NORTHWESTERN UNIVERSITY

Computer Programming Games and Gender Oriented Cultural Forms

A DISSERTATION

SUBMITTED TO THE GRADUATE SCHOOL

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

For the degree

DOCTOR OF PHILOSOPHY

Field of Electrical Engineering and Computer Science

By

Sarah Abdulmalik AlSulaiman

EVANSTON, ILLINIOIS

December 2015

ABSTRACT

Computer Programming Games and Gender Oriented Cultural Forms

Sarah Abdulmalik AlSulaiman

I present the design and evaluation of two games designed to help elementary and middle school students learn computer programming concepts. The first game was designed to be "gender neutral", aligning with might be described as a consensus opinion on best practices for computational learning environments. The second game, based on the cultural form of dress up dolls was deliberately designed to appeal to females. I recruited 70 participants in an international two-phase study to investigate the relationship between games, gender, attitudes towards computer programming, and learning. My findings suggest that while the two games were equally effective in terms of learning outcomes, I saw differences in motivation between players of the two games. Specifically, participants who reported a preference for female-oriented games were more motivated to learn about computer programming when they played a game that they perceived as designed for females. In addition, I describe how the two games seemed to encourage different types of social activity between players in a classroom setting. Based on these results, I reflect on the strategy of exclusively designing games and activities as "gender neutral", and suggest that employing cultural forms, including gendered ones, may help create a more productive experience for learners.

ACKNOWLEDGEMENT

First of all, I would like to thank Allah for completing my dissertation, which could not have been written without all of his blessings.

Second, I would like to express my deepest gratitude to my advisor, Dr. Michael Horn for his endless support, guidance and encouragement. Mike, you taught me how to be a successful graduate student.

I also would like to thank my committee members Dr. Lawerence Birnbaum and Dr. Anne Marie Piper for their time and effort in guiding me through the years of my research.

I thank my friends at TIDAL lab for their support and valuable feedback.

I thank my parents who have always reinforced my confidence and helped sustain my ambition.

Most especially I thank my husband who have been with me every step of the way. Fahad, you have inspired me to reach my full potential.

DEDICATION

To my parents, Abdulmalik and Jawaher

for planting the seed of love for learning in the family and for developing a motivation for lifelong learning.

To my husband Fahad and my daughter Fahdah

Table of Contents

List of Tables

List of Figures

Chapter 1 Introduction

Computers and technologies are playing an increasingly integral part of our daily life. There is a growing demand for computer and technology professionals to design and develop technologies to further enhance the quality of human lives. Despite this growing demand, only a few, unrepresentative sample of the population choose to be involved in creating new technologies. The National Center for Women and Information Technology (2013) reports that 57 percent of 2012 undergraduate degree recipients were female but only 18 percent of 2012 Computer and Information Sciences undergraduate degree recipients were female. According to the Taulbee report, only 14.2% of bachelor's degrees, 21.2% of master's degrees, and 17.2% of PhD degrees were awarded to women. The gender gap in the technology industry is also evident, with women comprising only 26% of the computing related occupations (NCWIT, 2013). The need to broaden and diversify technology related occupations among gender and racial lines has become a necessity rather than a trivia. Probably of the most important reasons for this need is to help ensure that creating new technologies include the voices of all those who it is intended to serve. In addition, the Bureau of Labor Statistics (2013) consistently lists computer science jobs as one of the fastest growing professions, with over 40 million new positions expected to be available by 2020, so it is critical to ensure that computer science attracts a wider segment of the population. Attracting more women to computer science will increase the qualified labor pool, open new opportunities for their financial welfare and can help in diversifying technologies to meet the needs of a wider segment of the population.

To address the lack of women in computing related fields, researchers suggest maximizing the opportunities for women and girls to explore technology and challenge prior assumptions about identities associated with IT expertise (Cheryan et al., 2015; 2013; Buecheley et al., 2010; 2008; Gee and Hayes, 2010; Hayes, 2008; 2005; Cohoon and Aspray, 2006; Margolis and Fisher, 2002).

