitive educational games were preferable, Mubireek (2003) found gender-neutral games more useful.

Mubireek (2003) set out to determine which of *Mind Twister Math, Phoenix Quest,* and *NFL Math* were more influential in increasing interest in mathematics for fourth-grade boys and girls. He points out that *Mind Twister Math* is a gender neutral game while *Phoenix Quest* is more female oriented and *NFL Math* more male (Mubireek, 2003). His findings showed that the gender-neutral game, *Mind Twister Math*, was the favorite among fourth graders (Mubireek, 2003). Contrary to Steiner et al.'s (2009) findings, Mubireek (2003) point out gender-neutral games as best for a classroom.

In contrast to Mubireek's (2003) study, De Jean, Upitis, Koch and Young (1999) found both sexes liked *Phoenix Quest* (PQ), a gender specific game geared towards girls. An extensive study was conducted among seventh and eighth graders, 41 boys and 57 girls (De Jean et al., 1999). The study concluded that the game was effective in teaching math and language and was enjoyed by both genders (De Jean et al., 1999). Thus, while Mubireek (2003) found a gender-neutral game more advantageous among fourth graders, both Steiner et al. (2009) and De Jean et al. (1999) found gender-specific games as favorable. Whatever the consensus on gender-specific versus gender-neutral, the result of all three research conclude that video games are an effective learning tool and, therefore, is operative in promoting STEM.

Chatterjee, Mohanty and Bhattacharyan (2011) conducted their study on 108 seventh-grade and eighth-grade students. They used an existing educational game and had students play it in four different settings. The four settings were collaborative with a facilitator, collaborative without a facilitator, independent with a facilitator, and independent without a facilitator. Their findings showed that a collaborative game environment with a facilitator was best in teaching the subject matter in the classroom (Chatterjee et al., 2011). The study results suggested that GBL is influenced by the pedagogical context in the actual game-play activity (Chatterjee et al., 2011, para. 1). Similar to Chatterjee et al. (2011), Wood (2011) also looked at the importance of the facilitator in the classroom while providing GBL. Wood (2011) looked at a simulation video game to teach world history to 128 students. Students played a single player or a multiplayer version of the game with or without instructor guidance (Wood, 2011). The findings showed the players did better in the multiplayer version of the game with instructor guidance.

Leitch (2008) developed a game called *Physical Science Fun* for middle school students to determine what game interface would be most useful in educational computer games. He had 103 students play the game using a keyboard, a mouse and Nintendo's Wii-mote (Leitch, 2008). He found that the Wii-mote was the best interface to engage the students in the computer game and, therefore, learn the subject matter (Leitch, 2008).

Habgood and Ainsworth (2011) developed a game called *Zombie Division* and found that integrating the subject matter into a game helps improve students' learning. Habwood and Ainsworth (2011) studied 58 children as they played two versions of *Zombie Division.* One version of the game had mathematics integrated into the game while the other reviewed the material between game levels (Habgood & Ainsworth, 2011). They found that integrating or intrinsic application of the learning material to the game was the best method to teaching a subject matter via computer games (Habgood & Ainsworth, 2011). Whatever the method, Leitch (2008) and Habgood and Ainsworth (2011) support that educational games can help teach a subject matter such as math and science, and promote STEM.

Barab, Thomas, Dodge, Carteaux and Tuzun (2005) looked at a game called *Quest Atlantis* (QA), a virtual world for learning, and evaluated it in terms of an effective learning tool. They state educational video games are the only way the educators can adequately engage the 'video game generation' (p. 86). The researchers found that elementary students who used QA demonstrated statistically significant learning in the areas of science, social studies, and sense of academic efficacy (Barab et al., 2005, p. 86). This study also demonstrates how influential games are to promoting STEM.

Johnson et al. (2012) list many organizations and games being applied through K–12 that follow the instructivist approach. Organizations such as Creative Academies and EdGE are helping K-12 schools incorporate GBL. Some games already created include *Legends of Alkhimia*, which teaches chemistry, and *Minecraft*, which teaches humanities (Johnson et al., 2012). Games that come in tablet or mobile format are *SimCity* (social studies), *Catalysts for Change* (world poverty), and *Newark Earthworks* (lunar observatory) (Johnson et al., 2012).

Massachusetts Institute of Technology (MIT) has announced that they will create a massive multiplayer online game (MMOG) to teach math and biology to high school students. This project has a $3 million dollar budget (Smith, 2012). The MIT Education Arcade has already developed more than 15 educational games teaching STEM (Smith, 2012).

Code.org, a non-profit computer science education organization, includes various software and instructional material on its website that teaches coding to students. According to code.org (2013) its mission is to make computer science a part of the K-12 curriculum. Some of the instructional materials found on code.org include *Scratch*, Code Academy, Khan Academy and Code HS (code.org, 2013). This organization also offers some mobile apps, online tutorials and offer free courses that teach coding (code.org, 2013).

Several researchers have examined the constructivist approach: Baytak and Land (2011), Carmichael (2008), Clark et al. (2009), Hayes and Games (2008), and Peppler and Kafai (2007).

Peppler and Kafai (2007) support the constructivist approach to educational gaming. They suggest that students should develop games to learn their subject matter. Clark, Brandt, Hopkins and Wilhelm (2009) suggest that not only can students learn from playing video games but from designing them as well. Clark et al.'s (2009) study looked at 19 children between five and thirteen years of age. The students were taught to design an educational game prototype to teach mathematics, and the results showed that the children had increased interest in the subject (Clark, Brandt, Hopkins & Wilhelm, 2009).

Baytak and Land (2011) focused on teaching programming concepts to middle school aged children. They focused on learning by game design (Baytak & Land, 2011). Ten fifth grade students used software called *Scratch* to develop a computer game to learn programming (Baytak & Land, 2011). The findings show that students were able to design functional games, and this led to gaining informal knowledge (Baytak & Land, 2011).

Carmichael (2008) taught girls computer science concepts using GameMaker, a game development tool. Findings show the girls liked designing games and learning from game development.

Hayes and Games (2008) believe the constructivist approach is the right method to use due to the easy programming and design tools available. They suggest that creating games will help students learn computer programming. Additionally, Hayes and Games (2008) argue that this way of design thinking leads to better understanding and learning about the complexities of modern life. They also suggest that using games for learning need further exploration, whether by playing or making games.

Johnston et al. (2012) list organizations that promote the constructivist approach as well. Design Corps and Big World Learning show students how to develop games to learn. President Obama's initiative to promote STEM education, the National STEM Video Game Challenge also encourages using game design to learning STEM (Johnston et al., 2012).

This review showed that there are many different areas of study when it comes to educational computer games. Researchers have shown that games can be effective in the classroom or the home. Studies reveal that computer games are effective teaching tools in today's digital world, since most students play video games and games are highly motivational.

Some researchers used pre-developed games to determine the best game learning facilitation while others explored gender-specific versus gender neutral educational games. Other researchers looked at designing educational games, and existing virtual worlds and their influence on learning.

Still other researchers developed games to determine the best game interface and intrinsic application of material to games. However, although the research is vast, the conclusion is that educational games are useful teaching tools. The fact that gender-specific educational games are more useful when it comes to seventh and eighth graders is also revealed (De Jean et al., 1999; Steiner et al., 2009). These findings influenced the study objective of this research on choosing the instructivist approach in developing a gender specific educational game to teach computer science.

Category 3: Studies on Developing and Designing Games for Girls

This analysis focused on companies and groups formed to design games specifically for girls and research on game design elements preferred by girls. According to the Entertainment Software Association's 2012 data, 47% of all game players are women (Devaney, 2013). Female players tend to play differently than the male players. Casual gamers, people who play games such as *Words with Friends* and *Farmville*, are 61% female (Devaney, 2013). Recently the number of women and girl video game players has increased (Danforth, 2011). Women play Mass Multiplayer Online (MMOs) games, Co-Op games, tabletop Role Playing Games (RPGs) and board games (Danforth, 2011). Girl gamers are becoming more visible and vocal (Danforth, 2011). Some of the more popular games for girls are *Mario Kart, Mario Brothers, Wii Sports, Rock Band* and *Guitar Hero* ("Girls Win", 2011). According to Flurry Analytics, almost 100% of the women gamers play social turn-based, simulation, brain/quiz and casual type games (as cited by Calvin, 2013).

Teenagers also play games on a regular basis. According to the Pew Internet and American Life Project Teen and Parents Gaming and Civics Survey (2008), 94% of teenage girls play games. Boys play more frequently than girls (Lenhart, Kahne, Middaugh, Macgill, Evans, & Vitak, 2008). Games platforms are consoles, portable devices, computers and cell phones. 60% of teens own three or four of those devices (Lenhart, Kahne, Middaugh, Macgill, Evans, & Vitak, 2008). Teenage girls are less likely to play a large variety of games. More teenage girls than boys play rhythm and simulation games (Lenhart, Kahne, Middaugh, Macgill, Evans, & Vitak, 2008). The genre that scored the highest among teenage girls is the puzzle genre, with 87% of the girls preferring it (Lenhart, Kahne, Middaugh, Macgill, Evans, & Vitak, 2008).

Many well-known companies involved in the game industry have focused on developing games for girls and women. However, the game industry is still not a female friendly environment. According to Belinda Van Sickle, chief executive of Women in Games International, women who play games are considered weird (Wong, 2010). Women who work in the game industry work in departments such as marketing rather than development or programming (Wong, 2010). Large game companies' female games often fail to resonate with their intended demographic (Wong, 2010, para. 3). Some opinion reveal that most games geared towards women is "like 'cooking mama', fashion design, [and] pink-little-pony-puppy-kitten" (Wong, 2012, para.4). There are games, companies, and research looking to change that, however.

Otome, "young woman" in Japanese, is a genre of dating simulation games aimed at the female audience (Lee, 2012). Although the genre is big in Japan, it has not caught on to much popularity in the West (Lee, 2012). One Otome game seen as popular in the West is *Angelique,* a simulation fantasy dating game (Kemps, 2011).

Silicon Sisters, a game development company for women by women, have developed two games, *School 26* and *Everlove: Rose,* for a female demographic. *School 26* is a game that involves a female protagonist in a high school setting while *Everlove: Rose* is a fantasy adventure romance game (Games by Women, for Women, 2011).

Her Interactive is a game development company based in Seattle, making games solely for girls. This company has sold over 9 million copies of a detective game based on the Nancy Drew book series (Long, 2013).

Goldie Blox (2013) is a toy for girls used to teach girls about engineering at a young age.

G.A.M.E.S or Girls Advancing in Math, Engineering, and Science is a new collaborative effort between university partners and gaming companies in Seattle. The focus of this partnership is to develop educational games solely for girls using professionals and researchers who study game science (Collette, 2013). The objective of this organization is to develop at least 20 test games by 2017 (Long, 2013).

Victoria Van Voorhis, founder and CEO of Second Avenue Software, focuses on designing educational games to increase learning outcomes (Devaney, 2013). Voorhis and Second Avenue Learning have received a grant from the National Science Foundation to develop *Martha Madison's Marvelous Machines* to teach physical science to middle school students (Devaney, 2013). Initial studies have shown that playing the game has increased student performance (Devaney, 2013). The researcher also found that girls like to play open-ended games, use problem-solving skills, collaboration and focus on the social good (Devaney, 2013).

Girls need to see the connection from the classroom out into the real world, motivation, and use of interactive educational games to learn about math and science (Devaney, 2013, para. 3).

There are other developers, including some no longer in business, who have focused on creating games for the female demographic. Swanson (1996) produced games for girls, and Ray (2001) created a development company focusing solely on games for girls (Mubireek, 2003). Purple Moon was an organization geared towards creating games for girls ages 8–14 (Laurel, 2001). E-GEMS consisted of a team focusing on creating educational games for math and science (Klawe, 1999; Mubireek, 2003). Games for Learning Institute formed at New York University in 2008, and the Institute created a fractions game for the game console Xbox 360's Kinect (Isbister, 2009). Even though both large and small companies are trying to attract girls to video games, the industry is still influenced by men and games exclusively made for women are rare (Bourgon, 2010).

Many of the games created by said companies do not focus on creating an educational game that teaches computer science to 13+ year-old girls. Companies that did create educational games created games that taught friendship, mathematics, collaboration and co-operative learning. Purple Moon and E-GEMS, no longer exist (E-GEMS, 2002; Laurel, 2001).

Various studies were conducted focusing on game design elements that attract girls. However, none aimed to develop a playable game prototype (Bertozzi, 2008; Chintakovid, 2009; Dickey, 2007; Fullerton, Morie, & Pearce, 2008; Hamlen, 2011; Hartmann & Klimmt, 2006; Homer et al., 2012; Ibrahim, 2011; Kinzie & Joseph, 2008; Lieberman, 2009; Schott & Horrell, 2000; Stone, 2009; Squire, 2008; Yee, 2008; Yi, Wei, Hendrix, 2009; Ziemek, 2006).

Ziemek (2006) found that gender does have an influence on what types of games are attractive to the player. For female players, she found that games should be two-dimensional, easy and fun; Ziemek (2006) claims that it is easier to identify dislikes than likes when it comes to video games and women.

A mixed methodology study conducted by Ibrahim (2011) resulted in a complete guide for designing a gender inclusive game. The measuring tool created by Ibrahim (2011) is used to test whether a game is gender-sensitive or not. She found that games that are more gender inclusive tended to be non-violent, simulation, adventure or puzzle games (Ibrahim, 2011). Ibrahim (2011) found that women liked having several support features while playing, several scenarios in gameplay, collaboration, personalization of avatars, different color schemes, personalization of sound/music and a meaningful story. Although her framework is helpful in evaluating games, her study did not involve the development of a game (Ibrahim, 2011).

Chintakovid (2009) found, through his mixed methodology research, that girls preferred exploring and moving freely in a game. He found that women had lower confidence than men when it came to computer-related tasks and, therefore, stayed away from unknown computer applications (Chintakovid, 2009). Chintakovid (2009) quotes Turkle (1988) stating that women stayed away from computers because computers represented something negative. Although this study focuses on what elements influence women's ease of use of an application, it does not attempt at creating an application using those findings.

Hartmann and Klimmt (2006) studied 316 females aged eighteen to twenty-six years old and learned that women liked the richness of social interaction, games that incorporated building, role-playing games and adventure games the most. Hartmann and Klimmt (2006) state, computer games that are more attractive to boys perpetuate gender imbalance in access to modern information technologies (para. 6).

Bertozzi (2008) finds that female players tend to play easier more casual games.

Yee (2008) examined the gender differences between men and women playing Massively Multiplayer Games (MMOs). The research spanned a long time in which Yee collected surveys from 2000 to 4000 respondents. Yee (2008) found through his research that 85.4% of MMO players were male. He found that if a female did play MMOs, they were usually much older than the male players. The research showed that only 20% of female players were ages 22 or younger (Yee, 2008). Additionally, 27% of female players were introduced to MMOs by their romantic partners (Yee, 2008). Finally, female players preferred someone else in the same room while playing, usually a male romantic partner (Yee, 2008). Female players score higher if motivated in the game through relationship and customization. In other aspects such as socializing, teamwork, discovery, role-playing and escapism, Yee (2008) found no differences between the male and the female players. Yee's (2008) research reveals a couple of things in terms of what attracts women to games. From this research, it can be deducted that women prefer to play with others and like to play games that allow customization and building relationship status.

Hamlen (2011) used a mixed methodology study to examine children's understanding of engagement and why they choose the games that they do. Out of the 233 children studied, 36% of the girls played simulation games while only 5% of boys did (Hamlen, 2011). 15% of the girls played educational games while only 2% males did (Hamlen, 2011). Girls preferred observation and exploration to innovation, cheats, action and adventure (Hamlen, 2011).

Yi et al. (2009) looked at two forms of educational mathematics games, competitive and non-competitive. Yi et al. (2009) used the qualitative method to determine which of the two games will four to seven-year-old boys and girls recall more. They found that girls did not recall winning or losing or the rewards they earned, they recalled the relationships they formed in the game and the friendships made (Yi et al., 2009).

Homer et al. (2012) looked at preadolescent boys and girls, ages 10–15 years and their characteristics in video gameplay. The study showed that more boys played games at 10 to 11 years of age, but more girls played at 12 years of age. However, more boys played at 13 years of age, and at 14 to 15 years of age, almost twice as many boys were playing video games as girls. As for the choice of game, girls preferred virtual life, puzzle, role-playing, and party games (Homer et al., 2012).

Schott and Horrell (2000) looked at girl gamers who play video games and their preference for video games. Looking at a small sample of both women and girls, the researchers found that girls possess an alternative playing orientation, style of play, competency and knowledge (Schott & Horrell, 2000). Schott and Horrell (2000) found that girls preferred role-playing games, especially with an animal or a creature as the principle character, liked non-purposeful exploration, avoided competition and wanted an open interpretation of game objectives. Girls prefer rich character descriptions and well-developed stories (Schott & Horrell, 2000).

Fullerton et al. (2008) state that game environments are catered to male constructions of space and play (para. 3). The game mechanics behind many games are about controlling and dominating. While females like to make things, males prefer to scatter and destroy.

Fullerton et al. (2008) also speak of game levels as having male organizational structure. In games, players need to dominate one level before moving to the next and females tend to like the opportunity to explore and have their fantasy space (Fullerton et al., 2008). Domestic spaces, a rich storyline, constructing, creating stories and community areas are what females prefer in games (Fullerton et al., 2008).

Mass Multiplayer Online Games (MMOGs) are discussed as being appealing to women but with most MMOGs not providing the right environment (Fullerton et al., 2008). Fifty percent of the players of the *Myst*-based MMOG *Uru* were female because of the cooperative exploration and the puzzle solving activities involved. Women are mostly disinterested in competition, killing or combat (Fullerton et al., 2008).

Fullerton et al. (2008) reveal virtual worlds as the best place for a female preferred space, due to the possibility of providing a story, emotion, and nature. The researchers ask for a more gender inclusive and balanced game space in today's games (Fullerton et al., 2008).

Other researchers list game design elements that attract female gamers (Becker, 2008; Cassell & Jenkins, 1998; Chatterjee et al, 2011; Clark, 2009; Dede, 2008; De Jean et al, 1999; Gorriz & Medina, 2000; Gredler, 1994; Habgood & Ainsworth, 2011; Inkpen et al, 1994; Li, 2008; Mubireek, 2003).

Researchers looking at designing games that are gender inclusive or gender specific believe that games should provide gender-supportive communities. For instance, games geared toward women should be sensitive to social and contextual factors, and they should include features to report harassment (Richard, 2013). They should also include challenging levels and fun quests (Amr, 2012; Esper, Wood, Foster, Lerner, & Griswold, 2014).

Clark (2009) lists active engagement, participating in groups, interaction and feedback as elements that attract females. Gorriz and Medina (2000) state that girls like collaboration instead of competition, openness and exploration, puzzle solving and complex social interactions. Gorriz and Medina (2000) also list that girls like to identify with the characters in the game, rich texture, good audio, good story, real-life characters and to interact socially.

De Jean et al. (1999) list storyline, characters, goals, social interactions, creative activities and challenges as what girls prefer in educational games. De Jean et al. (1999) also indicate that girls like having the same age and gender as the game character and puzzle solving. Girls did not prefer non-linear storytelling (De Jean et al., 1999).

Cassell and Jenkins (1998) suggest girls like cooperative play, creative play, communication-related play, and adventure games.

Another study lists rich narrative, action roles, appropriate levels of challenges, opportunities to design or create, engaging characters, communication and collaboration, and strategies and skills beyond shooting guns as elements that attract girls (Li, 2008). Li (2008) adds peer collaboration and focusing on creativity and building as essential gameplay elements to attracting girls to video games.

Inkpen et al. (1994) found that girls preferred playing games on the computer as suppose to a video game console and like social interaction.

Studies have looked at using educational games in the classroom and looked at game elements that are attractive to girls, as seen above. In fact, Figure 6 lists many STEM based games that are currently being used in the K-12 educational system. Although researchers found frameworks and evaluation methods to rate a game in terms of appeal to girls and women, none has applied the elements to develop a game.

Educational STEM Games

*Statecraft X (social studies)
*Legends of Alkhimia (chemistry)
*Minecraft (humanities)
*Catalysts for Change (world poverty)
*Dr. Friction (Multiplayer Educational Gaming Application)
*Civilization III (history)
Crazy Machines (Puzzle – Engineering)
Zoo Tycoon (Business Simulation)
Mind Twister Math (Math)
NFL Math (Math)
Pet Vet (Cure Animals/Science)
Physical Science Fun (Free Interactive Science Game)
Zombie Division (Math)
Newark Earthworks – (Teaches about Newark Earthworks)
Flower – (PS3 Adventure Single Player Game - Physics)
Thomas Was Alone (Programming/AI)
Dragonbox (Math Game – Ages 8 and Up)
LightBot (Computer - Puzzle Game - Robotics)
StarLogo TNG – (MIT) –(Older 3D puzzle blocks game)
Other Games from MIT Education Arcade – education.mit.edu

*Used in K-12
*(Johnson, Adams, & Cummins, 2012) (Miller, 2013)

Some Mainstream Entertainment Games Popular among Girls/Women

The Sims – (Strategic Life Simulation Video Game)
Words with Friends - (App & FB – Word Game)
Farmville – (FB – Online Social Game – Farming Simulation)
Mario Kart – (Racing Game)
Mario Brothers - (Side-Scrolling Platform Game)
Wii Sports - (Sports/Exercise Games)
Rock Band - (Music Game)
Guitar Hero - (Music Game)

*(Devaney, 2013)

Educational Computer Programming Games for Mobile

Toontastic – (iPad, Creative Learning App - Draw, Animate and Narrate own Cartoons)
CargoBot (iPad Game – Puzzle – Robotics)
Move the Turtle (iPad & iPhone – Puzzle – Programming)
*(Miller, 2013) (code.org, 2013)
Bo & Yana - play-i.com - Robotics

Educational Games that Teach CS/Math based Subjects Specifically to Girls

Rapunsel - Rapunsel.org – (Single Player Computer Dance Game – Programming - 10-12 Year Olds)*
Phoenix Quest - (Mathematics for Girls 9 – 14 Years Old)*
Gram's House - (Computer Science for Middle School Age Girls) - gailcarmichael.com/research/projects/gramshouse

*(Hayes & Games, 2008) (Mubireek, 2003)

Computer Programming based Board Game/Blocks

Robot Turtles – (Board Game Teaches Programming to kids ages 3+)*
Goldie Blox - (Engineering for Girls 4+ Years) - goldieblox.com

*(code.org, 2013)

Online Multiuser Community based Educational Games/Environments

Quest Atlantis (QA) - (3D Multiuser Computer Graphics Learning Environment – Ages 9 -15 – Science and Math)
Kafai's WhyVille – (Online Multiuser Community – Learn Science)
Mars Geothermal – (Online Virtual Environment Simulation to Promote STEM)
Martha Madison's Marvelous Machines – Collaborative Multiplayer Game to teach Middle School Students Physical Science – (In Progress)
MOOSE Crossing – (No Longer Running - Used for 11 Years - Text-Based Multiplayer Online Game World)
MIT's Mass Multiplayer Online Educational Game - (In Progress)
World of Warcraft – battle.net/wow
Second Life – secondlife.com
OSGrid - osgrid.org

*(Johnson, Adams, & Cummins, 2010) (Barab, Thomas, Dodge, Carteaux, Tuzun, 2005) (Peppler & Kafai, 2007)(Hayes & Games, 2008)

Figure 6. Education STEM-based games and Entertainment games—some specifically for girls.

Category 4: Studies on Developing and Designing Educational Games

Whereas the researchers listed previously identified game elements that make successful games for girls, other researchers conducted studies to find game elements that make successful educational games (Becker, 2000; Bourgonjon, Valcke, Soetaert, & Schellens, 2010; Chatterjee et al, 2011; Dickey, 2007; Foster & Mishra, 2008; Gee, 2012; Gredler, 1994; Gros, 2007; Habgood and Ainsworth, 2011; Haskell, 2012; Hong, Cheng, Hwang, Lee, and Chang, 2009; Huang and Plass, 2009; Kinzie and Joseph, 2008; Klopfer, Osterweil, and Salen, 2009; Lieberman, 2009; Mubireek, 2003; Noor Azli, Nor Azan, & Shamsul Bahri, 2008; Rice, 2007; Squire, 2008; Stone, 2009; Wood, 2011).

Becker (2008) suggest that educational games should have consistency, keep scores, inventories and information organized and displayed correctly, and accurately track player's progress in a game.