Research suggests that an individual's sense of identity (or identities) strongly influences his or her motivation and orientation towards learning (DiSalvo and Bruckman, 2010; Falk, 2006; Harré and Moghaddam, 2003). The concept of 'identity' has been studied extensively in the fields of psychology, sociology, and social psychology. Identity, as used in this dissertation, generally follows Erving Goffman's view, in which he discusses that identity is not issued to individuals at birth, but is rather continually socially constructed. Thus, identity is "not a material thing to be possessed and then displayed; it is a pattern of appropriate conduct, coherent, embellished, and well articulated" (Goffman, 1959). In this view, an individual's interactions with social, cultural, and physical environment shapes his/her identity over time (Falk, 2006; Gee, 2001). In the words of Rounds (2006), "Identity is both an enabler and a constrainer, and sometimes we resent the constrains identity can enforce on our actions. We value the structure and predictability provided by a clear sense of who we are and how we should lead our lives, but we also value our independence of those structures."

Gender is a complex, situated, and socially constructed facet of identity (Basow, 1992; Butler, 1990; West and Zimmerman 1987) with far-reaching implications on learning, particularly with respect to computational literacy (Patitsas et al., 2014; Abbis, 2011; DiSalvo and Bruckman, 2010; Jenson and De Castell, 2010; Stepulevage, 2001; Wajcman, 1991). In addition, ample evidence in the literature indicates that computing is usually thought of as a masculine domain (e.g [Abbis, 2011; Cohoon and Aspray, 2006; Margolis and Fisher, 2002; Schofield, 1995; Cockburn, 1992; Wajcman, 1991]). Recent studies focusing on the issue of girls' *disidentification* with computing provides evidence that social and cultural factors and norms constrain girls' participation in computing opportunities (Cheryan et al., 2015; 2012; 2010; Patitsas et al., 2014; Frieze et al., 2013; Abbis, 2011; Jenson and de Castell, 2010; Misa, 2010; Cohoon and Aspray, 2006; Margolis and Fisher, 2002; Schofield, 1995; Cockburn, 1992; Wajcman, 1991). Some researchers argue that many girls resist participating in the computing culture because it is associated with stereotypes that are inconsistent with the female gender role (Cheryan, 2010; Jenson and de Castell, 2010; Misa, 2010; Cohoon and Aspray, 2006), which could threaten their social identities as females (Schofield, 1995; Cockburn, 1992; Wajcman, 1991).

Researchers suggest that maximizing the opportunities for women and girls to explore technology and challenge prior assumptions about identities associated with IT expertise could be one possible way to address the lack of women in computing fields (Cheryan et al., 2015; 2013; Buecheley et al., 2010; 2008; Gee and Hayes, 2010; Hayes, 2008; 2005; Cohoon and Aspray, 2006; Margolis and Fisher, 2002). Substantial recent effort has been dedicated to helping girls identify with computing by exposing them to computer science and programming at a young age. These efforts mostly come in the form of outreach programs such as Google's Made With Code initiative, she Plus Plus, Technovation Challenge, Girls Who Code, and Black Girls Code, among many others. In June 2014, Google (with other partners) started Made With Code initiative to engage girls with programming and sustain their interest by creating alliances and community around girls and coding. It also aims to inspire young girls by celebrating women and girls who do computer programming. She Plus Plus is another initiative created at Stanford University and was founded in 2012; it started as a conference on women and technology and has now expanded into a full-fledged community that inspires women and builds a momentum for female technologists. For example, they created the '#include fellowship program' which "provides resources and content to high school students who wish to cultivate their own technical skills and facilitate conversations about computer science and the importance of diversity in technology." Furthermore, Girls Who Code is a national non-profit organization launched in 2012 targeted at high school girls to inspire, educate, and equip them with the skills and resources to pursue opportunities in computing fields. Black Girls Code reaches young girls from underrepresented communities and introduces them to coding lessons such as Scratch and Ruby on Rails with the aim of growing the number of women of color working in technology. They provide variety of events for girls in elementary through high school years.

The efforts to make computer science education more inclusive have corollaries in the broader domains of science and engineering. For example, LEGO announced the release of a new set of all-female scientist minifigures to expose children—and particularly girls—to female scientists to help mitigate the negative stereotypes associated with science and women (Guzdial, 2014). Similarly, GoldieBlox (Dockterman, 2014) is a building toy targeted toward girls designed to develop early interest in engineering and confidence in problem solving to empower them to embrace technology and engineering fields.

The emphasis on the importance of creating more inclusive computing culture has impacted the design of online learning environments where many of these environments have been developed to engage girls in computation, but with a different strategy. In particular, these environments make a conscious effort to be 'gender neutral' and appeal equally to boys as well as girls. For example, code.org, the biggest educational website dedicated to computer programming actively endorses gender neutral games over gender oriented ones. In their guidelines to developers who want to create programming activities, they indicate that activities will be listed lower if they have a gender-specific bent. However, in 2014, they announced that the Hour of Code event will feature a theme of Disney's popular *Frozen* characters Anna and Elsa in an effort to increase participation by girls and women.

Given these two perspectives, I was interested in investigating whether utilizing gender-oriented cultural forms in the design of learning environments would provide an advantage over more gender neutral designs. In other words, will children's learning and attitudes toward computer programming be impacted differently using a gender-oriented design than when using a gender-neutral design?

In this dissertation, I present findings from a study on the effect of two games that I developed to help elementary and middle school children learn fundamental computer programming concepts. The first game was designed to be "gender neutral", aligning with what might be described as a consensus opinion on best practices for computational learning environments. The second game, based on the cultural form of *dress up dolls* was deliberately designed to appeal to girls. In this dissertation I treat gender as a social and cultural construction that is distinct from biological sex. Thus, when assessing the impact of my games, I construct measures of participants' gender identity in relation to the computer games they engage with. In addition, given that gender is socially and culturally constructed, I replicated the study in two cultural regions with distinct cultural norms and expectations regarding gender roles in society: one in the Middle East, Saudi Arabia and the other in the USA.

Intriguing work (Buechley et al., 2010; Buechley et al., 2008; Horn et al., 2009; Kelleher et al., 2007) suggests that the nature of the programming environment and of the activities can dramatically change girls' interests, motivation, and engagement with computer programming. Recent studies show that e-textiles (Kafai et al. 2014, Weibert et al., 2014, Buechley et al. 2010) can promote female interests in electronics and computer science and "disrupt binary gender roles" by leveraging girls' cultural practices and traditions of play and incorporating them creatively with advanced computing activities. For example, Horn's work on programming systems in museum setting's showed that girls were significantly more likely to use a tangible programming exhibit than a graphical programming exhibit. In addition, Buechley developed an e-textile construction kit, called LilyPad Arduino, which enables novices to build soft interactive clothing. This construction kit was especially appealing to an unusual community of developers; it was successful in engaging a large number of women in designing and engineering technology. Buechely and Hill compared LilyPad community to the traditional electronics community who used Arduino and found a strong relationship between user's gender and the type of board they purchased and used. The difference between the proportion of females and males who bought and used LilyPad and the proportion of females and males who bought and used the traditional Arduino was highly statistically significant. In addition, Weibert et al. (2014) study on e-textiles in computer clubs for children in mixed gender groups showed how children's thematic choices of projects were initially influenced by conventional binary gender roles. However, these choices were changed and did not seem to matter later, in the practical context of the e-textile project work. Weibert et al. argue that e-textile can "disrupt normative binary gender allowing for the development of feminine technical identities, masculine creative identities, and everything in between. In addition, it alleviates girls from feeling gender inauthenticity when engaging in technical skills, which has been argued to be key barrier to the inclusion of women in computing".

Kelleher's et al. (2007) work 'Storytelling Alice' also shows how changes to the programming environment itself can promote girls' interest programming. In her study, Kelleher added a support for story creation to the programming environment 'Alice' and compared groups of middle school girls who used Alice and Storytelling Alice. Kelleher found that girls who used Storytelling Alice were more motivated to program than girls who used Alice and they also showed stronger evidence of engagement with programming. These studies paint more of a picture of why we should be interested in the programming environment itself. It also shows how we can support new cultures of computing and open new directions to broaden participation instead of using "*boys' activities as the benchmark for girls' computational opportunities, in which the underlying assumption of such benchmarking is that it elevates one group's activities as the norm for others, which also reifies the notion of gender as a biological construct rather than a social construct that is performed*" (Kafai, 2014).

In addition, ethnographic research around computer game play (Stevens et al., 2008) has revealed that social interactions while playing can affect the ways in which people learn in the game context and how that learning becomes entangled with everyday life. To this end, I was also interested in finding out how practices surrounding a gender-oriented programming game would differ from a gender neutral one. In other words, I was interested in what happens in the room between participants during game play.