Gredler lists curriculum-based knowledge, elimination of luck or chance for winning, and focus on teams and cooperation as elements that make a good educational game (as cited by Mubireek, 2003, p. 6).

Mubireek (2003) suggest using educational computer games for any of four general academic purposes: (a) to practice or refine knowledge, (b) to identify gaps or weaknesses in skills, (c) to serve as a summation or review, and (d) to develop new relationships among concepts and principles (p. 7).

James Gee, a lead researcher in teaching children with games, believes that video games support many learning principles (Miller, 2013). Gee believes that effective educational games should incorporate social and collaborative learning, problem-solving and students developing the material (Miller, 2013). According to Gee, the educational game itself is just one piece to the educational game puzzle (Gee, 2012). Gee introduces a good educational game as a game that includes not only the play itself, but also a meta-game (Gee, 2012). A meta-game, Gee explains, inspires social interactions inside and outside the game (Gee, 2012, para. 3). He believes that what makes a successful educational game is the game itself, plus the social interactions and interest-driven "affinity spaces" on the Internet (Gee, 2012, para. 4). Gee also feels that most educational games do not do a good job because they are not created by game designers (Miller, 2013).

Sean Bouchard, who works with the University of Southern California's Game Innovation Lab, believes that educational games are not working, comparing it to "chocolate covered broccoli" (Bouchard, 2011). He believes that "wrapping educational content around games is not good" and games should be dynamic, should challenge kids, and be personalized to the individual student (Bouchard, 2011).

Habgood and Ainsworth (2011) conclude that delivering the learning material through fun gameplay is the best way to create an effective educational computer game.

Stone (2009) attempts to find a guideline for creating an educational game for children aged three to seven years old. His guidance includes having a good game controller, good graphics, readable text, fun audio, interactivity, consistency and challenges with upbeat and non-intimidating tone, with good feedback (Stone, 2009).

Squire (2008) suggests mass multiplayer online platforms as a platform for educational video games. He (2008) also suggests that epistemic games, games that put players in professional roles, are an effective gameplay element.

Chatterjee et al. (2011) and Wood (2011) suggest collaborative play with a facilitator. Gros (2007) also indicate that the teacher is fundamental to students' being successful in GBL. Kinzie and Joseph (2008) surveyed 42 middle school aged children and developed an

Educational Game Preferences Survey. Kinzie and Joseph (2008) found that most children liked having their game characters be the same gender as them, wanted street scenes and girls preferred creative play while boys preferred active play. Kinzie and Joseph (2008) found that when elements of games attract girls, it benefits both boys and girls. Using an instructional game with challenge features and fantasy features, Amr (2012) found that instructional games are more useful when there are challenging levels to the game.

Dickey (2007) proposes that MMORPGs (mass multiplayer online role playing games) act as an excellent platform for educational games. Dickey (2007) suggests that learning environments should include opportunities for interactive challenges, which require players to synthesize multiple modes of information and use critical thinking skills (Dickey, 2007, p. 254).

Lieberman (2009) looks at serious games as an effective learning tool. Lieberman (2009) focuses on factors that influence serious games development for an informal setting. For informal settings, Lieberman (2009) states, games compete with many other leisure-time activities. Games for informal settings should be fun, exciting, edgy to play, and do not need to motivate a great deal of learning or skill development (Lieberman, 2009). Informal games do not need to be evaluated before they reach consumers or to align with specific curriculum standards. They can be targeted at a small population with specific and unique characteristics (Lieberman, 2009, p. 124).

Along with all the elements listed for developing educational games, students can still create games instead of playing them to learn. Therefore, creating a game is also considered as a potential gameplay element an educational game should have.

Huang and Plass (2009) emphasize that to create an effective educational game, one need to understand what play is and why play in education is important. They feel a successful educational game should be fun and engaging and prepare students for future careers (Huang and Plass, 2009). Huang and Plass (2009) feel that educational games should promote social development, intellectual and cognitive development, deal with emotion and stimulate creativity and fantasy.

Haskell (2012) believes quest based learning is the key to hold students' interest in educational games. Haskell (2012) found that once a quest based game became too difficult, time-consuming, or uninteresting, students stopped playing. Out of the two types of quests in games, task-based versus goal-based, Haskell (2012) found that the goal-based approach was best. The goal-based approach provided students more freedom and creativity (Haskell, 2012). Haskell (2012) found that asking students to create word processor documents, presentation software, or spreadsheets were the least attractive solutions to quest-based games. Embedded video did not automatically make quests interesting, but web tools were most favorable, especially when students created their portfolio pages (Haskell, 2012).

Rice (2007) provided a detailed scoring rubric for teachers to use to evaluate whether a game encourages higher order thinking in participants. Such games allow players to assume a role in the game rather than just playing it. They also create meaningful interaction and dialog with non-playable characters (NPCs) and have a complex storyline with characters the users care about (Rice, 2007). Other suggestions include simple puzzles, 3D graphics, multiple views (camera pans, zooms in, zooms out), different ways to complete the game, and lifelike avatars (Rice, 2007). Rice (2007) feels that a good educational game requires interaction with virtual elements, knowledge beyond mouse prompts and number entry, synthesis of knowledge, artificial intelligence and replayability (Rice, 2007).

Hong et al. (2009) stated effective content design is crucial to the success of digital GBL (p. 423). Hong et al. (2009) created a game evaluation index that listed what digital educational games should include. Some essential elements listed were: rules, goals and objectives, outcomes and feedback, competition/challenge, interaction, and representation (p. 427). Good educational games promote adventure, belonging, knowledge enhancement, memory enhancement, strategic thinking, negative emotion management, spatial ability and hand-eye coordination (Hong et al., 2009).

Noor Azli et al. (2008) state that most children play games because they are fun and challenging. Children play games for social and entertainment reasons (Noor Azli et al., 2008). Noor Azli et al. (2008) list motivation, engagement, challenge, clear goals, fantasy, story, curiosity, feedback and playability as the elements that make good educational games.

Foster and Mishra (2008) created a framework for teachers to identify which games are most appropriate for their classroom. Teachers should look at the game genre and content, and whether the game provides practical skills, cognitive skills, motivation and social skills (Foster & Mishra, 2008).

Bourgonjon et al. (2010) looked at what made students accept educational video games. They found that students preferred educational games in the classroom based on the usefulness of that game, ease of use, the learning opportunities it provided, and their personal experience with video games in general. Male students look at using video games in the classroom more positively than female students (Bourgonjon et al., 2010). Prior video game experience and ease of use were the main reasons for accepting educational video games in the classroom with usefulness as the number one factor (Bourgonjon et al., 2010).

Klopfer et al. (2009) listed suggestions to game designers making educational games. They felt that a developer must learn game design principles before making educational games (Klopfer et al., 2009). Designers should think small, choose wisely and put learning and gameplay first (Klopfer et al., 2009). Developers need to find the game in the content of the topic being taught and break the mold of where the game is played (Klopfer et al., 2009). Game developers should harness soft skills learning, define learning goals, forge partnerships, and consider the what, where, when, and why (Klopfer et al., 2009). Also, developers should avoid being too constrained by academics, and they should not ignore teacher training (Klopfer et al., 2009).

These findings show that although there are many educational games research and helpful game elements identified, an educational computer science game was not one of these games mentioned. Figure 7 lists studies on GBL and games research.

Free Software/Tools/Activities/Curriulum that teach Computer Science/Programming

CS Unplugged – csunplugged.com
Globaloria – globaloria.org
AgentSheets – agentsheets.com
Code Academy – codeacademy.com
Khan Academy – khanacademy.org/cs
CodeHS – codehs.com
Scratch – scratch.mit.edu
Alice – alice.org
Kodu – kodugamelab.com
KidsRuby - kidsruby.com
Code Avengers – codeavengers.com
Mozilla Thimble – thimble.webmaker.org
AppInventor - appinventor.mit.edu
Codea – twolivesleft.com/Codea
Hackety Hack - hackety.com
Games for Change - gamesforchange.org
Hour of Code - csedweek.org
Karel J. Robot - http://csis.pace.edu/~bergin/KarelJava2ed/Karel++JavaEdition.html
Jeroo - jeroo.org
Greenfoot - greenfoot.org
GridWorld - apcentral.collegeboard.com
Squeak - squeak.org
Phrogram - phrogram.com
Lego Mindstorms - legoeducation.com
Python Tutorials - dabeaz.com/usenix2009/pythonprog
Codin Game - www.codingame.com
CodeSpells - codespells.org

Educational Game Based Research

3DGameLab – 3dgamelab.com
The Learning Game Network – learninggamesnetwork.org
Center for Game Science – centerforgamescience.org
Gooru – gooru.go.nmc.org/gooru
The PLAYground – playnml.wikispaces.com/PLAY!
Build Augmented Reality [BuildAR] – builder.com
Games for Learning Institute (NY) – g4li.org
MIT Gamebit Lab – gamebit.mit.edu
Edu Games Research - http://edugamesresearch.com/blog/

Massive Open Online Courses/Online Course Publishing Platforms

LearnStreet - learnstreet.com
Lynda.com - Lynda.com
Udemy – udemy.com
Arduino (Robotics) – arduino.cc
Lego Mindstorms (Robotics) – mindstorms.lego.com
Coursera – coursera.org
Edx – edx.org
Udacity - udacity.com
TeachingTree.co - teachingtree.co
Versal – versal.com
World Educational Gamers Mathletics – http://www.worldeducationgames.com/

Making Educational Games for Girls/Women Only

Second Avenue Software – secondavenuelearning.com

Girls Advancing in Math, Engineering, and Science [Girls GAMES]
http://www.northeastern.edu/seattle/explore-northeastern/g-a-m-e-s-s-t-e-m-national-initiative/

Purple Moon and E-GEMS - [No Longer Running]

Making Entertainment Games for Girls/Women Only

Her Interactive – herinteractive.com
Silicon Sisters – siliconsisters.ca

Figure 7. Tools and educational game based research—games companies and STEM programs/courses.

Literature Review Findings (Gaps in Research)

To show that GBL can help increase girls' interest in CS the topic of studies on the lack of women in STEM was explored. Many researchers' work was examined and analyzed. Although studies list different reasons for the lack of women in CS, a commonality conclusion among researchers looking at precollege factors is the lack of exposure to computer games. The general age of this loss of interest is 13 or adolescent years. These findings show that exposing girls to games, especially games played on the computer platform during their teenage years, increased interest in CS.

The second topic explored was studies on using games for STEM education. Researchers agree that computer games are effective learning tools in both instructivist and constructivist form in formal and informal settings. While the success of GBL is not disputed, researchers in this literature review do not look at games directed towards teaching computer science. If researchers focused on gender, it is in passing or as a sub-category to their research. Those who have developed or looked at games for STEM educational purposes studied games that teach mathematics, science, or language to girls and boys. The researchers do not look at games that teach computer science to adolescent girls, or if they did, it was on games that are no longer in existence or games that relied heavily on storytelling and animation.

The third area of study was developing and designing games for girls. While current and past organizations and companies have formed to develop entertaining or educational games for girls, none of them focused on computer science. E-Gems, and Purple Moon, no longer exist. Those set out to study what types of games attract women only looked at game elements that women prefer rather than developing a video game.

The fourth area of study was in designing and developing games for education. Those who looked at game elements needed in educational games did not focus on CS and did not focus on educational games for girls. While there are games already being used at the K-12 level, all the researchers focus on what makes a good educational game for both boys and girls and does not focus on making educational games for girls only.

Along with the four broad areas of literature review topics examined, online games and games research sites were explored, and game design books read. Game design books have listed game elements that make a successful game. Some elements are measurable results, customization, high completion rate, ease of deployment, rewards, dynamic content, and high engagement levels (Aldrich, 2009; McGonigal, 2011). Other game design books teach game theories, game player characteristics, game genres, game stories, gameplay, game audio/music, game interactivity, player testing, and designing and prototyping a game (Fullerton, Swain, & Hoffman, 2004; Novak, 2011; Schell, 2008). In this study, the lessons learned from these design books and sites visited, as well as, direct experience were applied to develop the game.

From this review, there are two conclusions:

1. Many studies were conducted on the designing and development of educational games; however, none of the studies looked at how to create an educational game to teach CS to adolescent girls.
2. This analysis identified game design elements that attract girls and elements that make good educational games. Figure 8 summarizes what girls prefer in games and game elements that educational games need. These findings were used to develop the educational game Arr*ay[7]* and its companion world *Gamher World*.

Girls

Free Moving/Open/Non-Closure
Social Interaction/Collaboration
Build Up
Adventure
Exploration
Observation
Non-purposeful Exploration
Creative Play
Easy
Casual
2D
3D
Fun
Nonvoilent Action
Simulation
Puzzle
Support Features/Feedback
Scenarios
Personaliztation
Different Color Schemes
Music/Sound Personal
Meaningful Linear Story
Relationship
Active Engagement
Real-World Connections
Transmedia
Rich Texture
Worthwhile Goals
Computer Games rather than Console
Customization
Discovery
Role-Playing/Role-Playing as Animal/Creature
Escapism
Education
Virtual Life
Party/Dance
No Competition
Open Interpretation of Game Objectives

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Educational Games

Good Game Controller
Good Graphics
Large Text
Fun Audio
Good Interactivity
Challenge/Problem Solve
Consistency
Upbeat
Non-Intimidating
Feedback
Recognisibility
MMOG/Social/Multiplayer
Having Avatar be same Gender
Street Scene
Fun, Exciting, Edgy
Unique Characteristics
Situate player in Professional Role
Open ended/Explore/Maniuplate Objects in World
Soft Skills
Deliver Learning Material through fun part of Game
Keep Good Score
Maintain Inventories
Progress Tracked
Practice/Refine Knowledge
Identify Gaps in Knowledge
Review
New Relationships among Concepts and Principles
Designing Games to Learn
Curriculum Based Knowledge
Luck of Chance of Winning Eliminated
Focus on Team Play
Adventure
Engaging/Motivate
Dealing with Emotion
Sense of Belonging
Strategic
Spatial Skill
Hand-Eye Coordination
Facilitator Involved
Fantasy/Story
Creativity
Quest Based
Dialogue
AI in NPCs
Ease of Use/Useful
Characters users care about
3D Graphics
Multiple Camera Views
Lifelike Avatars
Virtual Elements
Represent Real World
Replayability
Rules/Goals/Outcomes
Different ways to compete
Adjustments to Game/Personalization
Meta-Games - social interaction inside/outside Game

Figure 8. Game elements that attract girls versus elements that make good educational games.

Filtering out the repeated elements in the above list resulted in a more concise list of game elements preferred by girls versus game elements best used in educational games. Figure 9 depicts this list.

Girls	Educational Games
Social Interaction	Team Based
Creative Play	Fun/Engaging/Ease of Use/Useful
Building	Design and Create Game to Learn
Adventure/Open Exploration	Explore/Adventure
Puzzle	Open Ended/Good Story/Dialogue in Game
Meaningful Story	Deliver Material/Curriculum Based Knowledge
Good Audio	Manage/Organize Player Progress
Personalization/Cutomization	Put Player in Professional Role
Computer Platform	Luck is eliminated from Gameplay
No Competition/No Violence	Consistent Challenges
Exploration/Observation	3D/Multiplayer
Relationship	Deal with Emotion/Soft Skills/Creativity
Engagement/Immersion	Spatial/Hand-Eye Coordination/Multiple Camera Views
Virtual Life	Quest Based/Strategic
Simulation/Education	Replayability/Customization
Party/Dance	Facilitator Involved/Meta-Game
Real World Connections	Life like Avatars/Characters users care about (NPCs)
	Sense of Belonging

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Figure 9. Game elements that attract girls versus elements that make good Educational Games (Revised).

Derived from the above lists, Figure 10 shows a summary of what game properties are required to develop gender-specific educational games.

A highly engaging team based, socially interactive, 2D/3D/puzzle/action/adventure/simulation/Virtual Life/Party computer game that builds relationships and is open ended and has replayability with different choices and outcomes and directions with consistent challenges that is fun and puts the player in a professional role or role play. The game allow players to design their own game, allow creative play and building, deal with emotions, learn soft skills as well as curriculum based knowledge with a facilitator (teacher), has a meaningful story, creates belonging, connection with game characters, with personalized audio/music and avatar, no competition or violence, and allows for open, quest based, non-purposeful exploration. The game is well managed, keeps good track of player progress and contains many help features as well as encourages/provides space outside of the game for socialization and game related discussions.

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Figure 10. Game properties needed for an educational game geared toward girls.

Figure 11 categorizes the game elements identified in terms of platform, genre, gameplay, game features and player mode.

Educational Game for Girls
Game Design Guide

Platform:	Genre:	Game Play:	Game Features:	Player Mode:
Computer Game	Puzzle	Fun	Allows Customization	Multiplayer
Online Virtual World	Simulation	Meaningful Story	Highly Engaging	
	Quest Based	Non-Purposeful Exploration	Soft Skills	
	Adventure	Consistent Challenges	Curriculum	
	Action	Building	Good Track of Player Progress	
	Party	Socially Interactive	Creates Belonging	
	Open Ended	No Competition/Violence	2D/3D	
		Player in Professional Role	Well Managed	
		Role Play	Deal with Emotions	
		Creative Play	Connection with Game	
		Builds Relationships	Replayability	
		Design Own Game	Meta-Game	
		Different Choices	Many Help Features	
			Facilitator	

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Figure 11. Game design guide for creating educational games for adolescent girls.

Figure 12 lists the game design guide in the format of Jessie Schell's (2008) Key Game Design Elements.

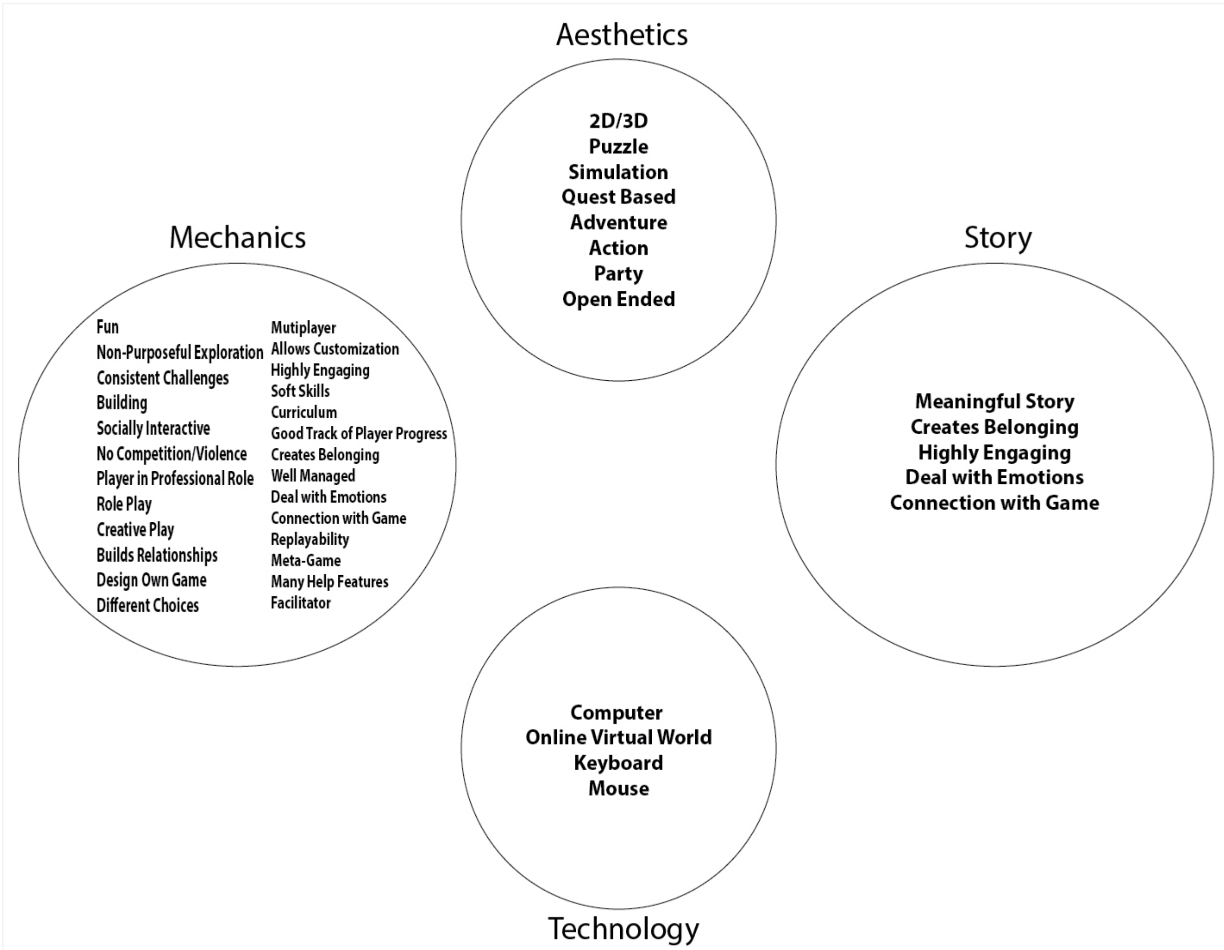


Figure 12. Categorization of the educational game design guide for girls into Schell's game design elements.

The idea for *Array[7]* came from these key elements identified. A detailed game design document helped the initial development stages of the game.

Game Design Document

The Game Design Document (GDD) is a detailed description of a game design for a video game (Novak, 2011). The GDD includes title, hook, game back-story, a summary of gameplay, game characters' descriptions, game story and sound and music used in the game. The GDD also lists user interface/game controls, level design, features and platform and production details. Essentially the game design document is the plan of the entire game to make the development stage quick and easy.

The literature review helped identify elements that should go into the game design of an educational computer game. Each element listed got incorporated into the developed game. Research showed that girls like two-dimensional games and three-dimensional games; and 3D games help spatial recognition in women. That is the reason the game for this study contained a 2D game with a 3D virtual world companion site.

Two-dimensional and three-dimensional open-ended games were one of the many elements found as needed in a game geared toward girls and educational games. A quick study resulted in the discovery of GameMaker and a free virtual world creation site OpenSim Virtual World. OpenSim is an online multiplayer 3D virtual world environment. Having the computer game companion site on this platform provided an open environment. GameMaker is a 2D game making progrrram. This software facilitates the creation of an interactive fun, educational game.

In the 2D game, the main story, curriculum content, gameplay, scoring, challenges, and goals are delivered more linearly. In the 3D companion site, the gameplay is more non-linear and open, for girls to explore, socialize, and enhance their learning experiences.

Having a personalized avatar and personalized music was possible because of OpenSim. OpenSim is a virtual world similar to Second Life, and it provides personalization. Players can choose their avatars and change their clothes, physical appearance, makeup, and other characteristics. Moreover, because music plays throughout the world, players can personalize that as well. All of these elements were pre-defined just through the selection of using a mass multiplayer virtual world as the presenting environment and platform for the companion site.

To add to the personalized element, players have rights to build in the virtual world and edit their virtual world gadgets. This feature meets not only the criteria for having personalization within a game, but also the game element of the ability to build in a game. This gameplay implies creative play and touches on the subject of both the constructivist and the instructivist approach to using games to teach.

Due to the research findings, the game did not contain rough competition or violence. A meaningful story was developed for the 2D game to motivate the player. The genre of *Array[7]* is action, adventure, simulation, and puzzle; based on the findings of the literature review that suggests those genres as the preferred ones for girls. To support exploration, teleportation, already supported by OpenSim, helped the girls experience an exploratory gameplay in the 3D game site. In the 2D game, through the puzzle/mystery solving gameplay, the Java learning elements were taught. The challenges were kept consistent and fun, and the learning material was woven into the educational gameplay to take away the feeling of learning. Players took on the roles of the game character and used the 3D virtual space to socialize and interact with each other.

The proposed 2D game and the 3D companion virtual world site incorporated all of the essential game design elements identified in the literature review as much as possible.

Along with the game design elements identified, the educational software was developed with a particular curriculum in mind. The curriculum came from the Computer Science Teachers' Association (CSTA). CSTA's purpose as an organization is to support the teaching of Computer Science in the K-12 discipline (Frost, Verno, Burkhart, Hutton, & North, 2009).

CSTA is part of the Association for Computing Machinery, and the organization has published a model curriculum for K-12 computer science (Frost et al., 2009). The model curriculum is made up of four levels: foundations, CS in the modern world, CS as analysis and design, and topics in computer science (Frost et al., 2009). This research borrowed its curriculum from the level 1 foundations of the computer science model (Frost et al., 2009). The learning objectives of the CSTA Curriculum are in Table 1 (Frost et al., 2009).