In the remainder of this chapter, I briefly discuss cultural forms as a foundation for interaction design. Then I discuss the importance of technological fluency and introduce the current movement in educational computer games and explain my approach in utilizing computer games to develop technological fluency skills for young girls. I will then list the research questions for this dissertation and provide an overview of the study that was carried out to examine the research questions.

1.1 Cultural Forms

Cultural forms have received recent attention as a foundation for interaction design that influences how people use and experience digital systems, particularly in collaborative settings (Horn, 2013; Horn et al., 2013). When users perceive a cultural form in an interactive system, it can shape their expectation about the activity and cue resources and patterns of social activity. Cultural forms also interact with users' constructed identities, including their gender identity. When an interactive system evokes a gender-specific cultural form, it can facilitate (or restrain) users' participation and interest in the system (Weibert et al., 2014). For example, a study on e-textiles (Weibert et al., 2014) showed how children's thematic choices of projects were initially influenced by conventional binary gender roles. It also describes how one Turkish boy refused to participate in the sewing part of the activity because he believed sewing was not appropriate for men.

In this study I intentionally attempted to evoke the cultural forms of dress-up dolls and doll houses to understand how youth would react and how it would shape their collaborative interaction when combined with programming activities. I chose to focus on gendered cultural forms to further understand its role in enabling the development of "feminine technical identities." (Weibert et al., 2014)

1.2 Technological Fluency

The term technological fluency was coined by Seymour Papert (1980) to refer to not only the ability to use technology tools, but also to the ability to construct things of significance with those tools (Papert and Resnick, 1995). Papert and Resnick explain this idea through the analogy with learning a foreign language "*If a person is able to understand and speak a few sentences of a foreign language, say French (for example, read a menu in a restaurant and ask for directions on the street) would people consider him fluent in French? Certainly not. That type of phrase-book knowledge is equivalent to the way most people use computers today. Is such knowledge useful? Yes. But it's not fluency. To be fluent in a language, a person must be able to articulate a complex idea – that is, make things with language*" (Papert and Resnick 1995). Similarly, a technologically fluent person should be able to implement a technological project from a mere idea.

Technological fluency has been recognized as an important skill set that can open career opportunities and empower meaningful participation in society (Kafai and Burke, 2014; Wing, 2008; Resnick, 2007; Papert, 1980; diSsesa, 2000). Technological fluency implies active engagement to create, manipulate and control artifacts within the technology tool. Computer programming provides an unrestricted venue to manipulate and create artifacts such as animations, stories and simulations. Papert argues that such activities are particularly important in the lives of children as most of their best learning experiences occur while they are engaged in creating things, particularly things that are meaningful to themselves or those around them (Papert, 1993).

In the 1980s, Papert envisioned a world in which computers would become an integral part of children lives, where children would program computers to control robots, design games, and compose music along with many other creative activities (Papert, 1980; 1993). Papert worked earlier to realize that dream by creating Logo in the 1969, the first educational computer programming language to explore mathematical problem solving. Logo combines a physical (and virtual in later editions) turtle as a new way to teach geometric concepts to children. Logo initiated an early enthusiasm for teaching computer programming to children. Millions of students from thousands of schools learned computer programming with Logo. However, this enthusiasm has slowly declined over time. Although a number of educational programming languages inspired by Logo were created, such as Boxer and StarLogo, they did not capture the general public interest as did Logo (Kafai and Burke, 2014). Computers in schools became merely machines for delivering and accessing information rather than machines to think and create with.

In the past few years, many organizations and websites renewed the public interest in computer programming once again, encouraging and supporting people, especially children, to learn computer programming. While Kafai and Burke (2014) situate this renewal of public interest as part of the larger maker movement, Resnick thinks of it as a standalone coder movement. Kafai, Burke and Resnick (2014) argue that this movement should expand beyond using computational concepts for solving problems to include personal expression, creative design, and social engagement.

One of the most influential organizations on this matter is code.org. It is a non-profit organization, launched in January 2013, dedicated to expanding participation in computer science by encouraging people, particularly school children to try coding. It aims to ensure that every K-12 student has the opportunity to study computer science and get a hands-on experience with computer programming. It also promotes including more computer science classes in schools' curriculum. The organization released a YouTube video titled "What Most Schools Don't Teach" that speaks of the shortage of computer science classes in schools and how critical it is to address this problem in order to prepare the next generations for the jobs of our increasingly computationally-oriented world. The video featured famous celebrities such as Bill Gates, Mark Zucherberg, and many others talking about their first experiences with computer programming. The video reached millions of viewers within only a few days. After six months of its launch, code.org partnered with the *Association of Computing Machinery* and launched the *Hour of Code* event during the annual national Computer Science Education Week (CSEdWeek). Hour of code is a one hour introduction to computer programming designed to show that anybody can learn the basics by trying a number of tutorials on the organization's website. This global movement allowed, in just five days, 15 million users from more than 180 countries to try coding with tutorials available in more than 30 languages. The organization also partnered with and had a tremendous support from major corporations including Apple, Google, Facebook, Amazon, Disney, Microsoft, Yahoo, Target and Electronic Arts, among many others. It seems that code.org have tension in creating gender-oriented tutorials (or games). In one hand, they seem to actively endorse gender neutral games over gender oriented ones as their guidelines to developers who want to create programming activities to be listed on their website indicate that activities will be listed lower if they have a gender-specific bent. However, in 2014, they announced that the Hour of Code event will feature a theme of Disney's popular *Frozen* characters Anna and Elsa in an effort to increase participation by girls and women.

1.3 Computer Games as a Learning Medium

Many researchers have argued that computer games offer rich learning opportunities and can work as a vehicle to spark children's interest around topics they never would have considered relevant or of interest before (Gee, 2007; Shaffer, 2006; Squire, 2006; Hayes, 2005). Gee (2007) outlines ways in which the design of video games embody effective learning principles in highly motivating contexts. He also discusses how computer games can challenge or reinforce prior assumptions about a semiotic domain by allowing players to take on different identities.

Computer games are often seen as "children's first and most compelling introduction to digital technologies" (Hayes, 2005) and are often considered a gateway into computer science and information technology careers (Tillberg and Cohoon, 2005; Margolis and Fisher, 2002; AAUW, 2000). Several studies have revealed gaps between college female and male students in their computer and programming experience and that this experience is often acquired informally through game playing, hacking, and unguided exploration (Margolis and Fisher, 2002; Kersteen et al., 1998; Taylor and Mounfield, 1994).

Hayes (2008) argues that young people's attitude toward computers, as well as their aptitude and interest in computer science are highly influenced by their informal experiences with computers and that video game play for girls has potential as a way to develop identities associated with IT expertise.

1.4 Design Summary

I designed and developed two computer programming games to help elementary and middle school children learn fundamental computer programming concepts that serve as the foundation for the studies reported here. The first game, called *Rosie the Fashionista*, was designed with an intentional gender orientation (Figure 1). The second game called *Build a House* was intended to be gender-neutral (Figure 2). The two games offer identical programming activities, but the first game is built around the cultural form of dress-up dolls, while the second around building and decorating houses. In these two games, players manipulate graphical elements, instead of text, to write computer programs. The computer programming concepts introduced in the games include sequential execution, conditionals, loops, and functions. Based on Horn (Horn et al., 2012) and Wyeth (Wyeth, 2008) work on programming curriculum for early elementary school children, we attempted to introduce children to a series of powerful ideas (Bers, 2008; Papert, 1980) from computer programming through these two computer games. Following (Horn et al., 2012) I selected programming activities to build on one another conceptually while remaining developmentally appropriate for children in my target age range.