Table 1. *CSTA Curriculum Learning Objectives*

Student Learning Objectives
A K-2 student will be able to:
1. State that computers are controlled by computer programs.
A 3-5 student will be able to:
1. State the purpose of programming languages.
2. Code and test a sequential program to perform a simple task.
A 6-8 student will be able to:
1. Write a computer program that implements an algorithm.
2. Code and test a program to solve a stated problem, using variables and at least one decision or loop.

In this study, the learning objectives for the sixth- to eighth-grade student curricula were followed. Students who played the game learned to implement an algorithm using the Java programming language and code and test a problem using variables, decisions, and loops. Table 2, *CSTA Curriculum Focus and Sample Activity,* illustrates what sixth- to eighth-grade students should focus on when learning computer science (Frost et al., 2009).

Table 2. *CSTA Curriculum Focus and Sample Activity, Grades 6–8*

Focus	Sample activity
Converting an algorithm to a computer program	Students are given a simple mathematical algorithm, such as converting from Fahrenheit to Celsius or determining the average of a list of numbers. On paper, they write a program to implement the algorithm and then write and run the program on a computer.
Planning, writing, and testing computer programs	Students work in teams of three or more, taking the roles of customer, programmer, and tester. The programmer and tester interview the customer and write down specifications for a simple computer program. The programmer writes a program that meets the specifications. The customer and tester devise a set of test cases that can be used to validate the program. The tester runs the test cases and reports the results to the programmer, who makes any needed corrections to the program. The customer writes a final report.

Based on the curriculum followed, after gameplay, students learned to convert an algorithm to a computer program and learned to plan, write and test computer programs. This curriculum and the design elements identified laid down the foundations of the educational game developed for this research. *For Full Game Design Document, See Appendix A.*

Summary of Literature Review

This literature review showed that educational games are useful tools in the classroom. The review also revealed the gap in current research studies on attracting girls to computer science, and a comprehensive list of game elements needed to make gender-specific educational games. This complete literature analysis led to the quantitative and qualitative based research questions and the null and research hypothesis. The next chapter explains the research design and methodology.

CHAPTER THREE

A fixed mixed method was used to evaluate the game developed for this research. The research design was sequential exploratory due to lack of available validated instrumentation. The first phase of the study involved a quantitative data collection and analysis (priority) then a qualitative ethnographic data collection and analysis (secondary). The meaning of such an analysis involves "using qualitative follow-up to evaluate and interpret the quantitative results" (Joyner, Rouse & Glatthorn, 2013, p. 73). The research was exploratory but used experimental procedures. The study involved three steps. First, the researcher selected a sample. Second, the researcher randomly assigned participants to experimental and control groups. Third, the researcher administered the treatment to the experimental group only (Joyner et al., 2013, p. 75).

In this research, five all-girl programming workshops were held. In two of the workshops, the comparison group (control group), the Java programming language was taught following a set curriculum using a traditional method of lectures and exercises *please see Appendix B for the curriculum*. In the next three workshops, the participant group (focus group), the Java programming language was taught following the same curriculum as the comparison group but with the game developed for this research.

Quantitatively this study analyzed the focus group's quiz scores against the control group's scores; and the focus group's number of positive survey ranking of computer programming versus the control group. Qualitatively an ethnographic study was conducted only on the focus group. This group was questioned to determine what game elements affected their quiz scores and positive response to CS, as well as gain feedback. The analysis will help explore the research questions and support the hypotheses.

Research Traditions

A fixed mixed method incorporates preplanned quantitative and qualitative methods before the start of the study. A researcher uses a mixed method study for complementarity, which means seeking elaboration or clarification on the results of one method with the use of the other (Creswell & Clark, 2011). Several types of mixed method research exist. One such variation is a sequential exploratory design (Creswell & Clark, 2011). This study involved a quantitative data collection and analysis followed by a qualitative data collection and analysis.

This study put the priority on the quantitative study, and the qualitative study came secondary to help explain the quantitative results (Creswell & Clark, 2011). There is different timing used in conducting the two methods: multiphase, concurrent, and sequential. Multiphase is the implementation of multiple phases with performing the processes sequentially or concurrently. Concurrent timing is implementing both quantitative and qualitative studies at the same time (Creswell & Clark, 2011). Sequential timing is the collecting and analyzing of data using two phases: a quantitative followed by a qualitative (Creswell & Clark, 2011). This research used the sequential timing method.

In a mixed method study, the data can be mixed during interpretation. During this stage, the researcher has completed data collection and analysis and is drawing a conclusion from the results by comparing the quantitative data to the qualitative (Creswell & Clark, 2011).

Quantitative research is research conducted with numerically based data and includes measurement of data and analysis of data. The research design is on how to conduct the study, and measurement involves recording the numbers, and analysis requires the interpreting of the results (Vogt, 2007). Main forms of research designs are document analysis, secondary analysis of data, naturalistic observation, surveys, interviews, experiments and quasi-experiments and participant observation (Vogt, 2007, p. 8). Although this study used the experimental procedure, due to not having validated instrumentation, this research design was labeled exploratory.

Measurements are observations expressed as a number (Vogt, 2007, p. 9). The types of measures include nominal, ordinal, interval and ratio (Vogt, 2007, p. 9). The level of analysis is from low to high, the higher the rank of measurement the more information the measurement scale contains (Vogt, 2007, p. 9).

There are three kinds of statistical analysis: descriptive, measures of association and inferential statistics (Vogt, 2007). The descriptive analysis looks at one variable at a time. Associational analysis involves the analysis of a correlation between two variables. The inferential analysis looks at whether the statistics calculated from a sample can be generalized to the population (Vogt, 2007, p. 11). This research used measures of association statistical analysis.

Statistical significance of the research results depends on a p-value or probability value. If the result found is less than .05 or 5% of the time, then it is statistically significant (Vogt, 2007, p. 13). If the statistical significance favors the rejection of the null hypothesis than it supports the research hypothesis, otherwise, it does not (Vogt, 2007, p. 15). There are two forms of errors when conducting a statistical analysis. Type I error is the data rejecting a valid null hypothesis. Type II error is when data accepts a null hypothesis incorrectly. Sample size can reduce such errors, with bigger the sample size the better (Vogt, 2007).

When working with a sample of participants and collecting their responses, it is important that all subjects have an equal probability of being assigned to the focus group (Vogt, 2007, p. 95). It is very imperative to write questions that lead to valid measurement (Vogt, 2007). Surveys are popular analysis tools and typically the response options would be arranged in a Likert Scale (Vogt, 2007, p. 88).

Within the various statistical calculations used to calculate data, the dependent *t* test is used when comparing two experimental conditions and the same participants are in each condition (Field, 2009). The independent *t* test is used when there are two experimental conditions, and different people have been used in each situation (Field, 2009, p. 334). In an experimental design with two groups (independent *t* test), the scores of the comparison group might differ from the participant group. This is not because of the experimental manipulation but because of other sources known as covariates (Field, 2009, p. 334).

Analysis of covariance (ANCOVA) is a statistical analysis that looks at covariates. Covariates are variables that are not part of a main experiment but have an influence on the dependent variables (Field, 2009, p. 396). As explained earlier, in a comparison such as a *t* test, factors such as motivation, IQ, and so forth can be influencing the dependent variable outside of the independent variable. Thus, if the analysis accounts for the covariates, a researcher can see how the independent variables affect the dependent variables *after* the effect of the covariate (Field, 2009, p. 396).

There are assumptions to each of the statistical analysis methods described. The *t* test assumes a normal sampling distribution and that the data are measured at least at the interval level (Field, 2009, p. 326). The independent *t* test assumptions are that variances are roughly equal, and scores are independent (Field, 2009, p. 326). The assumptions for an ANCOVA test are, variances in each experimental group are similar, observations are independent, measurements are on at least an interval scale, and the distributions normally distributed (Field, 2009). The independence of the covariate and treatment effect, and the homogeneity of regression slopes are also assumed (Field, 2009, p. 397).

Qualitative research is research conducted with non-numerical based data. This type of study focuses on meaning and understanding in naturally occurring situations (Joyner, Rouse & Glatthorn, 2013, p. 73). Case studies, ethnographic research and action research are examples of qualitative studies (Joyner, Rouse & Glatthorn, 2013). Case studies are research concerned with exploring a phenomenon (Joyner, Rouse & Glatthorn, 2013, p. 77). Ethnographic research is a type of case study that involves the study of the culture of schools and classrooms (Joyner, Rouse & Glatthorn, 2013, p. 78). Action research is a study that documents how an educational problem was identified, understood, and solved by practitioners (Joyner, Rouse & Glatthorn, 2013, p. 78). Data can be collected via interviews, observations and surveys (Joyner, Rouse & Glatthorn, 2013). Part of this research used an ethnographic study.

Research Questions and Hypotheses

Quantitative

1. How does the participant's pre-quiz score compare to her post-quiz score?
2. How does the focus group's post course quiz score compare to that of the control group?
3. How does the focus group's post survey response view of computer science compare to that of the control group?

Qualitative

1. What components of the game obtained participant interest? Why?
    - Graphics/Colors? Why?
    - Gameplay Elements? Why?
    - Characters used, interface, music, sound, other content? Why?

2. What can be done to improve the game?

    - What are some suggestions for making the game better in terms of fun level and educational level? Are there any other additional suggestions?

Null Hypothesis (H0): There is no difference between the response and quiz scores of the focus and the control group.

Research Hypothesis (H1): The focus group will score higher and, or respond more positively to the computer science course than the control group.

Research Design

This research followed the ADDIE (Analyze, Design, Develop, Implement, and Evaluate) instructional design model as the development framework for the study. The analyze and design stages included the literature review, that helped identify successful educational game design elements that attract girls. The findings from the analysis, as well as curriculum developed by the Computer Science Teachers' Association, were used to develop the educational game for the female demographic. The *develop*ing stage included the creation of the actual game.

In the *implement* and *evaluate* stages, a sequential exploratory research was conducted using quantitative and qualitative data collection and analysis.

The programming workshops in this study were held to teach the Java programming language. The main reason for using Java versus other programming languages was solely due to the preference and experience of the researcher. Since the objective of this research was to increase girls' knowledge of programming and view of computer science, the particular language selected didn't hinder the results.

Five Java programming workshops took place in the summer of 2014, and each workshop lasted four hours. Each workshop had different group of participants and had room for a maximum of 25 students, which could make 125 research participants in all. The girls participated in either the control or focus group based on their workshop date. A quiz and a survey were developed for the workshop and administered before the course began and given again after the session ended. Figure 13 illustrates this process.

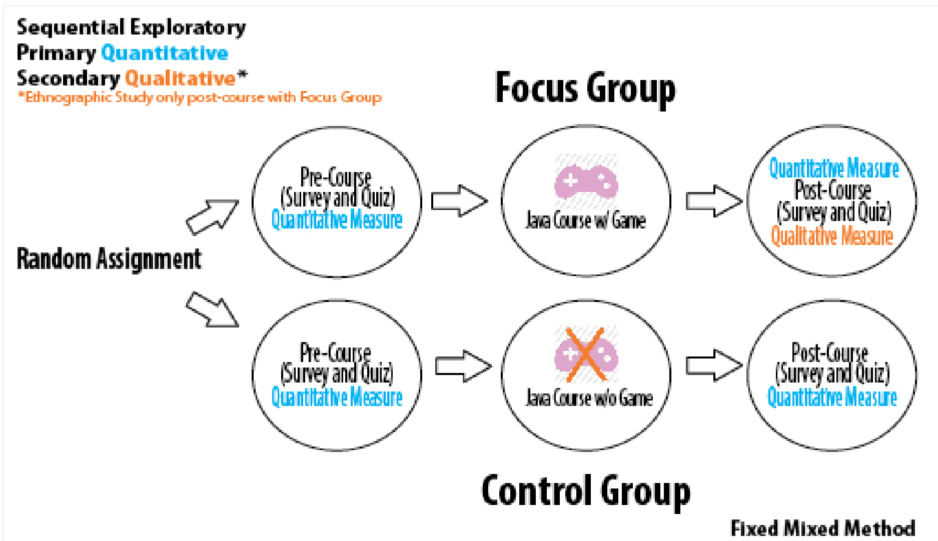


Figure 13. Research design.

Quantitatively, gender, grade level, quiz score, survey response, age group and number of students in each workshop was collected. In the ethnographic study, this research surveyed students for their feedback on the game developed such as what parts of the game were most fun and what can make the game better.

Population and Sampling Procedure

To conduct the experiment this researcher reserved a venue at 2450 Crystal Drive, Arlington, Virginia 22202 (*for permission to use site see Appendix H*). The location was the DeVry University Arlington Virginia campus. The workshops took place in a classroom computer lab with all the proper equipment.

Some non-profit organizations helped promote and market the event, sending out email blasts and tweets to their members and contacts. These groups include TechGirlz, Mason Game and Technology Academy, North American Simulation and Gaming Association, Mid-Atlantic Girls Collaborative Project, and the Washington DC Chapter of the Association for Computing Machinery. An Eventbrite site was created to help interested participants register for the event at javaworkshop4grls.eventbrite.com. The site contained a flyer that explained the workshop in detail. The information on the flyer included an explanation of the dissertation study's research methodology; including the difference in course delivery based on control versus focus groups. The site contained contact information for the researcher, information regarding consent forms, the type of workshop, time, date and location. Students took their own transportation (*for flyer please see Appendix C*).

The group of students that signed up for the workshops was the research sample; due to the location of the workshops, the sample was from the Northern Virginia/Washington DC/Maryland area.

The students in the study sample and their parent were asked to sign consent forms. (*For consent forms please see Appendix D*). Based on which of the workshops the student signed up for, they were either in a participant group or the comparison group. Random sample, or equal probability sample, is the opportunity given to the members of the population to have an equal chance to be in the sample (Vogt, 2007). The students in this study divided into groups based on workshop dates. The population did have an equal probability chance of choosing either being in the participant or comparison group. Figure 14 illustrates this step.

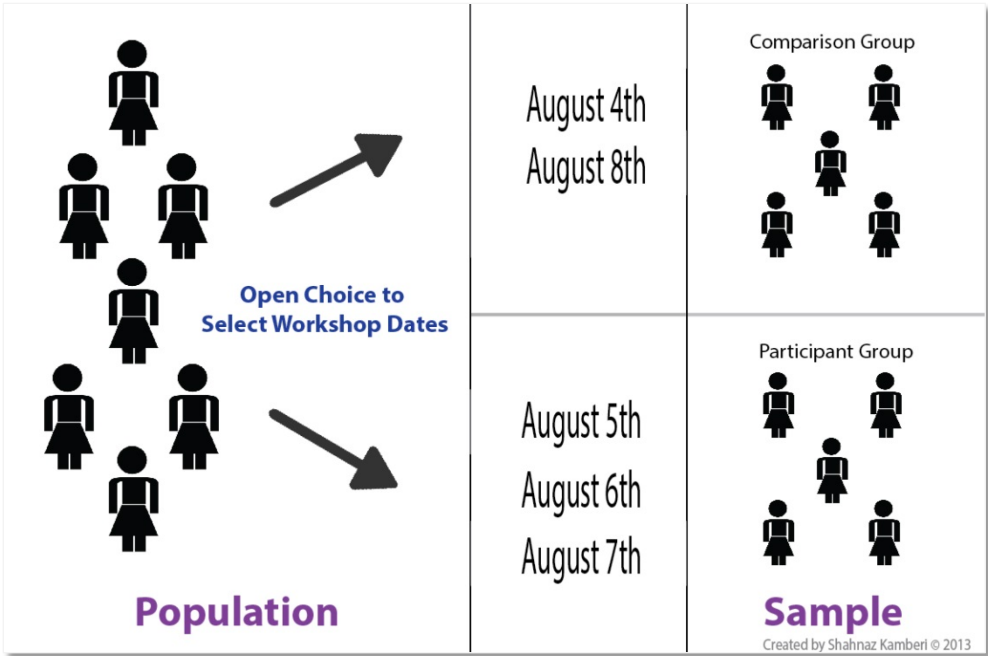


Figure 14. Population and sample procedure (workshop dates from 2014).

Instrumentation

As discussed in the research design, the instrumentation used in this experiment was a quiz and a survey. The survey was used to collect both quantitative and qualitative data while the examination measured only quantitative data. The quantitative data portion of the survey consisted of questions using the Likert Scale, asking students to rate their likes and dislikes of computer programming. The qualitative portion of the survey asked questions about feedback and suggestions for the game developed. Therefore, the qualitative questions were asked solely of the participant group and not the comparison group.

Question 4 on the survey is Drobnis' (2010) survey instrument. *For Surveys, See Appendix E.* Drobnis (2010) studied the benefits of an all-girl computer science class versus a mixed gender computer science class in a high school setting. She used a survey to determine girls' interest in computer science in the two modes of course delivery. Because Drobnis' (2010) study is similar in that it evaluated girls' view of computer science, the questions from her survey instrument were used and edited for this research's survey question 4. *See Appendix G for signed consent permission to use instrumentation.*

The quiz was used as an instrument to measure knowledge acquired within the workshop. It contains ten questions and follows a similar format to an exam provided by the Computer Science Teachers' Association (CSTA). The questions on the quiz covered the material taught in the workshops. The examination sample found on the CSTA site covered the programming language called Python (CS151 Computational Thinking Quiz 1 F10, n.d.). This research only used the formatting and organization style of the CSTA exam. The quiz format consisted of sample code followed by a series of questions regarding the syntax, to determine how much of it the student understood. *Please see Appendix F for the quiz and answer key.* The answers to the exam were not given to the students, pre or post workshop, to prevent the solutions from getting out to later participants.

Reliability and Validity

Reliability refers to the consistency of either measurement or design (Vogt, 2007, p.114). Due to using the same curriculum in both groups; and the same survey instrument and quiz versions used, this research design has reliability. The survey and exam questions are based off of previous instruments and previous curriculum deemed dependable. Reliability also refers to the reasonable expectation that similar results are achieved by someone else or by the same person when conducting the same research at a different time. In each of the five workshops, a survey and examination were administered at the beginning and end, and the difference in the before and after answers determined the effectiveness of the course. This test-retest method is easy to duplicate and can be recreated by other researchers or this researcher at any time using the provided instrumentations.

Validity refers to whether an instrument measures what it was designed to measure (Field, 2009, p. 11). Pre and post tests and surveys were given to determine the validity of the research design. Without a pre-workshop assessment, if the student does well on the final quiz the influencing factor might not be the video game. It might be prior knowledge of material, math ability, and an overall interest in the subject, motivation, and so forth. A pre-test allows for a more valid data collection. Regardless of one group's prior higher or lower ability, the posttest compared to the pretest can help determine knowledge acquired based on the course delivered. Thus, the pretest allowed for a better valid analysis since it helped identify *covariates*. Due to lack of previous research, parts of the instrumentation used in this study were developed by this researcher; thus the instrumentation used is not an established one.

Data Collection and Analysis

The data for this research was organized to conduct the form of analysis needed to explore the research questions. The data collected was organized using the data tables as illustrated by Figure 15.

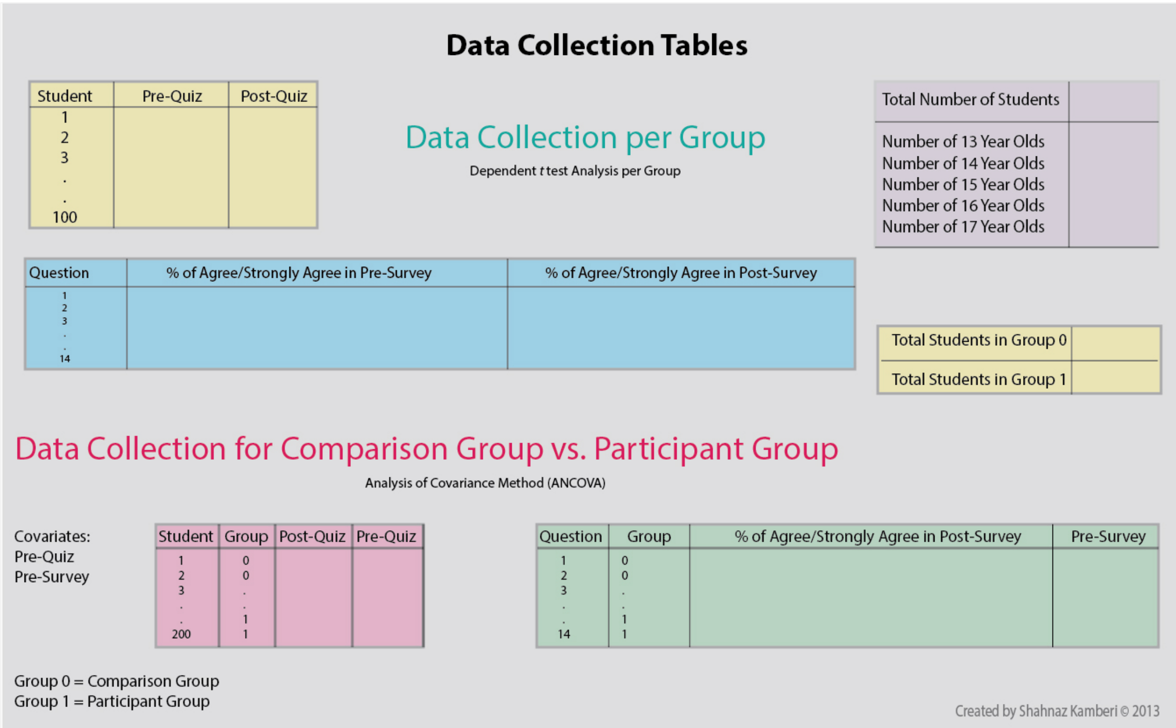


Figure 15. Data collection tables.

In each workshop, the total number of students, age, and the grade was logged. The student's pre and post exam scores were recorded once they were taken and graded. The data tables also contained the percentages of students who agreed or strongly agreed to each of the 14 questions adapted from Drobnis' (2010) survey. Once all five workshops were held, and data collected, then the comparison tables were made. The student, the group they belonged to (comparison or participant), and their post-workshop quiz and survey results were organized into data tables to be analyzed. The pre-workshop scores and survey results were covariates. The total number of students in both groups was noted down.

Data analysis was conducted to explore each of the research questions listed. The primary form of the statistical test used in the data analysis was the dependent *t* test and the ANCOVA or analysis of covariance test. Data was analyzed using the IBM SPSS software (statistics calculating software).

To explore the data for the first research question: *how does the participant's pre-quiz score compare to her post-quiz score?* First a bar graph was created displaying the mean scores for the pre and post quiz of each sample group. Then a dependent *t* test was conducted; if the result of the dependent *t* test's significance value was less than .05 the scores were considered significantly different (Field, 2009, p. 333). This score suggests that there is a significant difference between the participants' post-quiz score and pre-quiz score. A large increase in score shows that the participants did learn something during the workshop. The same method was used to analyze the pre and post survey results. This first research question does not compare the two groups' results to each other but examines the results of each group separately to help set the basis of whether the workshops had any effect in either group.

To review the data for the second research question: *How does the focus group's post course quiz score compare to that of the control group?* A bar graph was again created to compare the average exam scores between the comparison group and the participant group. Then an analysis of covariance test was conducted with the two groups' data. Again, a significance value less than .05 means the two groups are significantly different (Field, 2009). Achieving a value less than .05 suggests that the participant group's post quiz results differ significantly from those of the comparison group.

The same method was used to explore the third quantitative research question: *How does the focus group's post survey response view of computer science compare to that of the control group?* A significance value of less than .05 suggests that there is a significant difference between the two groups. The number of favorable responses will indicate whether the game group responded more or less positively to CS than the non-game group.

Having significant differences in comparable data supports the research hypotheses while not having significant differences support the null hypotheses.

To explore the research questions, *what components of the game obtained participant interest? Why? What can be done to improve the game?* Only the experiment group answered the qualitative survey questions after the workshop. Participants answered what components of the game piqued their interest the most and why and what could be done to improve the game. The answers to these questions were analyzed to identify which game elements were most successful in obtaining the girls' interest. The survey responses of recommendations given on what needs to be changed or edited within the game was considered, and the game will be re-designed or re-developed in the future as a result.

Summary of Chapter Three

This research used a mixed method study to explore the research questions and hypotheses. The study used a sequential exploratory design. The first phase (priority) of the research involved a quantitative study, collecting and analyzing data from a focus group versus a control group. The second phase (secondary) of the study included a qualitative ethnographic data collection and analysis conducted only post-workshop of the focus group. The mixed method study was predominately a quantitative analysis with a qualitative secondary analysis. By collaborating with local non-profit organizations, five free Java programming workshops were held.