Figure 1. Rosie the Fashionista game screenshot

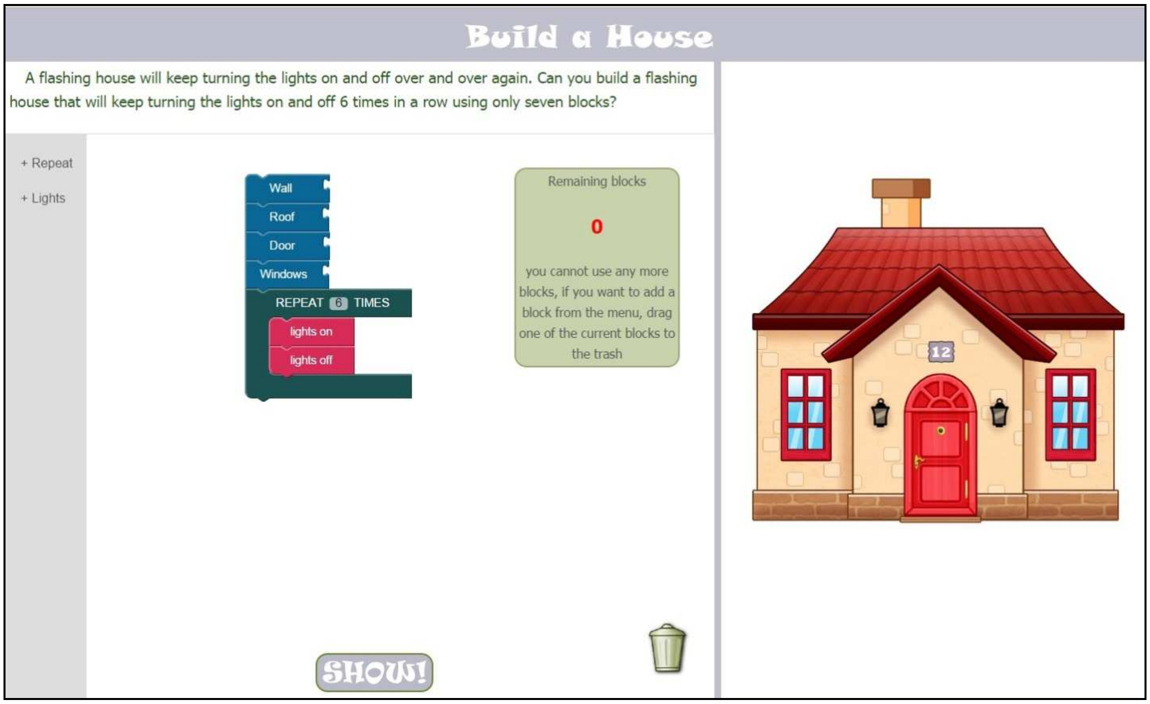


Figure 2. Build a House game screenshot

Rosie the Fashionista game follows the story of a young girl named Rosie who needs help in figuring out what to wear on several occasions. Each occasion prompts a programming activity that the player needs to solve. The programs which the players create are, in and of themselves, the outfit that Rosie will be wearing on that specific occasion.

The game emphasizes the sequences of actions by displaying the output of the program blocks one at a time. For example, when the player places a "boots" block after "jeans" block, Rosie will wear her boots on top of her jeans (Figure 3 left). On the other hand, if the player flips the order of the jeans and the boots, Rosie will wear her jeans on top of her boots (Figure 3 right).

Figure 3. Sequential execution in Rosie the Fashionista game

The game also emphasizes logic by creating weather and location related conditionals. For example, in level 4, the player is asked to dress Rosie according to unknown weather condition (Figure 1). In this level, the player is expected to choose a conditional block along with weather appropriate clothing, (e.g. jacket for cold weather condition and t-shirt for hot weather condition). If the player does not choose appropriate clothing, Rosie will end up in clothing-weather mismatch (Figure 4) and a feedback message will be shown to the player (Figure 5).

Figure 4. Weather mismatch look in conditional level

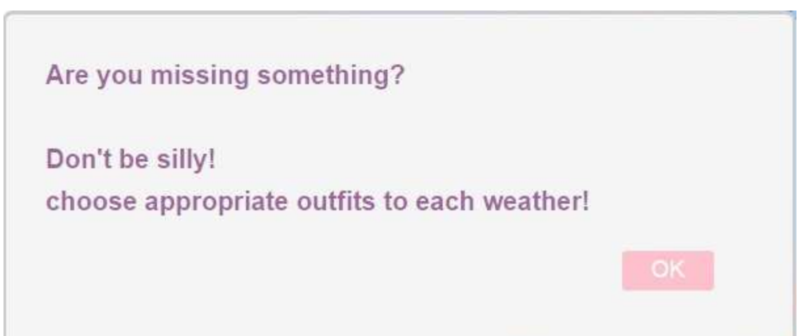


Figure 5. Feedback message to players in Rosie game

Build a House game allows players to build and decorate a house with different colors. Just as Rosie game, each level prompts a programming activity that the player needs to solve in order to build a house. This game similarly emphasizes sequences of actions by displaying the output of the program blocks one at a time. For example, when the player places a “wall” block after “windows” block, the wall picture will be displayed on top of the window picture, making the windows invisible. (Figure 6 top). On the other hand, if the player flips the order of the windows and the wall, the windows will be displayed on top of the wall (Figure 6 bottom).