The sample for the research consists of 13 to 17-year-old girls. Some of the girls were taught programming via a traditional method of lecture and exercises while others taught programming via *Array[7]* and *Gamher World*. The data was collected and organized into various data tables and analyzed by creating bar graphs, computing the dependent *t* test and the ANCOVA test. The statistical analysis was conducted by using the calculating software SPSS. The results of the study determined whether or not to reject the null hypothesis.

In the next chapter, the development phase is explained. The entire development procedure is discussed, including the building of the game, the tools used, the types of programming languages used, and so forth. The chapter discusses the challenges and obstacles in developing the game. Chapter four explores the process of taking a concept on paper and building it to a working, playable prototype.

CHAPTER FOUR

According to the ADDIE model, prior to implementation and evaluation there is the designing and developing of the educational game. The literature review analysis and an established curriculum helped in designing *Array[7]* and *Gamher World*. This designer used several programs to develop the game and the companion world. These programs included Adobe Photoshop®, Adobe Illustrator®, Microsoft Paint®, Camtasia Studio™, Audacity®, Second Life®, GameMaker®, Firestorm Viewer, OpenSim, and New World Studio. The 2D game was developed using GameMaker Studio Master ($499.99 at the time of purchase) from yoyogames.com. The 3D world was developed using OpenSim (free). New World Studio ($10 for a year's service, created by Olivier Battini) was used to make the world accessible via the web.

Game Development

Developing the Opening Cinematic

The development of the 2D game involved many steps. First, the opening cinematic to the game was created. The opening cinematic sets up the backstory leading up to the beginning of the game so that the player is aware of the game plot. Machinima was the method used to create the cinematic. Machinima is the method in which an existing set is used to produce animated shorts. Second Life, an existing 3D virtual world environment was used to create the cinematic. Camtasia, screen recording software, was used to capture scenes and avatar movement in various Second Life environments. Camtasia was then used to edit the scenes together in a movie-like fashion, along with subtitles, to create the animated short film. The researcher then uploaded the completed opening cinematic to YouTube. Figure 16 is an example of a scene from the opening cinematic (Kamberi, 2014a).

Figure 16. Screen capture of a scene from the opening cinematic.

Developing the Game Assets for 2D Game

The next step involved the development of the game assets. Assets are any graphics (static or animated), audio, texture, and other items necessary in a game. Images were created using Second Life, Adobe Photoshop, Adobe Illustrator and Paint. To create the 2D game environment and the characters, particular locations and avatars from Second Life was screen captured. The images obtained were then modified to make it cohesive in terms of color and theme.

Background images used in the game included a computer lab in a school setting, a girl's bedroom, a classroom, a kitchen, a living room, a desk, and a school hallway. Varying views of these environments were captured to provide a more dynamic look in the game. The background images were saved as Joint Photographic Experts Group (JPG) file types. Some examples of the background images used are shown in Figure 17.

Figure 17. Example of background images used in *Array[7]*.

As for the characters, an image of a male avatar was used for the central non-playable character (NPC) in the story. Two other different male avatar images were used to represent a non-playable character police officer and a student in a classroom. Five female avatars were used from SL to embody the main playable character's mother, best friend, the school bully, a neighbor, and the school principal. Each of these avatars was screen captured from the chest up. The background of the avatars was deleted and set transparent using Adobe Photoshop. The images were saved as Portable Network Graphics (PNG) file types. Figure 18 shows images of some of the characters from the game.

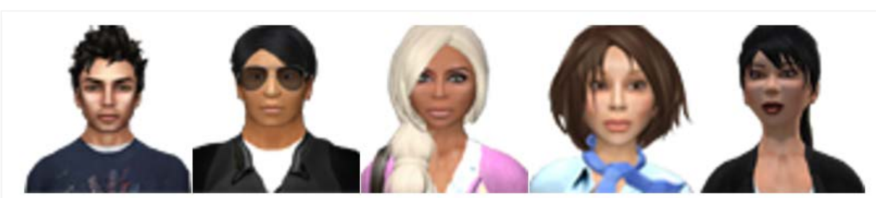


Figure 18. Example of game character images used in *Array[7]*.

Separate JPG files of the sprite in various rotated angles were used to create the animation in the game. The images were then put together in a sequence within GameMaker to create an animated effect. Figure 19 shows this sequence.

Figure 19. Different rotated angles of an image used for creating animated sprites.

Other assets in the game include screen captures of the Eclipse environment along with Java code examples and PowerPoint slide images. Microsoft PowerPoint was used to create the teaching material. The researcher exported each PowerPoint slide as a separate JPG image for use in the game environment. The same PowerPoint images from the game were used to teach Java to the control group for consistency. Figure 20 shows a slide image used in the game to explain variables.

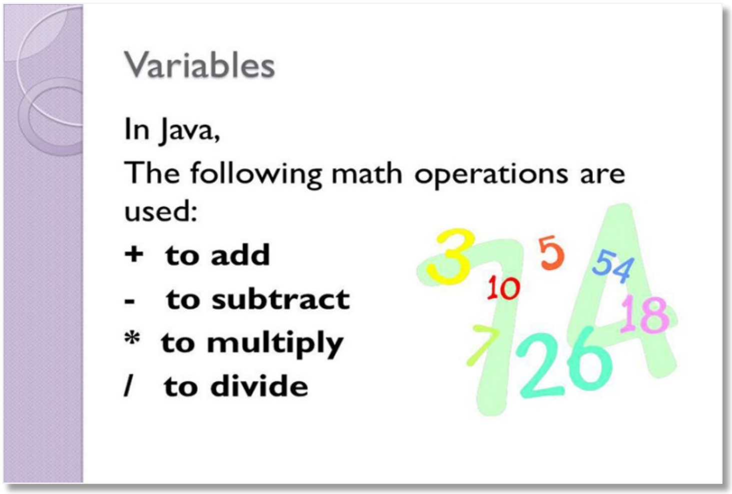


Figure 20. PowerPoint slide image used in the game.

Eclipse was used to create the code components needed for the entire game. Each step of the Eclipse process was screen captured as JPG files to place in the game environment. Code created using Eclipse is illustrated in Figure 21.

```
public class ControlStructures {

    public static void main(String[] args)
    {
        int a = 3 + 2/5 * 35;
        int b = 100;

        if(a >= b)
        {
            System.out.println("A is greater than or equal to B");

        }
        else
        {
            System.out.println("A is NOT greater than or equal to B");
        }


    }

}
```

Figure 21. Example Java code written in Eclipse. Screen captured to use in the game.

Finally, button and other puzzle piece images were created using PowerPoint clipart and Photoshop. Some of the puzzle pieces were created using Photoshop or Illustrator. PNG or JPG were the file types for each image used in the game. Figure 22 shows images of clickable buttons used in *Array[7]*.

Figure 22. Button images used in the game.

Developing the Game Assets for 3D Game

The game assets for the 3D companion virtual world were created using a combination of royalty free items from OpenSim resources and using Photoshop and Illustrator. Free resources such as 3D models of buildings, female avatars, desks, chairs, computers, pencils, and notebook and pencil cases were used in the virtual world to provide the setting. The developer used Open Source Virtual Collaboration Environment or OpenVCE buildings, and found the other 3D models via myopensim.com.

Figure 23 shows the overall layout of *Gamher World*. The world consists of five locations, a welcome center (middle), a resource building, sandbox area, a Java building and the *Array[7]* building. Players can choose avatars and learn how to use the environment at the welcome center. At the resource building, girls can find outside resources to understanding computer science. At the sandbox area, the girls can build and create. In the Java building, girls can view PowerPoint slides on Java code. In the *Array[7]* building girls can read about the game characters and watch the opening cinematic to the 2D game.

Figure 23. Birdseye view of the 3D world—arrow indicates center of world.

Figure 24 shows some of the 3D items used and the level design of one of the rooms in the Java building.

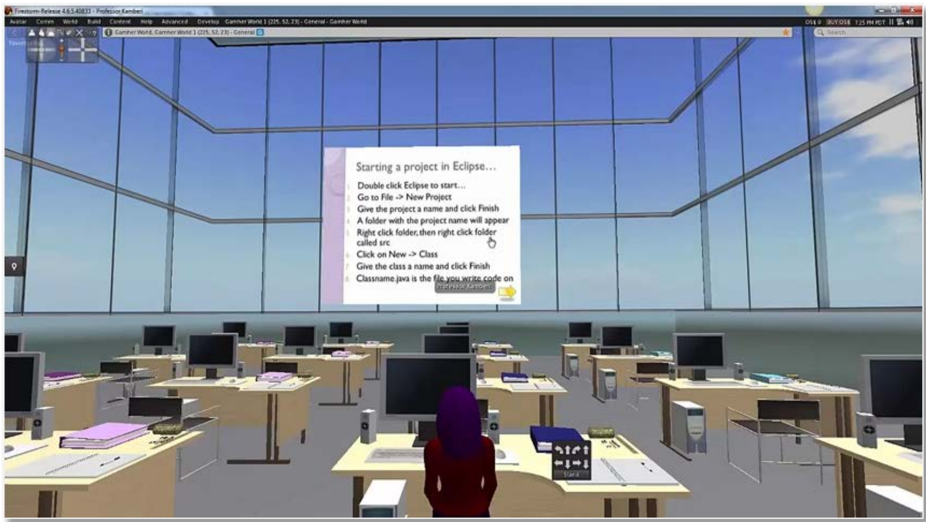


Figure 24. Inside one of the buildings in the 3D world.

Step by step instructions in the virtual world was created using Illustrator. All of the textures in the world were created using Illustrator or Photoshop. Textures included signs to put on the buildings and in-world maps. Figure 25 illustrates an example of a sign on how to change the player avatar.

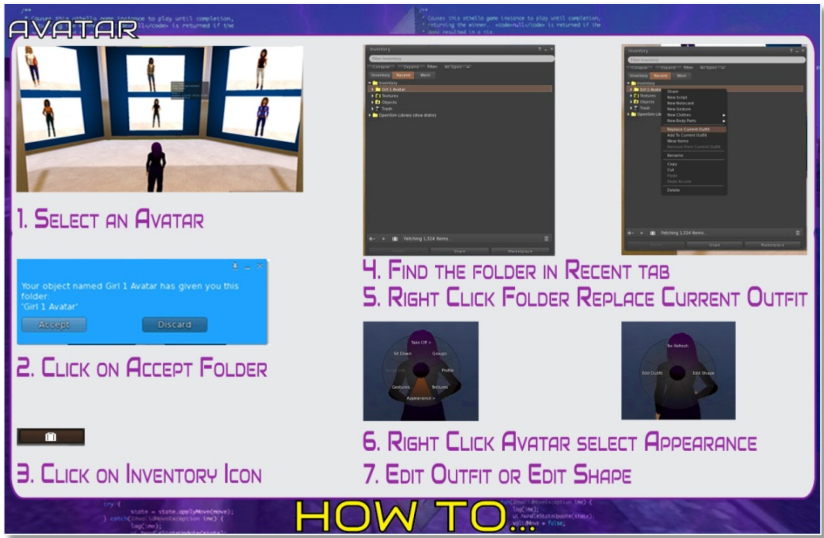


Figure 25. A 'How To' sign created using Photoshop—
Used in the 3D world as a guide for users to select avatars.

Other items such as the PowerPoint presentation boards were created using the OpenSim build tool, using primitive shapes such as the cube to make the displays. The female avatars imported in from free resources were updated and changed within the 3D virtual world using the in-world tools. The avatar shapes and clothing were altered to make them more age appropriate. Virtual world visitors had a total of 6 avatar options, as shown in Figure 26.

Figure 26. The six avatar choices in the 3D world.

Visitors also had the option of altering their avatar by selecting multiple avatars and mixing and matching their outfits, hair and shoes. Visitors could also change the shape of their avatars if they so choose.

Scripting the Games

For the 2D game, scripting involved learning the GameMaker scripting language. After learning the language, a free engine to help with dialog text display was downloaded and used. Lines of code were written to determine button interaction, interface interaction, game progress tracking, timing, puzzle gameplay, and sound. Figure 27 illustrates sample code written to create game dialog.

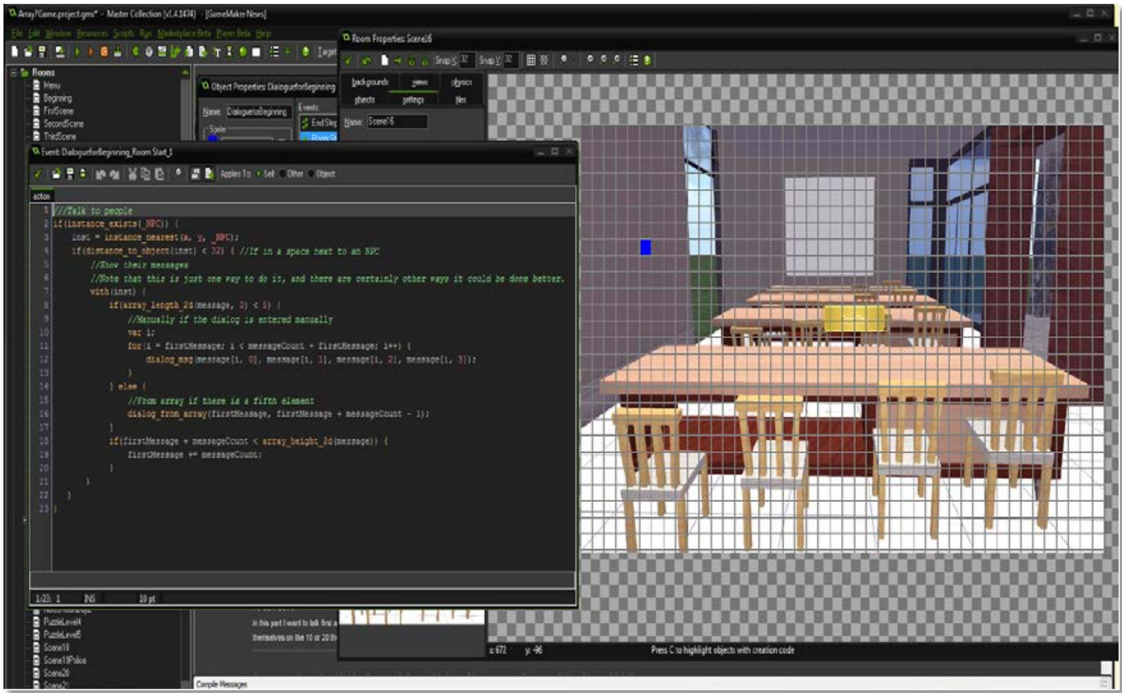


Figure 27. Sample of a script written in developing the 2D game.

For the 3D game, the OpenSim scripting language was used. Scripts were written to help teleport players within particular locations in the virtual world. Code was also written to help move slides on presentation boards. Scripts were written to correct avatar sitting positions, to make resource boards clickable, to create rotation animation and to offer items to visitors. Some of the teleportation script written is shown in Figure 28.

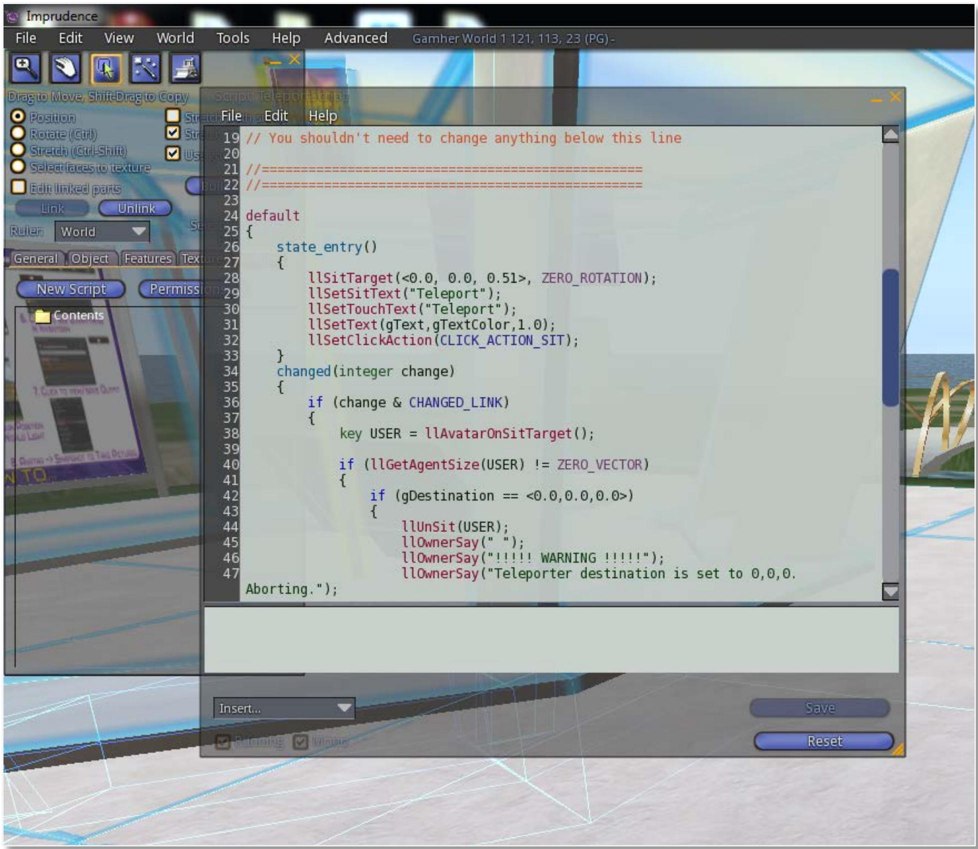


Figure 28. Sample of script used in developing the 3D world.

Game Sound Creation and Development

The sound for the 2D game was created using royalty free music and sound effects. Some of the sound effects, such as the page turning sound effect, were recorded on a laptop using the microphone while turning a page of a notebook. Music that was too long or in the wrong audio format was cut and edited using the free software Audacity; an example workspace is illustrated in Figure 29. The sound and music file types were either .mp3 or .wav files. Once created, the music files got imported into GameMaker. Scripts were written to play the sound effects and the background music during the right moments in the game.

Figure 29. Editing sound in Audacity.

The music used in the 3D world was simplistic. The virtual world provided music through an online streaming music site (initially used in Teen Second Life). Players were offered the streaming music URL link in the virtual world as an option for them to play or stop anytime they choose.

Gameplay

The 2D game prototype was developed and completed first prior to the development of the 3D virtual world. The 2D game prototype did not include a completed storyline; and the game ends with a cliffhanger to the story, telling the user that the story is 'to be continued'.

***Array[7]* Gameplay**

The gameplay of the 2D game is rather simple. Figures 30 and 31 are screen captures of the gameplay as shown in the game walkthrough video uploaded to YouTube (Kamberi, 2014b). When the game starts, the player is given some game instructions, after which the first scene begins. The scene starts with a dialog showing on the screen with an image of the speaker next to the dialog. The player sees everything in first-person view. The dialog from the non-playable characters reveals the storyline. The player chooses between one clickable option and two clickable options on the screen. The player has to click an option to progress through the game.

Figure 30. Gameplay example 1.

Figure 31. Gameplay example 2.

The interface shows that the player has to upkeep their chores, health, social and school statistics levels. This information shows on the upper left corner of their screen. Whenever any one of the levels is low, the user needs to raise the levels by doing homework, eating healthy, talking on the phone with a friend, cleaning their room or doing the dishes. Figure 32 shows what the player sees when they select to do their homework.

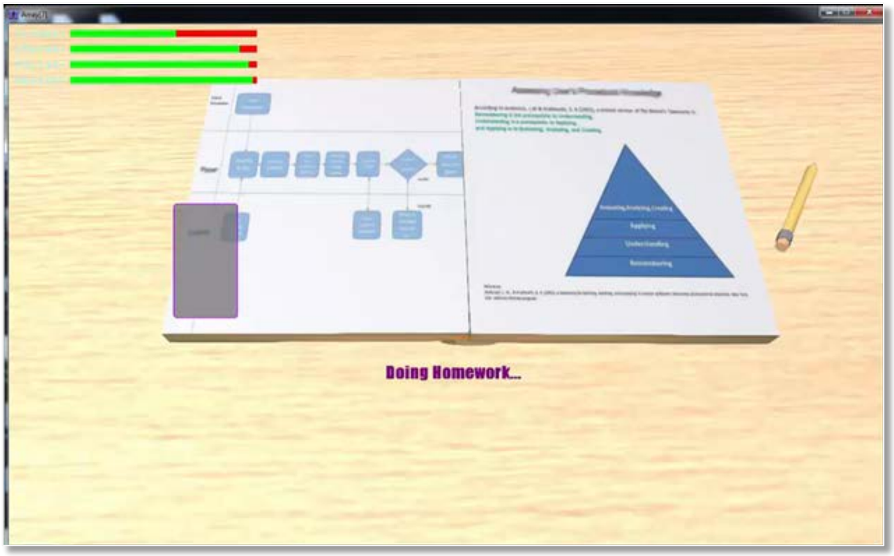


Figure 32. Activities players do to keep their player statistics up.

On the right-hand corner of the screen, the player can see the date and time and the number of days Ryder (the main NPC) has been missing. Following the game progress, the player finds a puzzle that is crucial to the story. The puzzle icon appears on the lower left corner of the screen along with a percentage showcasing how much of the mystery the player has solved. The player starts the lessons after going through some storyline.

There are ten levels in the lessons portion of the game as illustrated in Figure 33.

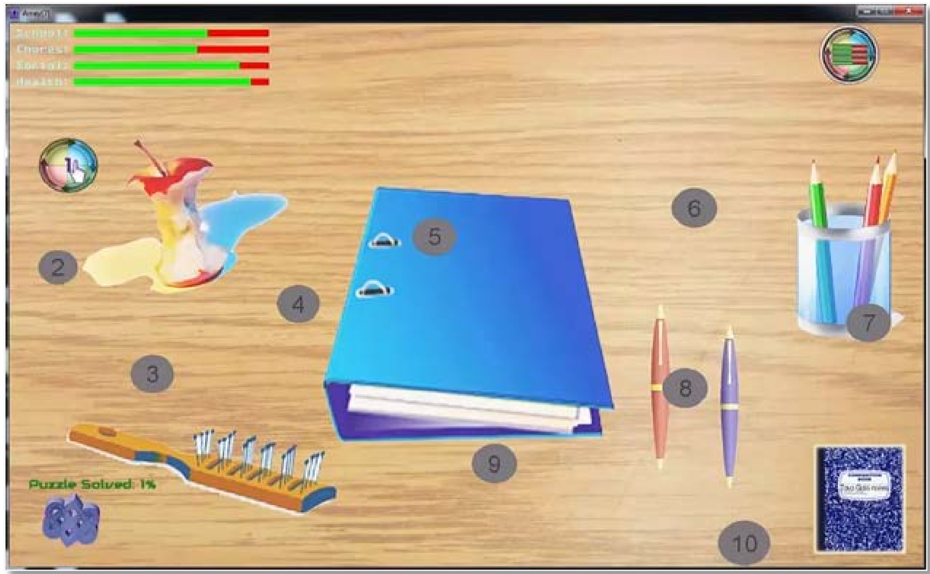


Figure 33. The ten puzzle levels to complete.

Puzzle levels 1 and 2 teach Java syntax on system output; displaying text to the screen. Levels 3, 4 and 5 explain variables and system input. Levels 6 and 7 show the if and if-else statements (selection structure). Levels 8 and 9 illustrate the for loop (repetition structure). Figure 34 shows puzzle level 1 of the game.

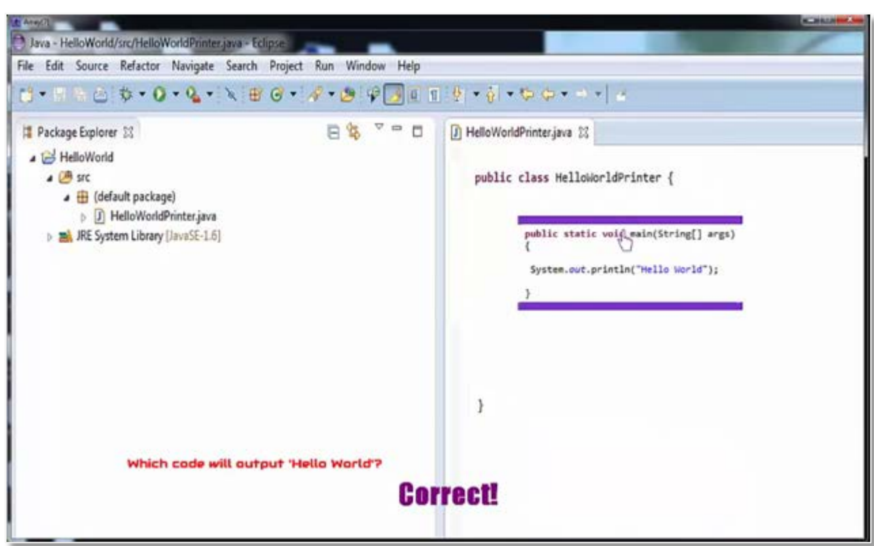


Figure 34. Example puzzle level.

Players cannot leave a puzzle level until they complete the level. Players can repeat the same level as many times as they wish. They can also continue to upkeep their statistics such as health, homework and chores while solving problems. A composition notebook provided the players with all the Java code notes, as illustrated by Figure 35.

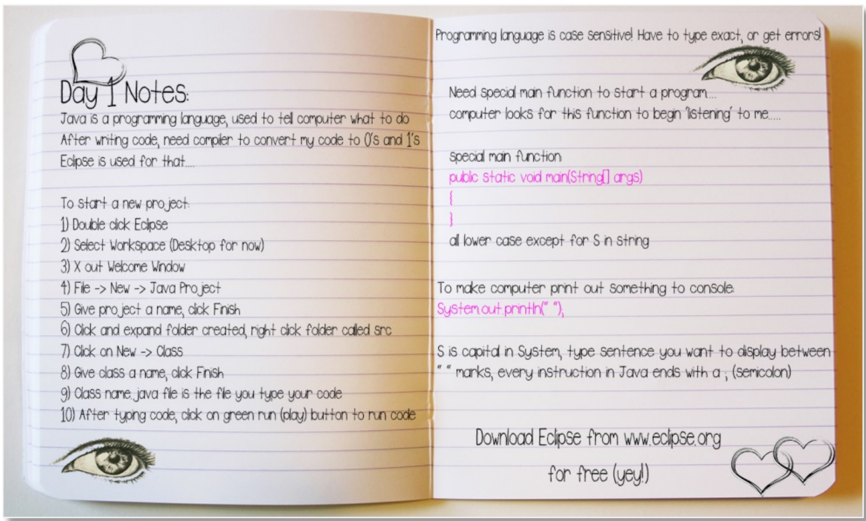


Figure 35. Notes provided to the students in the puzzle level.

The final level in the prototype, level 10, does not contain any gameplay; in fact level 10 is the last scene the player sees before the prototype is complete. This level includes three programming exercises to be solved using the Eclipse IDE itself. The instructions at this level tells the player to, please complete the tasks in Eclipse. After this level, the player is taken back to the main menu, as shown in Figure 36.

Saving in the game is automatic; the player does not have to save at any time in the game. If the player wants to quit, the player can exit out of the game window. When they restart the game, the player has to press the 'Continue' button if they prefer to continue from where they left off. If the player clicks the 'Start' button instead, the game will start from the beginning.

Figure 36. *Array[7]* main menu.

Compared to the 2D game, the 3D virtual world does not have strictly guided gameplay.

***Gamher World* Gameplay**

The 3D world is open for exploration and observation. Figures 37–41 are screen captures of the different locations players can visit in the world; as shown in the game walkthrough YouTube video (Kamberi, 2014c). The virtual world only comprises of five areas: the welcome location, the resource center, the sandbox, the Java building and the *Array[7]* building. When the visitor first signs into *Gamher World*, they start at the welcome location. Here they see avatar choices, a how to board on navigating the world and a map.

Figure 37. The Welcome Center in the 3D world.

The resource center has eight different ‘code for girls’ or free programming teaching tool and curriculum related websites. The building is set up as a museum. Each level contains a large frame with a website homepage image; clicking on the image results in the player being taken to the site.

Figure 38. The Resource Center in the 3D world.

The sandbox area is for building and has instructions on how to build. Players can take advantage of the free build tool available in the world.

Figure 39. The Sandbox Area in the 3D world.

The Java building is set up as a classroom and players can view PowerPoint slides on Java code in this area.

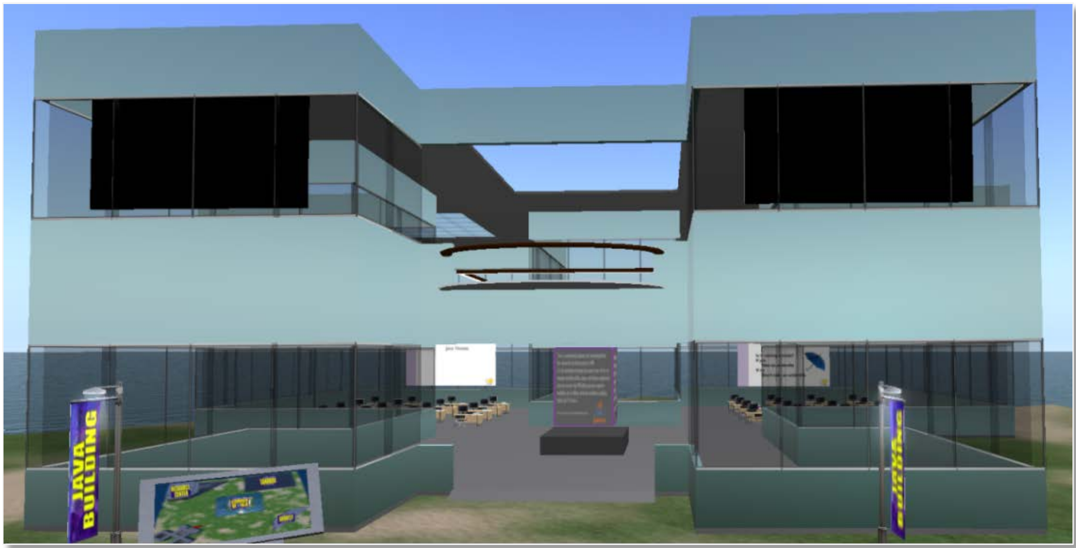


Figure 40. The Java building.

The *Array[7]* building contains posters of images of the 2D game characters. Here the player can read up on some of the main characters' background information. They can also view the opening cinematic video from a YouTube viewing board.

Figure 41. The *Array[7]* building.

There are no rules in this world in terms of obtaining points or finishing goals or levels. In this world, the player is free to visit any of the five locations in any order they prefer. They can also prefer to spend time personalizing their avatar. The players can also communicate with other players currently logged in via instant messaging. They can also fly around the environment.

OpenSim saves the look of the player avatars so that the next time the player signs in; their avatar looks as it did prior to logging out previously. Any item the user created can be saved by picking up the item and putting it in their inventory. Everything in their list such as objects, clothing items, hair, shoes, and so forth are saved and remembered. The user has access to all their items every time they sign in as long as they do not delete the objects.

Exporting the Game

Once the 2D game was complete, it was exported as an executable or .exe file. Figure 42 shows this process. EXE files run on Windows machines. The executable is not multi-platform and works only on the Windows operating system.

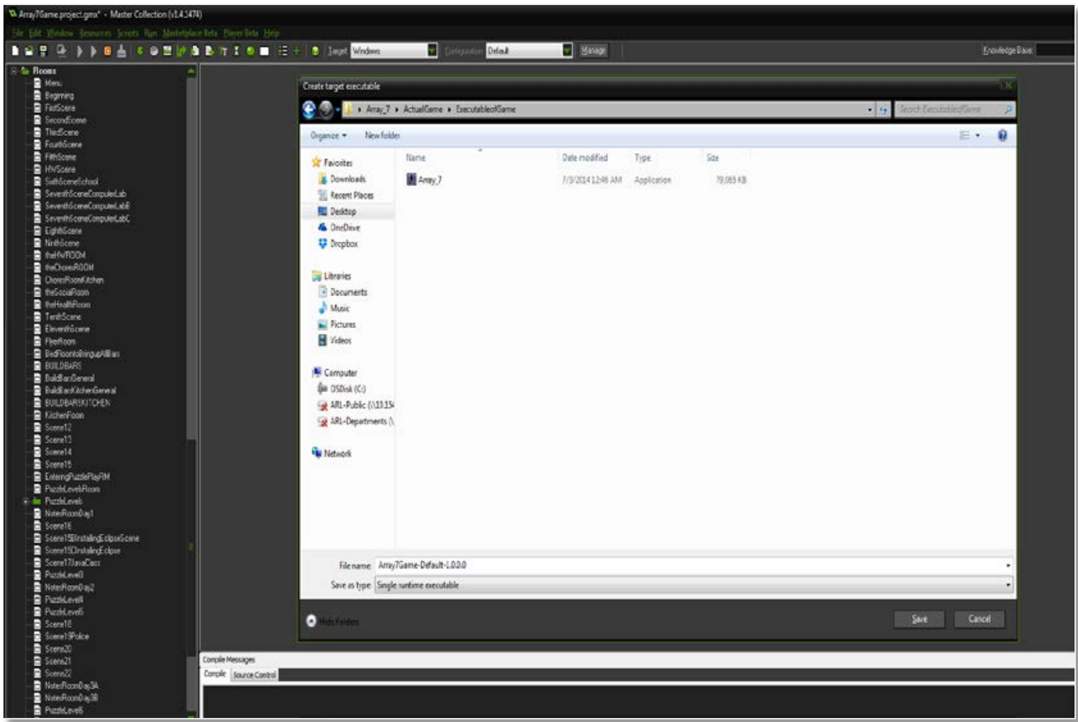


Figure 42. Creating the .exe of the game from GameMaker.

New World Studio, an easy to use OpenSim Launcher, is a start-up that provides quick creation of OpenSim worlds to be accessed by the public via the internet. This software was used to configure the 3D world and to launch it on a server. Figure 43 shows the process.

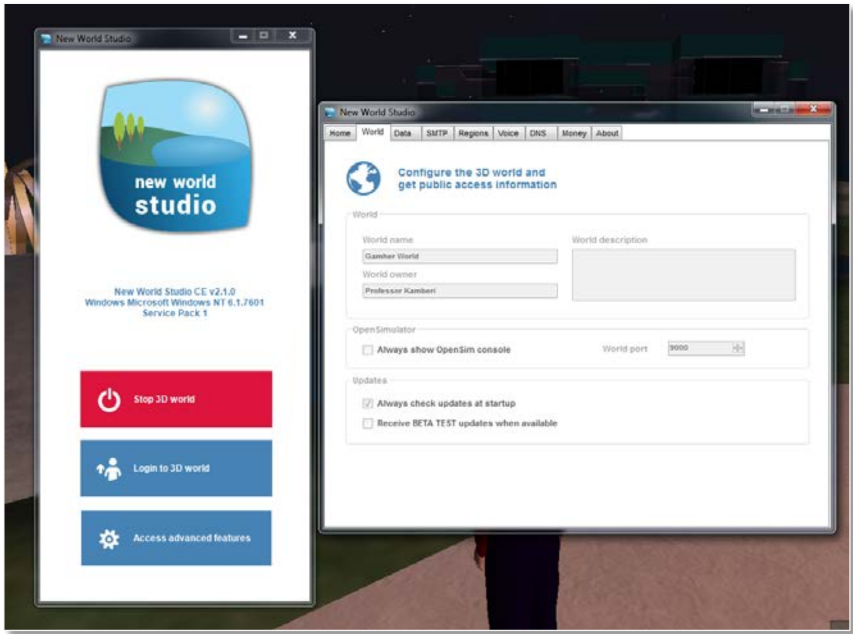


Figure 43. Using New World Studio to launch 3D world.

A website was created using New World Studio where users visit to create a username and password to enter the 3D virtual world. Figure 44 illustrates the one-page site.

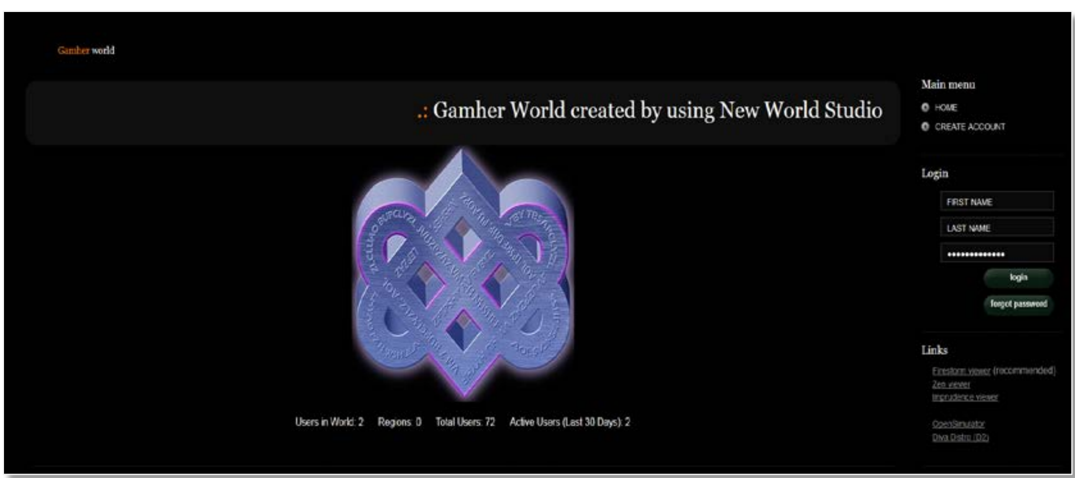


Figure 44. Gamher World website to create user login information.

Firestorm, an existing OpenSim/virtual world viewer, is downloaded and installed to log into the open world. After adding the *Gamher World* grid URL to the Firestorm viewer, the username and password created is used to sign in on any computer with internet access. The virtual region is an oar file, which is an OpenSim world compressed file. The connectivity was tested by signing into the virtual world using multiple computers from multiple locations. Virtual world accessibility was examined at the lab site to make sure it worked during the data collection stage.

Game Development Challenges

Challenges in Developing *Array[7]*

Challenges encountered during the development of the 2D game were scripting issues and hardware issues. Scripting issues include having syntax and logic errors in the code and debugging that code. Scripting the flow of the game was a challenge as there are multiple scenes within the game. It was difficult to make sure one scene correctly transitioned to another scene. Some errors include having finished one level, an incorrect level starting as a result. Hours of debugging and flowcharting the different scenes corrected the in-game errors.

Other problems that occurred in scripting were with variables. Local variables declared were later realized as needed as global variables, which resulted in rewriting of some code. Scripting and game assets also posed issues. Deciding to change one image representing a button to another better image resulted in having to update the script. Input was also an issue. The script for obtaining user input and recognizing the information was faulty in GameMaker. A whole new engine was required to create a customized interface for user input. Due to time constraints, an inefficient script for user input was used; therefore, input management is still buggy within the game prototype.

Hardware issues regarding development include not having the right laptop to complete the development of the game. Once the number of game assets increased and started becoming a larger entity, the hardware, an older HP laptop, could not handle the compiling of the game. Compiling the game became extremely long and often resulted in error messages towards the end of the game development phase. A new HP laptop was purchased to fix this problem. The new laptop helped in rapid development and completion of the game.

Challenges in Developing *Gamher World*

Challenges encountered during the development of the 3D game were mainly in asset creation and networking. The first challenge was in creating the player avatars. License free 3D models of female avatars were used. However, the available avatars were not all successfully imported into the world. Due to the lack of avatars, only two avatars were used in the game. The number of avatars was expanded by creating different outfits and different body shapes using the two avatars as a base. When completed, there were six avatars to choose from in the world.

Another challenge encountered was during the development of the resource building. There were eight cube shapes set up as media prims or primitives. Each prim's media, referred to as Media on a Prim or MOAP, included a helpful website on coding. However, while being tested, it was found that the websites will not load properly and sometimes will not show anything. So, instead of using MOAP, the game used scripted objects that loaded a website with instructions when touched. Once complete, a script was put into each prim where clicking on the prim would take the user to that web page via their browser. An example of a clickable resource site is shown in Figure 45. Changing the items in the resource building to work this way was the trick that solved the problem with media not loading.

Figure 45. A clickable primitive that takes users to a helpful website.

The main challenge involved in developing the Java building was setting up the classrooms. A desk with a computer, notebooks and pencils on top and a desk chair was created first, and then copied and pasted many times to create a classroom environment. The main challenge here was setting up the sit directions on the chairs. The researcher completed the level design of four classrooms before realizing there was a problem. If a user right-clicked a chair and selected to sit, their avatar would sit in a wrong orientation to the chair. A sitting orientation script fixed the direction problem. Figure 46, *A Sitting Avatar*, shows an avatar sitting in a chair after the sitting orientation code was applied.

Figure 46. A sitting avatar.

The *Array[7]* building is a smaller building. The main challenge in developing the *Array[7]* building was computer speed. The creation of the *Array[7]* building required the use of large sized textures. The size of the textures made loading them in-world much longer than expected. However, once the textures were loaded, developing the *Array[7]* building was pretty straightforward.

The development of the two games took from March 2014 to the end of June 2014. Three months were needed to complete the game assets, to make the games and to alpha test the games. During these three months, the other challenge of development was setting up the beta testing (implementation and evaluation stage).

Testing the Games

Testing the games and collecting data required the setting up of free Java programming workshops for the targeted age group. Originally collaboration was made with a local non-profit organization to help promote and hold the workshops. After six months of working with the non-profit organization, a change in their board of directors led to the organization canceling the events. The cancelation posed as the greatest challenge of this dissertation research, as six months of preparations were halted.

Eventually, a location was found at DeVry University Arlington, Virginia campus to hold the workshops. The workshops took place from August 4 to 8, 2014. A free registration site was set up using Eventbrite.com to promote the event. Part of the web page is shown in Figure 47.

Figure 47. Workshop registration website on Eventbrite.com.

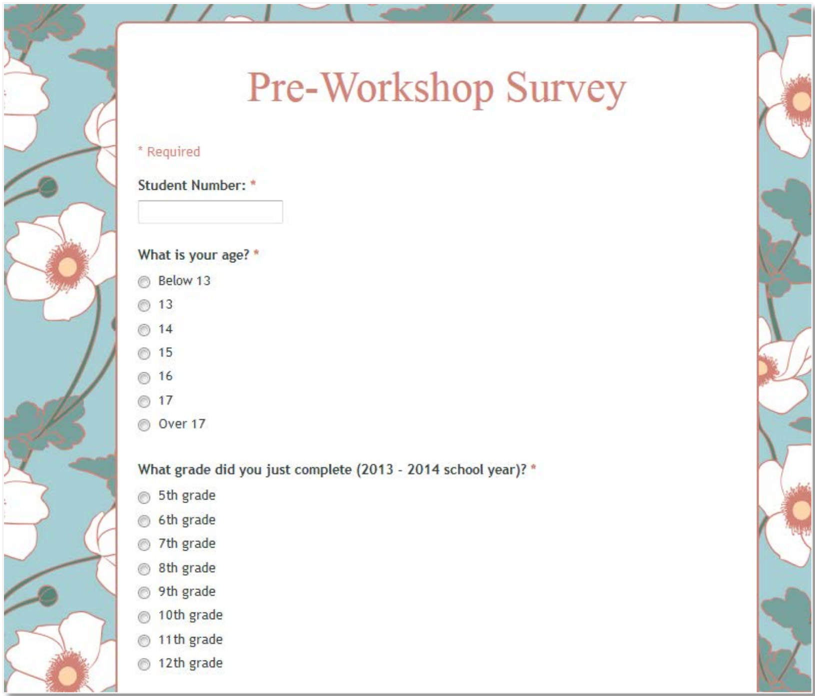
Once the registration site was up, the link to the site was distributed using social media sites and help from several non-profit organizations and individuals. George Mason University's Mason Game and Technology Academy helped send out an email to thousands of their email contacts promoting the free workshops.

Workshop Preparations

In time for the workshops, each of the computers in the room was prepared prior to the class dates; Figure 48 is a picture of where the instructions took place. Firestorm viewer was installed on each of the 22 computers in the classroom for use to log into the 3D world. After installing Firestorm viewer, the grid URL of *Gamher World* was added to the viewer on each computer. The 2D game was also set up on each of the 22 machines along with Eclipse. Prior to holding the workshops, each computer was signed into and checked to make sure the 2D game started, the 3D world loaded, and Eclipse worked.

Figure 48. The workshop classroom.

To collect the data, Google Forms was used. Separate pre-survey, post-survey, pre-quiz and post quiz forms were made for the control group and the focus group, making it a total of eight Google Forms created. Figure 49 shows a part of the pre-workshop survey created using Google Forms.


Pre-Workshop Survey

* Required

Student Number: *

What is your age? *

- Below 13
- 13
- 14
- 15
- 16
- 17
- Over 17

What grade did you just complete (2013 - 2014 school year)? *

- 5th grade
- 6th grade
- 7th grade
- 8th grade
- 9th grade
- 10th grade
- 11th grade
- 12th grade

Figure 49. Pre-survey created using Google Forms.

For easy access to the Google Forms, a free website was developed using Wix.com with the URL gamherworld.wix.com/research. The site contained links to the pre-survey, post-survey, pre-quiz and post quiz for both groups. Figure 50 shows the homepage of the research site.

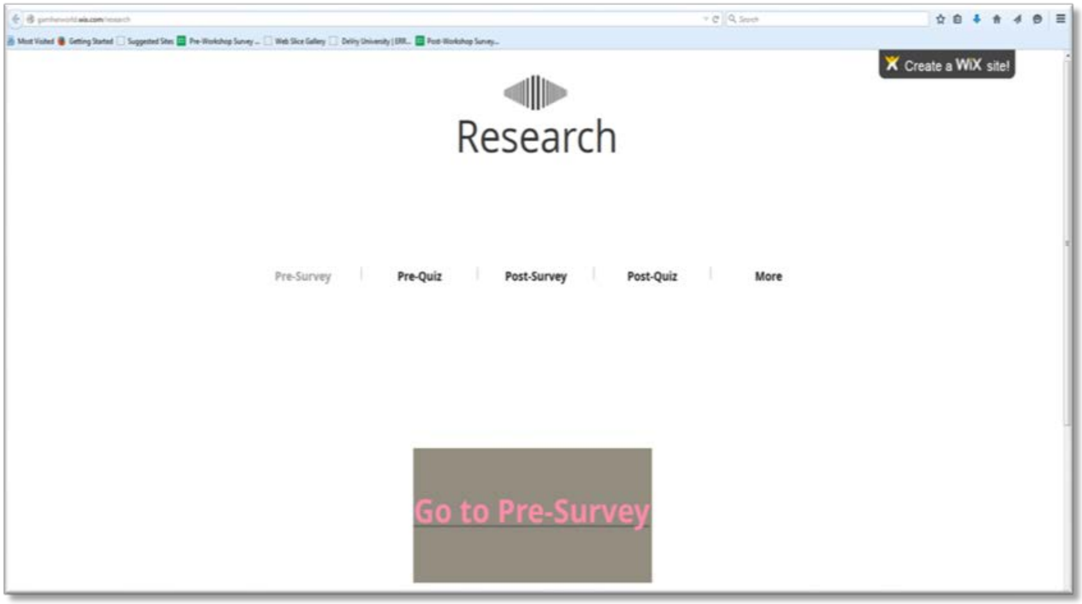


Figure 50. The website used to connect participants to surveys/quizzes.

The viewing of the forms was carefully monitored to make sure students did not fill in the incorrect survey or exam. For example, when holding a workshop involving the focus group, all of the survey and quiz links for the control group was denied access. With the researcher managing the website links, it was impossible for the students to fill in the wrong survey or quiz during data collection.

Each class started and ended during the same time of day to keep consistency. Participants were dropped off and picked up from the same spot. Each workshop day started with students and their parent signing in and receiving a badge. Each student received a name tag with a random number on it. The random numbers assigned to participants helped as identifying markers to match post-quiz/post-survey responses to pre-quiz/pre-survey responses.

At 10:00 AM, participants completed the pre-survey/pre-quiz. After survey and quiz completion, there was a short presentation of computer science, Eclipse, and Java programming.

After introductions, depending on the group, the participants were either told to play the game or took part in a lecture.

Regardless of which group, at exactly 12:00 PM they were told to pause and have a 30-minute lunch break. At around 1:20 PM, students were asked to stop what they were doing to fill out the post-survey and post-quiz. At 2:00 PM the researcher escorted the students to the drop off location for pick up by their parents. As a parting gift, each student was gifted the 2D game in a CD format along with a certificate of achievement; as shown in Figure 51.