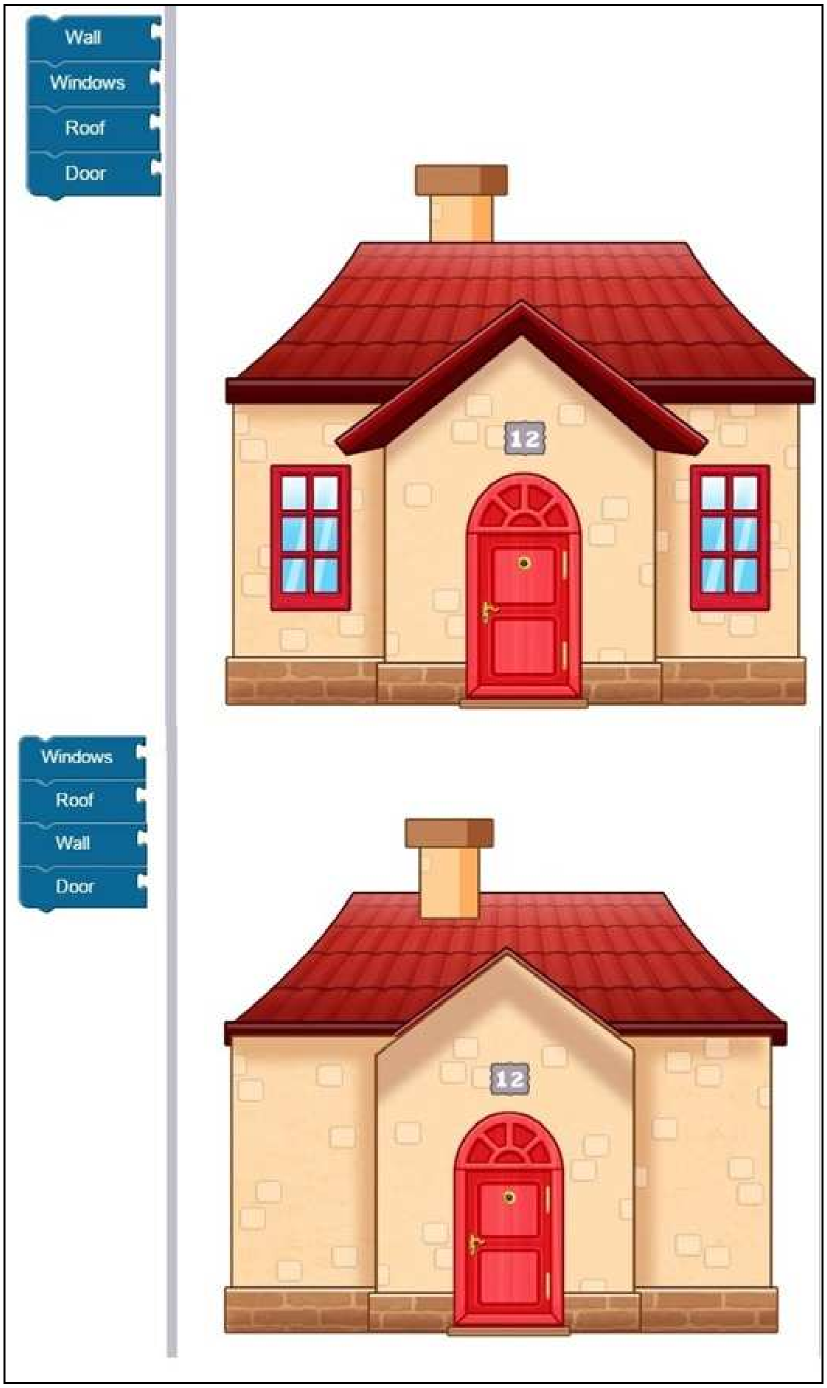


Figure 6. Sequential execution example in House game

In addition, the game emphasizes logic by creating time and location conditionals. For example, in level 4, the user is expected to use a time conditional block along with 'lights-on' and 'lights-off' blocks depending on the time of the day. If the player places a 'lights-on' block during the day (Figure 7), appropriate feedback will be given to the player (Figure 8).