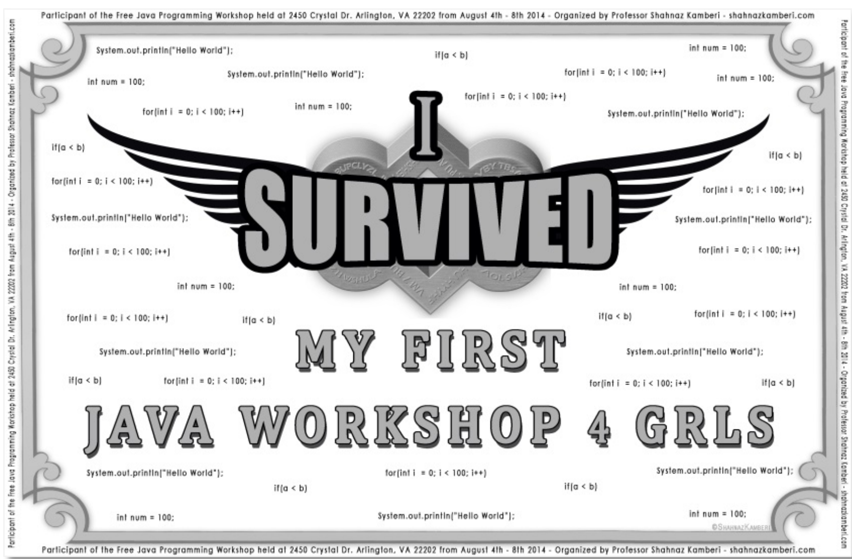


Figure 51. Certificate given to each participant.

Workshop Challenges

The main problem of organizing the workshops was that it was all done by the researcher. The lack of chaperones was a significant issue. Luckily some parents decided to stay as chaperones, and that helped.

Other challenges include receiving and sending off the students at the beginning and end of the workshop. Making sure everyone was signed in and safely picked up took much time and effort. The lunch breaks did present a challenge; the thirty minutes taken for the break interfered with the workshop duration. Instead of holding a four-hour workshop applying the entire time to teaching Java, about 30 minutes were taken up for lunch. The completion of the pre-quiz, pre-survey, post quiz, post-survey took up another hour. The breaks and time used for survey completion left only two and a half hours for actual teaching. Not all of the registered participants attended the workshops, which resulted in uneven number of participants in the control group versus the focus group.

Summary of Chapter Four

The game development process for the 2D and the 3D game was both challenging and fun. Developing the game assets and scripting the gameplay took three months. The tools used for game development include Adobe Photoshop®, Illustrator®, Microsoft Paint®, Camtasia Studio™, Audacity®, Second Life®, GameMaker®, Firestorm Viewer, OpenSim, and New World Studio. Developing the final prototypes led to many challenges and lessons learned. The testing process and data collection process was also both challenging and fun. Eventbrite.com, Google Forms, and Wix.com were some of the tools used to organize the testing stage. In August 2014, five workshops were held to test the games and collect data. The next chapter will discuss these research results; reporting in detail participant demographics, presentation of the data and research findings.

CHAPTER FIVE

A sequential exploratory research design was carried out as part of the data collection process of this research. The data collection was quantitative primary and qualitative secondary. The study involved two separate groups, a focus group, and a control group. The control group was taught Java programming via lecture and in-class exercises by a computer science professor (this researcher) while the focus group was taught Java via the 2D and 3D game developed. A pre-survey, pre-quiz, post-survey and post quiz was collected from every participant and analyzed to explore the research questions presented in Chapter 3.

Participant Demographics

A total of 78 girls participated in the workshops, with 49 girls in the focus group and 29 girls in the control group. The workshops took place in Arlington, Virginia; the participants were from all areas that were within driving distance of the research location in the Northern Virginia and Washington DC area. As discussed in Chapter 4, participants were recruited through an Eventbrite website with non-profits and other organizations' help in spreading the news about the event.

The target audience for this research was 13- to 17-year-old girls. The actual participants of the study fit the target well. As illustrated in Table 3, of the 49 girls who participated in the focus group, there were two participants below 13 years of age (4%). There were thirteen 13-year-olds (26%), ten 14-year-olds (20%), twelve 15-year-olds (24%), five 16-year-olds (10%), and seven 17-year-olds (14%). The participants represented every age within the target age group.

Table 3. *Focus Group - Participant Age Demographics*

Age (in years)	Number of participants
Below 13	2
13	13
14	10
15	12
16	5
17	7
Total	49

As illustrated in Table 4, of the 29 girls who participated in the control group, there were no participants below 13 years of age and no 17-year-olds. There were nine 13-year-olds (31%), eight 14-year-olds (27%), five 15-year-olds (17%), and seven 16-year-olds (24%). The target demographic represented all ages except for age 17.

Table 4. *Age Demographics of Control Group*

Age	Number of Participants
Below 13	0
13	9
14	8
15	5
16	7
17	0
Total	29

Both groups answered gaming background questions. The objective of the questions was to establish the gaming activity of the sample population. As illustrated in Figure 52, of the 78 girls who participated: 44 (56%) stated they played 0–2 hours a week, 19 (24%) reported 5–10 hours a week and 15 (19%) said they played over 10 hours a week.

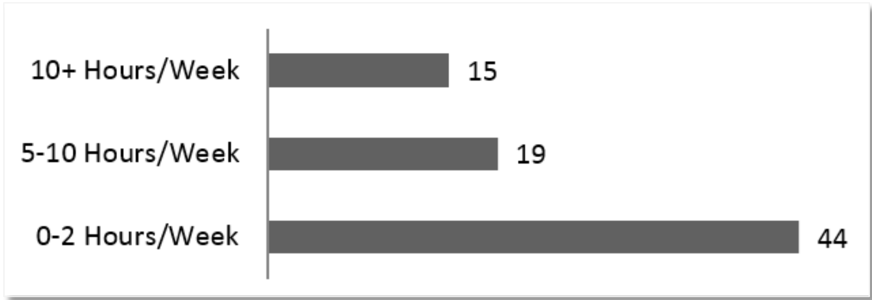


Figure 52. Participants answer to the question "How often do you play games?"

As illustrated in Figure 53, 9 (11%) rated themselves as advanced players, 28 (36%) as somewhat advanced, 23 (29%) as intermediate, 13 (17%) as a beginner, with 5 (6%) rating as not applicable; indicating that they do not play games. Although 44 (56%) girls responded as having played 0-2 hours a week, only 18 (23%) rated their talent level as not applicable or beginner. Thus, about 26 girls or 59% of the girls who play 0-2 hours a week believed their game playing skill level to be intermediate or above.

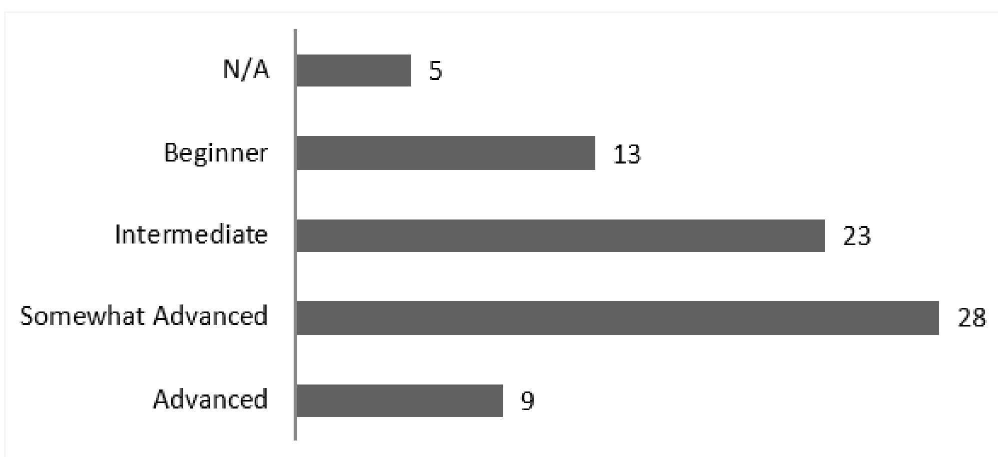


Figure 53. Participants answer to the question
"How would you rate your game playing talent level?"

As illustrated in Figure 54, 65 (83%) girls stated that they played games at home, whereas two (2.6%) said they played at school. Eleven girls (14%) selected 'other', citing places like 'everywhere' since they played on their mobile device or played at their friends' house.

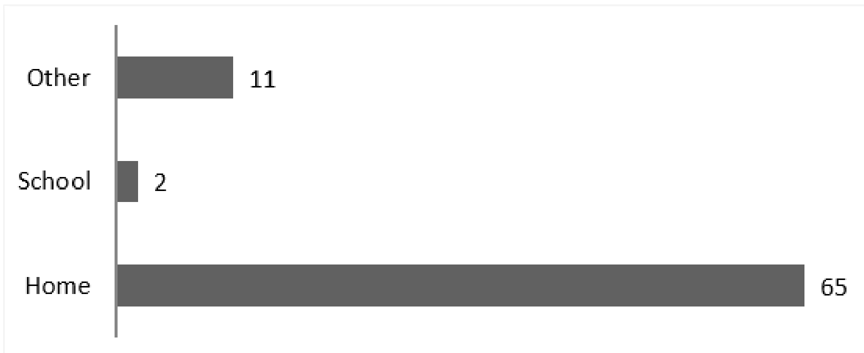


Figure 54. Participants answer to the question "Where do you play video games the most?"

As illustrated in Figure 55, in response to the question "Why do you play?" 61 (78%) reported that they played games for fun, 3 (3.8%) for competition, 1 (1.3%) for education, and 3 (3.8%) to escape. Ten (13%) listed "other" as their response, indicating either that they did not play or that they played for many different reasons.

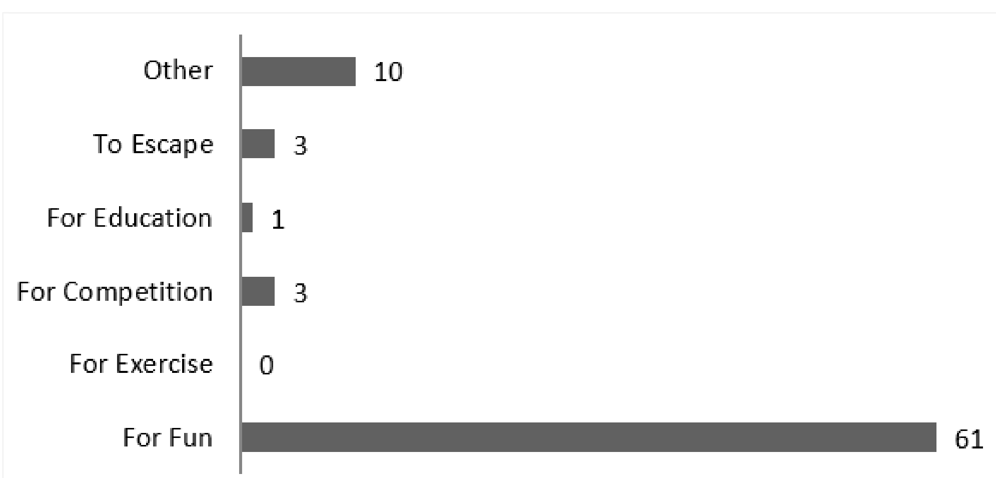


Figure 55. Participants answer to the question "Why do you play?"

When all the girls were asked to list the games they have played, a total of 72 computer/online/console/mobile game titles were named by participants. Five or more girls mentioned each of the following game titles or genre: Super Mario Brothers (7), Mario Kart (7), Minecraft (9), Kim Kardashian (7), Call of Duty (8), Pokémon (6), never played before (6), 2048 (7), Just Dance/Exercise Xbox games (5), Simulation or Role Playing Games (9), and White Tiles (5) (see Table 5).

Table 5. *Game Titles Mentioned By Five or More Participants as Games They Like to Play*

Game Title	Number of times repeated
Super Mario Brothers	7
Mario Kart	7
Minecraft	9
Kim Kardashian	7
Call of Duty	8
Pokémon	6
Never Played Before	6
2048	7
Just Dance/Exercise Xbox Games	5
Simulation/Role Playing Games	9
White Tiles	5

Presentation of the Data

Quantitative: Exploring Research Question 1

The first research question is "how does the participant's pre-quiz score compare to her post-quiz score?"

A dependent *t* test was conducted on the 29 girls in the non-game group (n = 29), comparing their pre-quiz score to their post-quiz score. As shown in Figure 56, the average pre-quiz score was 18 points out of 100 possible points while the average post-quiz score was 66.

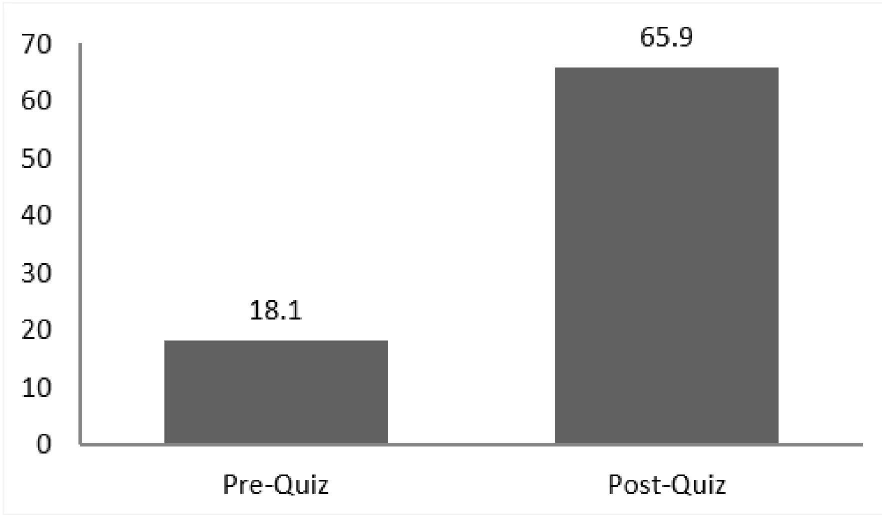


Figure 56. Non-game group's pre- and post-quiz average.

The dependent *t* test presented a significance of, $p = .004$ with $p < .05$, indicating that there was a significant difference between the non-game group's pre-quiz and post quiz. However the standard deviation was high due to the small number of participants; with a standard deviation of +- 27 for pre-quiz scores and +- 33 for post quiz scores.

In the game group, only 46 out of the 49 girls took the pre/post examination. Therefore, 46 (n = 46) scores were analyzed using the dependent *t* test. As shown in Figure 57, the average pre-quiz score of all the girls in the focus group was 21/100 points while the average post quiz score was 55.

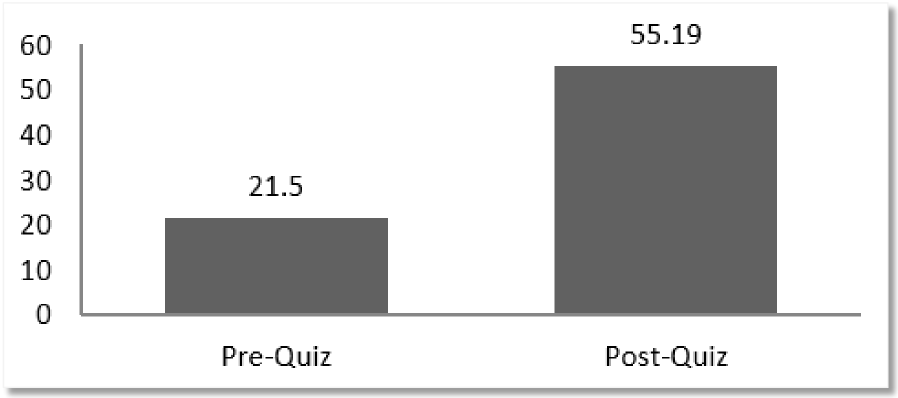


Figure 57. Game group's pre- and post-quiz average.

The dependent *t* test presented a significance of, p = .000 with p < .05, indicating that there was a significant difference between the focus group's pre-quiz and post quiz. The standard deviation was high within this group as well, with a standard deviation of +- 29 for the pre scores and a +- 35 for the post.

Quantitative: Exploring Research Question 2

The second research question is "how does the focus group's post-quiz score compare to that of the control group?"

The post quiz average of the game group versus the post quiz average of the non-game group was analyzed using an analysis of covariance (ANCOVA) test. The covariates were the pre-quiz average of both groups. Due to the unequal number of participants in each group, 29 quiz scores were randomly selected from the 46 total scores of the focus group (n = 29). Shown in Figure 58, *Game Group versus Non-Game Group Post-Quiz Average*, the average post quiz score for the control group was 66/100, while the average post-quiz score for the focus group was 53/100.

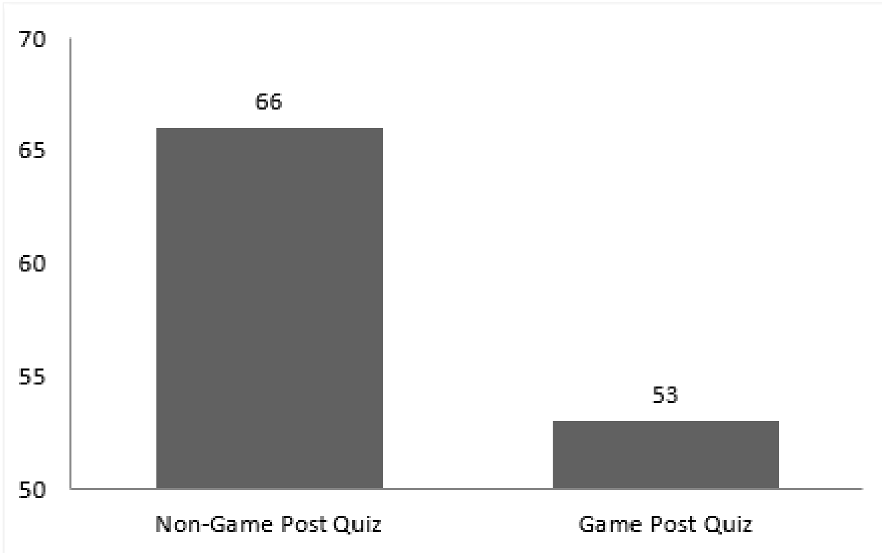


Figure 58. Game group versus non-game group post-quiz average.

The significance value, p = .147 with p > .05, shows that there were no significant differences between the non-game group's post-workshop scores and the game group's post-workshop scores. As for the covariate, with p = .000 and p < .05, there was a significant correlation between pre-quiz score versus post quiz score. The significance means, if the pre-quiz score for an individual were high then their post scores was also high.

Quantitative: Exploring Research Question 3

The third research question is "how does the focus group's post survey response compare to the control group?"

An ANCOVA test helped analyze the post-survey average of the game group versus non-game group; using the pre-survey average of both groups as a covariate. From the 14 questions asked regarding views on computer science, the percentage of girls who responded positively to each question was compared (n = 14). As shown in Figure 59, on average, after the workshop, 68% of the girls in the non-game group and 75% of the girls in the game group responded positively to computer science.

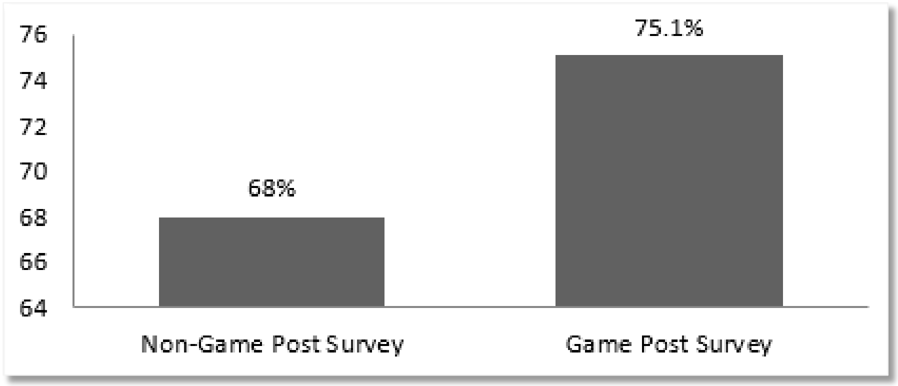


Figure 59. Game group versus non-game group post-survey response.

The significance value of the two groups, $p = .347$ with $p > .05$, shows that there were no significant differences between the two groups. As for the covariate, with $p = .000$ and $p < .05$, there was a significant correlation between pre-survey response and post-survey response. The relationship suggests that if the participant's pre-survey response was positive then their post-survey response was also positive. Table 6 shows the percentage population response to each of the 14 survey questions presented.

Table 6. *Percentage of the Population Who Strongly Agreed in Both Groups Pre- and Post-Workshop*

Question	Game group (%)		Non-game group (%)	
	Pre-workshop	Post-workshop	Pre-workshop	Post-workshop
I plan to take Computer Science classes in school	31	41	10	14
If there were more room in my schedule, I would like to take computer science classes in school	35	41	31	38
I will use computer science in other school classes	24	26	14	21
I understand what computer science is	18	47	10	34
I am looking forward to taking computer science	39	41	31	34
I enjoy programming in a computer science language	10	45	7	41
I plan on taking a computer science course in the future	28	45	31	31
I plan on studying computer science in college	14	22	10	17
I will take computer science classes while in college	22	33	14	21
I am considering a career in computer science	14	28	14	10[a]
I know that I will most likely use computer science in my career	24	35	17	24
I am a good computer science student	4	22	3	14
I enjoy working with computers	35	53	34	38
I am good at using computers	20	31	24	27

[a] The non-game group showed a decrease in agreement post-workshop for only one question.

Qualitative: Feedback on *Array [7]*

The qualitative portion of the research was gathering information from the participants on what parts of the game obtained their interest, what can be done to improve the game and getting any other suggestions to better the game.

The girls answered several questions to determine their feedback on the game developed. As illustrated in Table 7, when asked about their favorite part of *Array[7]*, 65% of girls stated that the game was fun, 63% of girls liked the story/mystery, 63% of girls liked the educational content, and 49% of girls liked the challenges in the game.

Table 7. *"What Was the Best Part of Array[7]?"*

Best part of *Array[7]*	% of girls
It was Fun	65
Story/Mystery	63
Educational Content	63
Challenges	49

Table 7 presents four areas thought as the best features in the game, and Table 8 reports the three areas that the players thought were the worst features in the game. When asked regarding the worst features, 37% of the girls did not like the sound used, 29% of the girls believed the story/mystery need improvement and 20% felt the characters needed refining. The rest sporadically answered with anything from colors to scoring and the interface—there was no majority (nothing over 50%) response to one single component as being the worst part.

Table 8. *"What Was the Worst Part of Array[7]?"*

Worst part of Array[7]	% of Girls
Sound	37
Story/Mystery	29
Characters	20

Other questions asked of the 49 participants revealed how influential the game was in teaching Java programming and what the participants' preferences were. Table 9, *Feedback regarding re-playability and influence of Array[7]*, illustrate these findings.

Table 9. *Feedback Regarding Re-Playability and Influence of Array[7]*

Question	Yes (%)	No (%)
"Would you play this game Array[7] again?"	84	16
"Would you recommend this game, Array[7], to anyone?"	80	20
"Was this game, Array[7], valuable in teaching you Java Programming?"	98	2
"Would you play more games like Array[7]?"	82	18
"Array[7] influenced my opinion of Computer Science for the better."	88	12
"I think Array[7] explained Java programming concepts in a fun way."	94	6
"Array[7] was an influencing factor in my understanding of Java Programming in this workshop."	94	6
"If I play more games like Array[7], I might consider studying computer science."	73	27
"Array[7] influenced my knowledge of the Java programming language."	98	2
"I think more 'made for girls' games like Array[7] is needed."	67	33

To the question “What would you change about the game *Array[7]*?” Because this was an open-ended question, numerous responses were given. After careful analysis of all 49 responses, it was identified that the main suggestions were mostly in the areas of character, plot, gameplay, game graphics, game interface, and sound. Table 10, *Feedback on changes to the game*, shows the results. There was also a handful of girls who indicated that nothing should be changed.

Table 10. *Feedback on Changes to the Game*

Game Component	Feedback
Character	More customizable, animated
Plot	Less romance, less corny/childish, less ‘made for girls’, less ‘chasing after boys.’
Gameplay	More interactivity, clearer instructions, smoother transitions
Game graphics	Better quality graphics
Game interface	Better navigation capability between ‘teaching’ and ‘puzzle’ portion of game
Sound	Better background music, sound effects and include spoken dialog

The last question asked of the girls was “what recommendations do you have to make *Array[7]* a better game?”—Another open-ended question. As seen in Table 11, the main recommendations identified were based on gameplay, game graphics, game characters, game plot/story, game interface and game sounds. 8% of the participants suggested that nothing is needed to make the game better as the game was good as it was, these girls recommended to make a full game out of the current prototype.

Table 11. *Recommendations for the Game*

Game Component	Feedback
Character	Better character development, character customization, more character animation, and control.
Plot	Less romance, better mystery and background story, the possibility of several story paths.
Gameplay	A longer game that teaches more about Java programming, more advanced gameplay and less romance, more levels, explorer mode, more socializing and more options in gameplay.
Game graphics	A 3D look rather than the 2D and having more depth within the imagery. Better quality graphics.
Game interface	Better navigation, less confusion with instructions, better personalization, being able to go back as well as forward within the levels, being able to exit out of levels accidently clicked into and easier more intuitive interface.
Sound	Better quality music and sound as well as spoken dialog.

Overall, the qualitative feedback from both groups on the workshop was positive. *For direct quotes from workshop participants, see Appendix I.*

Presentation and Discussion of Findings

The statistical calculations show that independently, both groups had significant differences between their pre-quiz and post quiz scores. There was an increase in exam grades regardless of the mode of course delivery. When comparing the two groups to each other, the results show no significant differences. The post-quiz score of the game group was not significantly higher or lower than the post quiz score of the non-game group. The post-quiz average of the control group was 66% while the post quiz average of the focus group was 55%. It is important to note that not everyone in the focus group was able to complete the full game within the four-hour time frame. This inability led to participants taking the post quiz prior to content completion. The post-survey response of the game group was not significantly higher than the post-survey response of the non-game group. The post-survey results show that 75% of the focus group and 68% of the control group showed positive views towards computer science.

Based on the feedback received, the qualitative data indicate that both groups had a positive response to the workshops. There weren't huge technical/workshop delivery issues presented by the students as needing improvement. The overall feedback was that of satisfaction with the course even if it was only for a short four hours. Response to feedback and suggestions to *Array[7]* and *Gamher World* was tremendous. The suggestions and feedback received were in these major categories: gameplay, game graphics, game characters, game plot/story, game interface and game sound. As a result of the feedback, a lot of new ideas for upgrades and changes to *Array[7]* and *Gamher World* was conceived for the future.

Summary of Chapter Five

A total of 78 girls participated in this dissertation research. 76 girls were between 13-17 years of age, while two were below 13 years of age. 49 girls participated in the focus group while 29 girls participated in the control group. Both groups were given pre and post quizzes and pre and post surveys to help explore these quantitative research questions: How did the pre-quiz score compare to the post quiz score of the game group? Of the non-game group? How did the post quiz/post-survey score of the focus group correspond to the post quiz/post-survey score of the control group? Moreover, qualitative feedback was collected regarding the game played. Dependent t test calculations showed that independently, both groups had significant post quiz scores versus pre-quiz scores. An ANCOVA analysis showed that the post quiz/post-survey of the non-game group was not significantly different from the post quiz/post-survey of the game group. Qualitatively, feedback was received from the focus group regarding improvements on *Array[7]* in areas of gameplay, game graphics, game characters, game plot/story, game interface, and sound. In the next chapter, the significance of these findings, limitations to the study as well as areas for future research is discussed.

CHAPTER SIX

The primary goal of this research study was to explore whether a gender-specific educational game would be successful in helping teach programming concepts to adolescent girls and change their negative views on computer science. A two-dimensional game and a three-dimensional virtual world space were developed, and a sequential exploratory research was conducted comparing the quiz and survey responses between two groups. *Array[7]* and *Gamher World* was indeed successful in teaching computer science concepts. However, the results show that the mode of delivery of the course, lecture versus game, did not make a significant difference in terms of knowledge attained and view of CS.

Findings and Conclusions

The following conclusions were supported by the quantitative data:

- The 49 girls in the focus group and the 29 girls in the control group learned computer science concepts in this research study. The dependent *t* test results showed significant differences in pre and post quiz grades.
- The post-workshop score of the focus group had no significant difference versus the post score of the control group as realized by an ANCOVA test. Those who did well in their pre-quiz scores did well in their post quiz scores—pre-quiz results were a significant covariate.
- Percentage of participants who responded positively to computer science did not differ based on the research group, as deduced from an ANCOVA test. Those who responded positively in their pre-survey answers responded positively in their post-survey answers—pre-survey was a significant covariate to the results.

The following conclusions were supported by the qualitative data:

- Over 80% of the girls liked the game developed for the research.
- 84% of the girls would play the game again.
- 98% of the girls felt the game was significant in teaching them Java programming.
- 80% of the girls felt the game was something they would recommend to others.
- The main suggestions from the focus group on bettering the game were in the areas of character, plot, gameplay, game graphics, game interface, and sound.

Quantitative Discussion: Research Questions 1–3

1. "How does the participant's pre-quiz score compare to her post-quiz score?"
2. "How does the focus group's post course quiz score compare to that of the control group?"
3. "How does the focus group's post survey response compare to the control group?"

The original research hypothesis (H1) prior to data analysis was: the focus group will score higher and, or respond more positively to the computer science course than the control group. The actual results support the null hypothesis (H0) which was: there is no difference between the response and quiz scores of the focus and the control group. The initial thought was that the game will cause the focus group to grasp the concepts better and have a positive response to computer programming. Unfortunately, the actual data results did not reflect the assumptions.

Although the null hypothesis (H0) was supported, this does not mean the game failed at what it was developed to do. The results support the point that the game was able to teach at the same level as a computer science professor with over seven years of experience. Because the researcher held the lecture class and developed the game, it is a positive thing to see that the game can deliver the same results as the lecturer.

Although not significantly different, the non-game group did slightly better on their post-quiz score than the game group. One of the major factors that influenced those results is that several of the game group participants did not finish covering the material in the game before taking the post quiz.

The game group had a slightly better survey response to computer science because the focus group participants felt that they had more fun and liked the hands-on activities. Figure 60 shows the girls having fun exploring the 3D world.

Figure 60. Participants in the game group during the workshop.

The non-game group had a positive response to the workshop even without the use of educational software. Some reasons for this based on workshop feedback and in-class observations are the enthusiastic and helpful instructor and the all-girl environment, these factors seem to influence the workshop experience positively.

Although there were no significant differences between the groups, there were significant differences when conducting the workshops from the perspective of the instructor. The energy in the room was different with the focus group versus the control group. It took a lot of work to teach the non-game group. As the instructor who was teaching the course for four hours including lecture and hands-on exercises. By the time the workshop was over, the instructor was exhausted. In the non-game group the instructor was controlling the classroom linearly, covering the material and exercises in a single step by step manner. In this environment, if a student needed help with a particular concept—the instructor stopping the class to help an individual student would halt the entire class. The rest of the class waited for the instructor prior to continuing. However, because the instructor controlled the classroom, she was able to cover all of the material within the four-hour period.

In the game group the students were managing the class, this course was controlled non-linearly. Students were asked to play the game, and each student individually progressed through the course material at their pace. In this setting, if a student needed help with a particular part of the game, the instructor stopping to help that student did not affect any other student. While the instructor in the non-game group managed the classroom and taught the material, in the game group, the instructor became the facilitator. As a moderator, the instructor had more time to help students individually and had more freedom to explore each student's progress. However, because the students self-monitored their progress, some students were not able to complete the entire game within the allotted time.

Qualitative Discussion

The qualitative research question "what components of the game obtained the girls' interest and what feedback is given to improving the game?" was refined by asking several sub-questions for a better focus:

1. What components of the game obtained participant interest? Why?
    - Graphics/Colors? Why?
    - Gameplay Elements? Why?
    - Characters used, interface, music, sound, other content? Why?
2. What can be done to improve the game?
    - What are some suggestions for making the game better in terms of fun level and educational level? Are there any other additional suggestions?

The qualitative analysis showed that the components of the game that obtained participant interest were mainly the fun gameplay, the story/mystery involved, the educational content and the challenges. The sound, the plot, and the look of the characters were the least liked features of the game. It is interesting to note that story/mystery was the most liked and the least liked feature of *Array[7]*. One of the main reasons for this is due to the frustration of playing an unfinished story. The game ends with a cliffhanger, which the participants did not like. The girls wanted a finished story and not a 'to be continued', which influenced their response. Other factors for this include wanting better stories, less romance and a story more relatable to CS. Younger girls seem to like the story more. One girl with prior knowledge of CS felt she just needed the lecture slides and not the game.

The girls liked that the game was a fun way to learning Java programming in comparison to a lecture. The word 'fun' was used more by the focus group versus the control group. The girls liked that the game story had mystery, but about 8% of the girls did not like the specifics of a girl saving a boy with a romantic backdrop. 6% of the girls suggested to have a better mystery/story but did not give details as to how to better the story or mystery. Participants liked learning new content within the game platform, and the challenges presented to them in the different levels.

The researcher observed that girls with advanced game playing experience felt the 2D game was too simplistic, while the girls with a lower game playing experience felt the 3D world was harder to navigate. Girls who had prior exposure to computer programming preferred more CS lessons in *Array[7]* while girls with no prior exposure to computer science wanted more gameplay rather than lessons. About 8% of the girls, who were within the 16-17 year age group, felt the game story to be too childish. 33% of the girls had an adverse view of the term 'made for girls.'

Some of the suggested areas of improvements for the game included character, plot, gameplay, game graphics, game interface, and sound. The participants felt that the characters should be more animated rather than 2D static images. There were some usability issues during gameplay that the girls made suggestions for, for example, not being able to exit a level after entering it to explore other areas of the game. The graphics in the game prototype were not high-end graphics. As discussed in Chapter 4, many of the graphics were screen captures borrowed from Second Life. It is not surprising to see that participants felt the graphics needed updating in terms of higher quality and content. Participants also mentioned the game interface such as the text-based dialog, the placement of buttons and the score and goals keeping sections to be updated to make it easier to understand. Finally, participants felt the sound and sound effects used in the game were outdated and did not enhance the gameplay.

The game developed for this research was only a prototype; therefore, the graphics and sounds used were either borrowed graphics or license-free, which did not complement the game well due to not being customized. It is not surprising, therefore, to get the type of feedback that was given by the research participants.

The research results did help identify which game design elements are important to this demographic. Based on feedback analysis, findings listed in Figure 12 were updated. As shown in Figure 61, several major game design elements are needed for gender-specific educational games. A game should incorporate creativity and be fun and engaging. A game should have a meaningful story, good audio, and consistent challenges. The game should be guest-based, with adventure, simulation, and open exploration of virtual worlds/life. The game should manage the player's progress well and should allow personalization and customization. Finally, the game should be replayable. Game design components that were not important to this demographic include having a character of the same age, a dance theme, an easy game, romance/relationships, and violence. Other not so essential components were the existence of discussion forums, real world connections, and a story made just for girls.

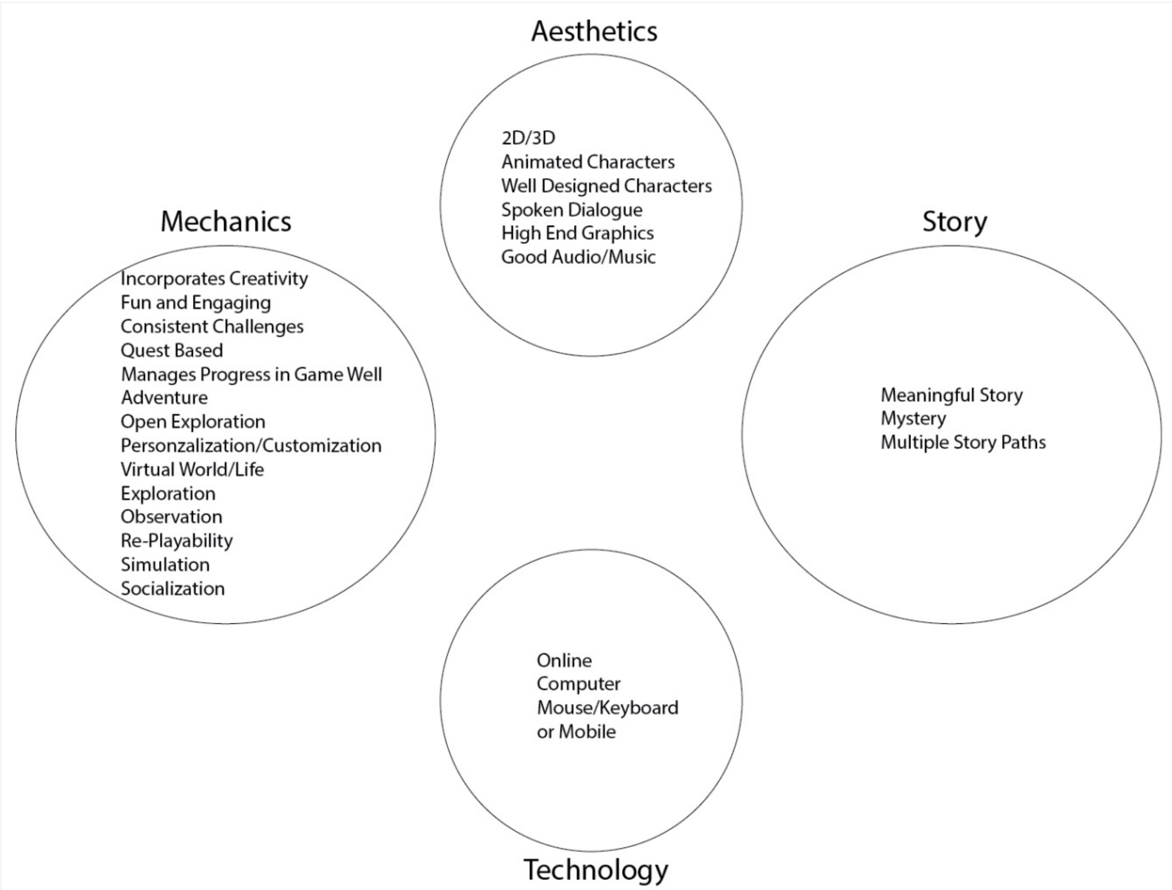


Figure 61. Game design elements most likely to succeed among 13- to 17-year-old girls.

Research conclusions show that exposing girls to computer science does not have to be done via a gender-specific game. There is no particular tool that is the answer to increasing the number of women in the computer science industry. It is the experience of being exposed and engaged in computer science that seems to do the trick. To increase the girls' interest in computer science, it is the entire event that matters. The organization of the event, including engaging activities (games or otherwise) is the important part. The activity done in the classroom does not have to be a gender-specific educational game as long as it is attractive to the 13- to 17-year-old demographic. What is important is the workshop experience itself. The simple act of having a four-hour workshop that exposed the girls to Java programming and showing them that they can do it was enough.

Limitations of the Study

There were limitations to the study within several stages of the framework followed.

As discussed in detail in Chapter 4, the limitations in the design and development phase include the software and game assets used. The resources and tools availability limited the game development. *Array[7]* used borrowed assets. The developer created the game with no real expenses. A higher budget and a bigger development team could have resulted in a much more polished and advanced game to use during the research study.

During the implementation and evaluate stage, the main limitations were the inability to secure a collaboration with a non-profit; and the organization of the entire event being done by one person. Other limitations include, not having enough support in conducting, holding, and marketing the workshops; not having sufficient resources to conduct a class for longer than four hours. Some technical issues also hindered the study in terms of slow internet and hardware crashes during instruction.

An additional limiting factor is the self-selection bias, as many of the workshop attendees already had an interest in computer programming because they signed themselves up for the free workshops. However, some of the participants were signed up by their parents. The instructor was both the lecturer and the developer of the game being assessed, which could be an influential factor to the research results.

Implications for Practice

This study revealed that exposing 13- to 17-year-old girls to computer programming requires a carefully planned workshop. Just being exposed to CS with an enthusiastic instructor and having a good experience will influence girls' view of computer science positively. This research was able to identify some factors that a workshop for girls should incorporate.

The all-girl workshops held in this study seem to influence the girls positively by putting them at ease. Having a passionate instructor with industry experience made the subject more attractive to the girls. The participants' eyes lit up when this researcher identified herself as a computer science professional. All the workshops conducted in this study started with explanations of what computer science is and how women helped shape the industry. In both groups, the researcher discussed women who influenced the industry such as Ada Lovelace, Hedy Lamarr, Top Secret Rosies and Grace Hopper.

Explaining what a computer scientist does help the participants understand the types of careers women can do. Girls liked that computer scientists do not just sit and code but create applications to help everyday people. A workshop should have a fun activity, whether using a game or not, the activity must be hands-on and involve either playing a game or creation of code or an application. The workshop instructor should be more of a facilitator. The facilitator should not lecture but hold an active/interactive/engaged classroom.

Besides learning how to conduct an influential workshop for girls, this study also identified educational game elements preferred by 13- to 17-year-old girls. When developing an educational game for this demographic, keep in mind that the game does not have to be gender-specific; however, the game should be sensitive to gender preferences. A game developer should focus on a game that allows creativity, a meaningful story, a game with excellent sound effects/music that is quest based and incorporates consistent challenges. The educational application should have a good user interface (intuitive), involve open exploration, observation and multiple outcomes, socialization, personalization, specific customization with minimum competition/violence.

Implications of Study and Recommendations for Future Research

This exploratory research revealed a lot regarding the workshop experience for the adolescent girl as well as gender-specific gameplay. Now that the participants' feedback on *Array[7]* and *Gamher World* is collected, the next step involves the re-design and development of the game. The ADDIE model is a cycle, which means it repeats based on the evaluation results. In this case, the game will have to be updated in terms of game story, game interface and other game components as identified by the girls in this research.

The newly completed prototype will require a higher budget and more developers to upgrade to the level of what the girls prefer. Once updated and complete, the same research design can be applied to determine whether the changes to the game make any difference in the research findings. Multi-platform versions of the game, playable on different systems such as Mac computers, mobile devices, and tablets, will be created to determine if the technology affects the end results. Once the new prototype versions meet the target audience's needs, the full playable version of the game will be developed and distributed with the goal of teaching Java programming to girls.

The time on task issue also needs to be re-evaluated. Because the girls in the game group could not finish the game within four hours, a future study can determine whether having more time to play will change the results between the control and the focus groups.

As listed in the delimitations of this study, the game was only compared to a control group that was taught programming via lecture and exercises. A future study will involve the game group versus another group learning programming via well-known tools such as *Scratch* or

Alice. No difference between the two groups will further support that it is the workshop experience and not the tool that affects girls' view of computer science.

Eight months after the study, participants were contacted to ask 'where are they now.' Eight students replied back to the email in April 2015—seven from the game group and one from the non-game group. Two students (both who participated in the game group) reported that they were graduating in June 2015 and going to college as Computer Science majors. All of the eight who responded had positive things to say. *For direct quotes from participants eight months later, see Appendix J.*

Based on the responses, another goal of this researcher is to conduct a longitudinal study with both the focus group and the control group. The results can show whether more control group participants went on to study computer science or more game-group participants did, which, in turn, can further support GBL and the gender-specific game approach.

Reflections and Conclusion

The purpose of this research was to develop a gender-specific educational game to teach Java programming to girls. The objective was to show that teaching programming via a gender-specific educational game would be the answer to the problem of the lack of women in computer science. As the research has concluded, it was found that, in fact, a gender-specific educational game was not the answer to increasing the number of women in the CS industry. The main components to influencing girls are not in the tools used in the classroom but the entire classroom experience. However, if a gender-specific game were to be used, the software needs to include the following game elements: good story, open exploration and customization/personalization with excellent music/sound.

The research does not stop here. A comprehensive package on how to conduct a workshop to influence girls' views on computer science is in development. Further research to test the gender preferred game design elements identified is necessary. There is still more to explore in terms of how to create that perfect workshop and how to apply the identified design elements to make a successful educational game.

In the next 3–5 years, the objective of this research is to continue and obtain funding to develop *Array[7]* and *Gamher World* further. Although a particular tool is not the answer, it still is helpful to have an educational game that is well received by the target demographic. At the time of writing this dissertation, an Advancing Informal STEM Learning (AISL) grant proposal was submitted to the National Science Foundation in hopes of furthering this research. If funding is received, *Array[7]* and *Gamher World* is taken out of the prototype stage and brought into being fully developed (with changes made to the game based on participant feedback). The fully developed game is a tool within a whole workshop package, to help other organizations and educational institutions to introduce Java programming to girls.

The implications of developing a workshop package include: more girls taking part in a positive programming experience and more teenagers exposed to Java programming at an early age. Students, regardless of gender, can find programming to be easy and less intimidating. Girls will believe they can study programming in college. Institutions can adopt the workshop and customize it for their location to further meet their students' needs. Finally, a vast educational multi-player virtual world that covers Java programming concepts can be created based off of *Gamher World*, where teenagers from across the globe can sign in and take part. The positive implications of this study are numerous. The continuation of the study is necessary until a significant change in the number of women in the computer science industry is observed.

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APPENDIX A

FULL GAME DESIGN DOCUMENT

Title: *Array[7]*

Hook: "Can you save him?"

Back-Story: Your father's new job made you and your family move again. This time to a small boring town with only one movie theater and one post office. Your first day at school does not go well as the 'mean girls' don't give you the time of day. Your background as the city girl and your do-it-yourself clothing did not impress them. The boredom at home and school leads you to wonder in search of some action and adventure after school around town. Your wanderings lead you back to school; lights flickering from the school IT classroom window capture your attention. You sneak into the room and see a lone student sitting there working on the computer. He notices your presence and invites you in. The two of you soon become friends. You find out his name is Ryder. He tells you his dreams of becoming a computer programmer; you tell him your dreams of becoming a fashion designer. Soon you realize you are falling for him, his goofy ways, his unkempt hair, and his crooked smile. After months of friendship, you two are identified as best friends. He makes you feel better when the 'mean girls' are in your case, and you sit through his tedious programming. The senior prom is approaching fast, and you realize you want to tell him your real feelings. You go to school prepared for the big reveal, and you find he is absent. He doesn't reply to your texts or calls. Several days go by without you hearing from him. One day you see a text message on your cell phone from Array[7], it just states "help me." You know the message is from Ryder, but you don't know what to do. Your text reply to Array[7] is not answered. Nobody in town seems worried about his disappearance or seems to be looking for him; it is as if he never existed. His family seems to have relocated, and police will not search for a non-existent person. Your parents think you are acting out due to the move. No teacher or student seems to remember him. Now along with living your everyday life, you must figure out why Ryder is gone.

Summary of Gameplay: The 2D game starts with a text message from Ryder. The player is led through several decisions through game locations, before going to school during after-school hours to check Ryder's computer. A puzzle piece is picked up at this location. Once the puzzle piece is found, the player is taken through several decisions until the player enrolls in a Java programming class. In the course, the student is walked through several lessons and unlocks the puzzle level. The first lesson is on how to download and install Eclipse and how to start a project. Then the puzzle levels start – the first two puzzle levels cover how to output using Java syntax. Once the player completes the first two puzzle levels – they go through some game story. Their progress through the puzzle levels leads to more story being revealed. They are taken from another lesson on variables and input, after which the puzzle levels start. The puzzle levels three, four and five cover how to use variables and how to obtain user-input. Puzzle levels six and seven cover the decision structure, looking at if and if-else statements. Puzzle levels eight and nine cover repetition structure, looking at how to use the for loop. Finally, puzzle level ten reveals some programming exercises to be completed outside of the game in the Eclipse environment. The game story ends at a cliffhanger for this prototype and Ryder's where about is not revealed.

Character Descriptions:

You:

Physical Appearance: Not described in detail – teenage girl.

Personality: Spunky, intelligent, and fun incorporated with other personalities of the player.

Background: This character is described as an only child. This character used to live in a big city before moving. In the big city, this character had many friends. On her free time, this character makes her own clothes and likes to change her fashion. She wants to change her outer appearance based on her fashion sense. She was against the big move in the first place but because of the economy and her father being laid off they had no choice. Her mother quit her job as a pre-school teacher to move to the new town as well. In the game, her father works as a store manager while her mother works at a day care center.

Ryder:

Physical Appearance: Tall, dark and handsome. He has unkempt hair and a crooked smile. He has smile lines around his eyes and mouth, a dimple on his left cheek and has black hair and hazel eyes. He usually wears faded jeans, a gray t-shirt, and a black leather jacket.

Personality: An introvert who can stay hours in front of the computer, playing video games and hacking. He keeps to himself and does not have any friends but 'You'. From the outside, he looks unapproachable, a bad boy type and too cool; but as a friend, he is funny, charming, caring and loyal.

Background: His background is a mystery.

Game Story: Through solving programming problems and getting clues and upgrading skills the player of the game will progress through the game story. The game story is not complete for this prototype.

Sound/Music: Music and Sound Effects are created in an as needed basis. Sound effects are used in various stages. Royalty free music is used as looping background music in the puzzle levels.

User Interface/Game Controls: The user interface used is that of an action/adventure/puzzle game. The main controllers used are the keyboard and mouse.

Level Design: Linear storyline with leveling up opportunities as players progress through the game.

Features: The main features of this game are mystery/adventure/puzzle. Players get help through the facilitator in the workshop classroom.

Platform: Computer and a companion online virtual world site in OpenSim

The OpenSim Companion Game Design Document

Title: *Gamher World*

Hook: "Explore Programming."

Back-Story: An exploratory space for learning programming and socializing.

Summary of Gameplay: In this companion site, girls can explore several locations and get more information regarding programming as well as customize their avatars and socialize with other girls.

Character Descriptions:

***You* –**player avatar – the player will be able to choose an avatar and change the appearance.

Sound/Music: Available through the OpenSim virtual world. Music is streamed if the user turns it on – they have the option of turning it on or off.

User Interface/Game Controls: The user interface is similar to the primary interface seen when using Firestorm Viewer. Users have the option to see if their friends are online, look at their inventories, teleport, walk, run, fly, update their appearance and build objects. The main controllers used are the keyboard and the mouse. Users can also chat with friends through text.

Level Design: An open virtual world space with several locations to visit.

Features: The main features of this game are the ability to build, share and interact. As well as get access to outside resources regarding computer programming.

Platform: Mass multiplayer online virtual world called OpenSim and the computer.

APPENDIX B

CURRICULUM

Learning Objectives:

- Write a computer program that implements an algorithm
- Code and test a program to solve a stated problem, using variables and at least one decision or loop

Focus and Activities:

Convert a simple algorithm to a computer program

a) Plan the program out on paper

b) Write and run the program on a computer

Planning, Writing and Testing Computer Programs

a) Come up with specifics for a simple computer program

b) Write the program

c) Come up with test cases to test the program

d) Test the program

e) Make corrections based on test

f) Create final report of program when finished

*****_Curriculum based off of the Computer Science Teachers Association Curriculum Model (Frost, Verno, Burkhart, Hutton, & North, 2009)._

APPENDIX C

PROMOTIONAL FLYER FOR WORKSHOP

APPENDIX D

PARENT AND CHILD CONSENT FORM

I and my registered child(ren) both agree to allow my child(ren) to participate in a Java programming workshop and research study conducted by Shahnaz Kamberi, a professor of Computer Information Sciences at DeVry University and a Doctoral Candidate of Colorado Technical University.

I understand that the workshop will be held on the date that I have selected at 2450 Crystal Dr. Arlington, VA 22202. The workshop will be held from 10:00 AM - 2:00 PM. I understand that my child(ren) will need her own transportation to attend the 4 hour workshop.

I understand that the workshop is to teach Java programming using a software called Eclipse (a Java programming environment) using a Windows PC. Due to the research study, I understand that a two dimensional educational game and a three dimensional virtual world might also be used within the workshops.

I understand that the workshops are part of a dissertation research on the benefits of gender specific educational games to teach Computer Science in the classroom (games made just for girls). I am aware that due to the study, depending on the workshop date selected the course is delivered either through lecture and interactive exercises or by using a two dimensional instructional computer game with an accompanying three dimensional online virtual world game companion site.

I and my child(ren) agree to allow my child(ren) to fill out a pre-workshop survey and a post workshop survey that evaluates her knowledge of programming and/or evaluating of the instructional game used in class.

I and my child(ren) allow my child(ren) to be quizzed before and after taking the workshop to determine how much she has learned.

I and my child(ren) understand that findings from the research study may be reported in scholarly journals, at academic seminars, online blogs and journals, and at research association meetings.

The data will be stored only for the purposes of the study and report, and will be destroyed afterwards.

No identifying information about my child(ren) is made public and any views my child(ren) expresses will be kept completely confidential.

Participation in taking the surveys and quizzes is voluntary and may be stopped at any time. A report of the results of this study is provided upon request.

I understand that there are minimal risks to this research study and will take the entire workshop (4 hours) to complete.

Should you have questions regarding the research project and for more information please contact Shahnaz Kamberi at [email address]

[ ] I agree to participate.
[ ] I do not agree.

Print ___________________________ Sign ___________________________

Date ___________________________

APPENDIX E

GAME AND NON-GAME GROUP PRE- AND POST-SURVEY

Pre-Workshop Survey

* Required

1. **Student Number:** *

____

2. **What is your age?** *

Mark only one oval.

- ◯ Below 13
- ◯ 13
- ◯ 14
- ◯ 15
- ◯ 16
- ◯ 17
- ◯ Over 17

3. **What grade did you just complete (2013 - 2014 school year)?** *

Mark only one oval.

- ◯ 5th grade
- ◯ 6th grade
- ◯ 7th grade
- ◯ 8th grade
- ◯ 9th grade
- ◯ 10th grade
- ◯ 11th grade
- ◯ 12th grade

4. **For each question or statement below, please choose the answer which best characterizes your feelings using the following responses:** *

Questions derived from: Drobnis, A. (2010). Girls in Computer Science: a Female Only Introduction Class in High School (Doctoral Dissertation, George Mason University, 2010). Used with Permission.

Mark only one oval per row.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
I plan to take Computer Science classes in school					
If there was more room in my schedule, I would like to take computer science classes in school					
I will use computer science in other school classes					
I understand what computer science is					
I am looking forward to taking computer science					
I enjoy programming in a computer science language					
I plan on taking a computer science course in the future					
I plan on studying computer science in college					
I will take computer science classes while in college					
I am considering a career in computer science					
I know that I will most likely use computer science in my career					
I am a good computer science student					
I enjoy working with computers					
I am good at using computers					

See Appendix G for Consent.

Non-Game Group Post-Survey

Post-Workshop Survey

* Required

1. **Student Number:** *

2. **What is your age?** *
   Mark only one oval.
   - Below 13
   - 13
   - 14
   - 15
   - 16
   - 17
   - Over 17

3. **For each question or statement below, please choose the answer which best characterizes your feelings using the following responses:** *
Questions derived from: Drobnis, A. (2010). Girls in Computer Science: a Female Only Introduction Class in High School (Doctoral Dissertation, George Mason University, 2010). Used with Permission.
Mark only one oval per row.

	Strongly Agree	Agree	Disagree	Strongly Disagree	N/A
I plan to take Computer Science classes in school	⬭	⬭	⬭	⬭	⬭
If there was more room in my schedule, I would like to take computer science classes in school	⬭	⬭	⬭	⬭	⬭
I will use computer science in other school classes	⬭	⬭	⬭	⬭	⬭
I understand what computer science is	⬭	⬭	⬭	⬭	⬭
I am looking forward to taking computer science	⬭	⬭	⬭	⬭	⬭
I enjoy programming in a computer science language	⬭	⬭	⬭	⬭	⬭
I plan on taking a computer science course in the future	⬭	⬭	⬭	⬭	⬭
I plan on studying computer science in college	⬭	⬭	⬭	⬭	⬭
I will take computer science classes while in college	⬭	⬭	⬭	⬭	⬭
I am considering a career in computer science	⬭	⬭	⬭	⬭	⬭
I know that I will most likely use computer science in my career	⬭	⬭	⬭	⬭	⬭
I am a good computer science student	⬭	⬭	⬭	⬭	⬭
I enjoy working with computers	⬭	⬭	⬭	⬭	⬭
I am good at using computers	⬭	⬭	⬭	⬭	⬭

4. **What I liked about this workshop:** *

____
____
____
____
____

5. **What I didn't like about this workshop:** *

____
____
____
____
____

6. **Now that I have done this workshop, I think programming is:** *
List your opinion on programming based on today's workshop...

7. **The following would have made this workshop better...** *
List your suggestions for how this workshop could have been better.

8. **I think programming is for me / is NOT for me...because...** *
Explain why you think programming is something you'd enjoy or will not enjoy...

9. **This workshop would have been better if we played an educational game that taught Java Programming...** *
Mark only one oval.

- Yes
- No
- Woudn't have made a difference

10. **How often do you play Computer/Video/Mobile games?** *
Mark only one oval.

- 0-2 Hours/Week
- 5-10 Hours/Week
- 10+ Hours/Week

11. **How would you rate your game playing talent level?** *
Mark only one oval.

- ◯ Advanced
- ◯ Somewhat Advanced
- ◯ Intermediate
- ◯ Beginner
- ◯ N/A

12. **Where do you play video games the most?** *
Mark only one oval.

- ◯ Home
- ◯ School
- ◯ Other: ______________________________

13. **Why do you play?** *
Mark only one oval.

- ◯ For Fun
- ◯ For Exercise
- ◯ For Competition
- ◯ For Education/To Learn
- ◯ To Escape
- ◯ Other: ______________________________

14. **The type of game I like to play is...** *
List any game titles you liked playing...

____
____
____
____
____

15. **It is important that the game I play have a female lead character...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

16. **It is important that the game I play have a lead character my age...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

17. **It is important that the game I play has mystery/puzzle solving...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

18. **It is important that the game I play has party/dance theme...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

19. **It is important that the game I play is educational...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

20. **It is important that the game I play teaches some topic in a fun way...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

21. **It is important that an educational game be used in the classroom...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

22. **It is important that the teacher is there to help while I play an educational game...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

23. **It is important that the game I play allows me to be creative...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

24. **It is important that the game I play is fun and engaging...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

25. **It is important that the game I play have a great story/meaningful story....** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

26. **It is important that the game I play is easy...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

27. **It is important that the game allows me to design or create a game...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

28. **It is important that the game I play allows me to build...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

29. **It is important that the game I play has good audio...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

30. **It is important that the game has consistent challenges...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

31. **It is important that the game I play has romance/relationship...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

32. **It is important that the game I play is quest based...** *

Quest based means a game that sends you on a quest - you have to complete a quest to move on in the game...

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

33. **It is important that the game allows me to manage my progress in the game...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

34. **It is important that the game I play has adventure/open exploration** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

35. **It is important that the game is 2D and multiplayer...** *

Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

36. **It is important that the game is 2D and single player...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

37. **It is important that the game is 3D and single player...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

38. **It is important that the game is 3D and multiplayer...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

39. **It is important that the game I play has personalization/customization...** *
Allows me to change my avatar's look, change the colors, change the music, etc.
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

40. **It is important that the game has multiple camera angles...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

41. **It is important that the game I play has virtual world/virtual life...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

42. **It is important that the game I play is team based...** *
A team of players playing together against another team of players...
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

43. **It is important that the game I play has violence...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

44. **It is important that the game I play has exploration/observation...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

45. **It is important that the game I play has replayability...** *
Replayability is the ability to play the same game twice or more and still get different results...
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

46. **It is important that the game I play has simulation...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

47. **It is important that the game deals with emotion...** *
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

48. **It is important that the game I play has life like avatars/characters... ***
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

49. **It is important that the game I play leaves a sense of belonging... ***
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

50. **It is important that the game I play has a website/discussion forum where I can go discuss about the game... ***
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

51. **It is important that the game I play has competition... ***
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

52. **It is important that the game I play has real world connections... ***
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

53. **It is important that the game I play is made specifically for girls... ***
Mark only one oval.

	1	2	3	4	5	
Not Important	◯	◯	◯	◯	◯	Very Important

54. **It is important that the game I play adjusts in difficulty based on how I'm doing...** *

A game where if you're doing well it adjusts to be more difficult or if you're not doing well the game adjusts to be easier...

Mark only one oval.

	1	2	3	4	5	
Not Important	⬭	⬭	⬭	⬭	⬭	Very Important

Game Group Post-Survey

Contained all of the questions from the Non-Game Post-Survey but also included:

54. **What was the best part of Array[7]?** *

You may select more than one option...

Check all that apply.

- ☐ Colors
- ☐ Sound
- ☐ Graphics
- ☐ Educational Content
- ☐ Characters
- ☐ Story/Mystery
- ☐ Challenges
- ☐ It was Fun
- ☐ Goals
- ☐ Scoring
- ☐ Socialization
- ☐ The 2D Environment
- ☐ The 3D Environment
- ☐ Virtual World
- ☐ The Levels
- ☐ The Interface (Buttons/Navigation)
- ☐ Other: ______________________

55. **What was the worst part of Array[7]? ***
You may select more than one option...
Check all that apply.

- [ ] Colors
- [ ] Sound
- [ ] Graphics
- [ ] Educational Content
- [ ] Characters
- [ ] Story/Mystery
- [ ] Challenges
- [ ] It was Fun
- [ ] Goals
- [ ] Scoring
- [ ] Socialization
- [ ] The 2D Environment
- [ ] The 3D Environment
- [ ] Virtual World
- [ ] The Levels
- [ ] The Interface (Buttons/Navigation)
- [ ] Other: ______________________

56. **Would you play this game Array[7] again? ***
Mark only one oval.

◯ Yes
◯ No

57. **Would you recommend this game, Array[7], to anyone? ***
Mark only one oval.

◯ Yes
◯ No

58. **Was this game, Array[7], valuable in teaching you Java Programming? ***
Mark only one oval.

◯ Yes
◯ No

59. **Would you play more games like Array[7]? ***
Mark only one oval.

◯ Yes
◯ No

60. **Array[7] influenced my opinion of Computer Science for the better.** *
Mark only one oval.

- Yes
- No

61. **I think Array[7] explained Java programming concepts in a fun way.** *
Mark only one oval.

- Yes
- No

62. **Array[7] was an influencing factor to my understanding of Java Programming in this workshop.** *
Mark only one oval.

- Yes
- No

63. **If I play more games like Array[7], I might consider studying Computer Science.** *
Mark only one oval.

- Yes
- No

64. **Array[7] influenced my knowledge of the Java programming language.** *
Mark only one oval.

- Yes
- No

65. **I think more "Made for Girls" games like Array[7] is needed.** *
Mark only one oval.

- Yes
- No

66. **What would you change about the game Array[7]?** *

____
____
____
____
____

67. **What recommendations do you have to make Array[7] a better game?** *

APPENDIX F

QUIZ AND ANSWER KEY

Java Code

```
import java.util.Scanner;
public class MainProgram
{
	public static void main(String[] args)
	{
		Scanner input = new Scanner(System.in);

		for(int i = 0; i < 10; i++)
		{
			System.out.println("Please enter a number: ");
			int a = input.nextInt();
			System.out.println("Please enter another number: ");
			int b = input.nextInt();

			int c = a + b;

			System.out.println(“The sum of the two numbers you entered is “ + c);
		}
	}
}
```

Questions

1. (10 points) Explain what this program does.
2. (10 points) What does the line Scanner input = new Scanner(System.in); do?
3. (10 points) Does this program use a loop? If so, how many times will the loop run?
4. (10 points) What does the line System.out.println(“Please enter another number: “); do?
5. (10 points) Change the code so that the program also calculates a – b and displays the answer.

Java Code

```
import java.util.Scanner;
public class MainProgram
{
        public static void main(String[] args)
        {
                Scanner input = new Scanner(System.in);
                System.out.println("Please enter a number: ");
                int a = input.nextInt();
                System.out.println("Please enter another number: ");
                int b = input.nextInt();

                if (a < b)
                {
                System.out.println(a + " is less than " + b);
                }
                else
                {
                System.out.println(b + " is less than " + a);
                }
         }
}
```

Questions

1. (10 points) Explain what this program does.

2. (10 points) If a is 3 and b is 10, what will this program display?

3. (10 points) If a is 33 and b is -90, what will this program display?

4. (10 points) What does the line System.out.println(a + " is less than " + b); do?

5. (10 points) Add a line of code at the end of the program that will display "Thank you for using this program, good bye!"

**Quiz style adopted from the Computer Science Teachers Association quiz sample model (CS151 Computational Thinking Quiz 1 F10, n.d.) and Questions are based off of the material taught in class.*

Answer Key

1) (10 points) Explain what this program does.

   Asks a user to enter a number and then enter another number, then the program adds those two numbers up and displays the result. The program will do this 10 times before stopping.

2) (10 points) What does the line Scanner input = new Scanner(System.in); do?

   It allows us to create an input object from the Scanner library, so we can get user input from the keyboard.

3) (10 points) Does this program use a loop? If so, how many times will the loop run?

   Yes. 10 Times.

4) (10 points) What does the line System.out.println("Please enter another number: "); do?

   It will display to the console the words 'Please enter another number: '

5) (10 points) Change the code so that the program also calculates a – b and displays the answer.

```
import java.util.Scanner;
public class MainProgram
{
    public static void main(String[] args)
    {
            Scanner input = new Scanner(System.in);

            for(int i = 0; i < 10; i++)
            {
                    System.out.println("Please enter a number: ");
                    int a = input.nextInt();
                    System.out.println("Please enter another number: ");
                    int b = input.nextInt();

                    int c = a + b;
                    int d = a – b;

                    System.out.println("The sum of the two numbers you entered is " + c);
                    System.out.println("The difference of the two numbers are " + d);
            }
     }
}
```

6) (10 points) Explain what this program does.

It asks a user for two numbers then tells the user which one of the two numbers is smaller

7) (10 points) If a is 3 and b is 10, what will this program display?

3 is less than 10

8) (10 points) If a is 33 and b is -90, what will this program display?

-90 is less than 33

9) (10 points) What does the line System.out.println(a + " is less than " + b); do?

It displays the data in variable a, then displays 'is less than', then displays the data in variable b

10) (10 points) Add a line of code at the end of the program that will display "Thank you for using this program, good bye!"

```
import java.util.Scanner;
public class MainProgram
{
    public static void main(String[] args)
    {
            Scanner input = new Scanner(System.in);
            System.out.println("Please enter a number: ");
            int a = input.nextInt();
            System.out.println("Please enter another number: ");
            int b = input.nextInt();

            if (a < b)
                {
                    System.out.println(a + " is less than " + b);
                }
            else
                {
                    System.out.println(b + " is less than " + a);
                }

            System.out.println("Thank you for using this program, good bye!");
    }
}
```

APPENDIX G

PERMISSION TO USE INSTRUMENTATION

PERMISSION: TO USE AN EXISTING SURVEY

1/22/2014

Ann W. Drobnis, Ph.D.
Director, Computing Community Consortium (CCC)
[redacted]

Dear Ann Drobnis,

I am a doctoral student from Colorado Technical University writing my dissertation tentatively titled *Gam(h)er: How to Increase Girls' Interest and Knowledge of Computer Science via a Gender Specific Educational Game with Two Dimensional and Three Dimensional Game Components* under the direction of my dissertation committee mentor Dr. Cynthia Calongne.

I would like your permission to reproduce and to use your survey instrument in my research study. I would like to use and print your survey under the following conditions:

- I will use this survey only for my research study and will not sell or use it with any compensated or curriculum development activities.
- I will include the copyright statement on all copies of the instrument
- I will send my research study and one copy of reports, articles, and the like that make use of these survey data promptly to your attention.

If these are acceptable terms and conditions, please indicate so by signing one copy of this letter and returning it to me through email:

[redacted]

Sincerely,
Shahnaz Kamberi
Doctoral Candidate

Ann Drobnis

Signature: 1/22/14

Expected date of Degree Completion: 09/15/2015

APPENDIX H

PERMISSION TO USE SITE

DeVry University

Crystal City Campus
2450 Crystal Drive
Arlington
Virginia 22202-3843
703-414-4000
866-338-7932
www.devry.edu

June 17, 2014

Shahnaz,

Thank you for going through the appropriate channels to get all of the approvals and clearances to move forward with you dissertation research. I approve your use of an open classroom during the month of August. Please work with Jay Louard Walters to ensure that your timeframe does not conflict with either DVU or Chamberlain classes.

Continued success in your research,

Loretta W. Franklin
President
Washington, DC Metro

DeVry University
2450 Crystal Drive
Arlington, VA 22202
[redacted]

APPENDIX I

DIRECT QUOTES FROM WORKSHOP ATTENDEES

Non-Game Group Participants

- *"[Now that I have taken this workshop] I think programming is for me because it makes me feel more confident and in control when I use computers, and also I want to learn how to code apps"*
- *"We learned the material at a good pace; it wasn't too fast to make it confusing nor was it so slow that it became boring. The instructor explained everything very well and thoroughly."*
- *"I enjoyed the way that the material was taught (very comprehensible, nice mix of your own exploration and instructing), and that all of it was new information for me. I had no previous experience with coding, and felt that this was a very valuable experience."*
- *"I liked how willing the teacher was to help and how much she wanted us to learn and it made me want to learn even more."*
- *"I liked being able to see something, a program, that I created and see it work."*
- *"The instructor was very nice, it helped me understand the basics of computer science."*
- *"I really like how you explained the details of how to work with Java and also explain the error I had made."*

Game Group Participants

- *"I think programming is lots of fun! Before this workshop I was pretty intimidated by programming. It was kind of like the European explorers who traveled to the New World, I didn't really know what to expect. But after doing the workshop, I can see that programming is a lot easier than I imagined it to be, and it is a lot of fun to do."*
- *"I think programming is a lot more fun and able to be grasped after this workshop. I have always been interested in these arts but I kind of always saw it as something beyond my reach of ability, now that I see that I can actually do basic things with a level of competence I'm a lot more excited for it!"*
- *"I think programming is exciting and now that it makes more sense I would like to look further into it."*
- *"It was fun talking to other girls about coding, and for once there isn't some lame boy who talks nonsense."*
- *"[What I liked about this workshop was] the game. It was very fun. I actually thought I would hate this but I really really REALLY liked it! The game made it a nice experience. If someone was just telling me all this stuff, I would have [fallen] asleep."*
- *"It was fun and the time flew by; it also crammed a lot of work into such a short time period."*
- *"I think it is something I would enjoy because I liked it here. Again, I honestly thought I would want to kill myself after this (LOL), but this class left me wanting more."*
- *"The course was presented in game form, and it was very easy to keep up with and follow. It was refreshing to have a very independent format because you didn't have*

to wait for anyone or hold anyone else up. There were so many nice girls surrounding me, and I felt very comfortable looking around and asking for help if needed. The professor was well spoken and helped whenever you asked her questions or if you were a little bit confused. I walked away with a good understanding of the programming field. Also, some of the girls participating were clearly experienced with computer programming, and they were proud of their knowledge/abilities."

Email from Parents

- *"I think that [name of student] is more interested in programming now than before the workshop, so that's good. BTW- she attended a week's worth of classes in Alice last summer, but she didn't come away with that much interest. I attribute it partly to the fact that the instructors were not the sort to be contagiously excited about what they were teaching and really wanting the kids to learn and accomplish things."*
- *"I was so surprised that my theatre bound daughter was captivated by programming. She came home to try the steps."*

APPENDIX J

DIRECT QUOTES FROM PARTICIPANTS EIGHT MONTHS AFTER WORKSHOPS

Game Group Participants

- *"It was my first live programming class, and it helped me transition to actually working towards a career in programming."*
- *"I knew I would be following this career path before I'd come, but my line of thought was more focused on formatting languages (i.e. HTML and CSS). Working with Java opened my eyes a bit more to the languages beyond that, to the more programmatic side of things. It's definitely helped shape my goals for during and after college (and gave me a head start in my AP Computer Science A course this year)"*
- *"I will be graduating high school this June, and will be pursuing a Computer Science major with Astrophysics as either a double major or a minor. And yes, your workshop did indeed help me make this decision. It taught me that computer science isn't as intimidating a field as I once thought and that I actually understand it pretty well. So thank you for that."*
- *"I plan to major in film at the moment, however, the workshop that I attended definitely opened me up to trying to learn basic programming skills outside of class. I actually plan to use sites like Code Academy and some other resources to learn more about programming in my free time."*
- *"After the Java workshop I was motivated to keep pursuing my dream of majoring in CS. I am in 10th grade and will be hopefully taking some more coding classes before graduating. The workshop was really wonderful, and I learned a lot."*

- *"After the workshop ended I have started another Python programming course. The workshop sort of convinced me to continue with comp science. My prior courses were exceedingly dull and boring. The class you taught made me think that comp science can be very fun and exciting."*
- *"We are currently taking AP Computer Science, and participated in your workshop so that we would have some background knowledge when the class started in September. We both enjoy the class and are considering STEM careers."*
- *"A lot of what got me interested in this was the idea that I could have fun with my job, which was what appealed to me about your workshop. I still have the CD and certificate you gave all of us."*

Non-Game Group Participant

- *"Your workshop last summer was my first real exposure to computer science, and I discovered I loved it. I spent hours throughout my eighth-grade year learning more coding online (such as through Code Academy and Khan Academy) and enjoyed every second of it. The exposure to CS really did impact my high school applications and decisions, and I plan to take a multitude of such classes [in high school]"*