Figure 7. Time Conditional level in Build a House game

Figure 8. Feedback message to players in Build a House game

In chapter 3, Design and Implementation, I describe the design process and implementation of the two games in detail.

1.5 Research Questions

In testing and evaluating the two games, I was interested in investigating three research questions:

RQ1. How do computer games help young children learn computer programming, and are there differences between a female-oriented and gender-neutral programming environment?

As computer games became more popular among females recently, I am interested in investigating the potential of using them as an informal learning environment to support the comprehension of fundamental computer programming concepts. Given the fact that computer programming is usually stereotyped as a masculine activity, I am also interested in investigating the impact of a female-oriented (counter-stereotypic) game theme versus a gender-neutral game theme on children's learning and attitudes. Previous study (Good et al., 2013) has shown that counter-stereotypic textbook images in science textbooks can significantly affect girls' learning of science materials. To the best of my knowledge, no formal studies have compared the impact of different game themes/designs on children's comprehension of computer programming concepts. Investigating this question can help us understand whether computer games can help in supporting emerging computational skills and how the contents and metaphors of such games can affect learning.

RQ2. How do computer games impact children's attitudes and perceptions toward computer programming, and are there differences between the two environments?

I am interested in the possibility of positively impacting children's attitudes and perceptions toward computer programming as a result of playing computer games. Hayes (2008) argues that young people's attitude toward computers, as well as their aptitude and interest in computer science are highly influenced by their informal experiences with computers and that video game play for girls has potential as a way to develop identities associated with IT expertise. To the best of my knowledge, no formal studies have been conducted to compare the effects of different game design themes on children's attitudes toward computer programming. If computer games prove to positively impact girls' attitudes, then it would be plausible to invest more in developing computer games in order to create a more inclusive computing culture. In addition, understanding how different design themes impact girls' attitudes and perceptions can help us design better interventions to engage girls with computing.

RQ3. How do patterns of social engagement differ between using a female-oriented computer game and a gender-neutral computer game?

Ethnographic research around computer game play (Stevens et al., 2008) has revealed that social interactions while playing can affect the ways in which people learn in the game context and how that learning becomes entangled with everyday life. To this end, I was also interested in finding out how practices surrounding a gender-oriented programming game would differ from a gender neutral one. In other words, I was interested in what happens in the room between participants during game play.

1.6 Design and Overview of the Study

I conducted my research study in two cultural regions with different cultural norms and expectations regarding gender roles in society. The first phase of the study was conducted in a private- all girls' school in Riyadh, Saudi Arabia during the computer lab time and the second phase was conducted in Chicago, United States in a public school's summer camp. My study used a quasi-experiment design in which I divided participants into two groups. One group played Build a House and the other group played Rosie the Fashionista. Participants took part in a total of four sessions over a two-week period (each session lasted approximately 40 minutes). In the first session, participants completed a pre-assessment and a pre-survey about computer programming and games. The second and third sessions were devoted to playing the game. In the fourth (and last) session, participants completed a post-assessment and a post-survey. The survey included fifteen statements about participants' attitudes toward computer programming and games, while the assessment included fourteen questions divided into code generation and code prediction sections. The purpose of the assessments and surveys was to detect possible shifts in learning and attitudes after playing the game.

In order to investigate the first research questions, I analyzed the effectiveness of using my computer games to support the comprehension of computer programming concepts by comparing the pre and post tests. I used a paired *t*-test on participants' pre and post scores for each game condition individually. Then, to investigate differences in learning gains between players of the two games, I conducted an ANCOVA test on the post scores using game condition as the independent variable, while controlling for the pre scores (and sex in the second phase) as covariant.

To investigate the second research question, attitude surveys were collected from the participants before and after introducing them to the game to detect shifts in perceptions and views of computer programming. I compared the pre and post scores on the survey items for each game condition individually. Then, I conducted an ANCOVA test on the post scores using game condition as the independent variable, while covarying the pre scores and sex of the participant to examine possible attitude differences between players of the two games.

I used field notes and observations along with video and audio recordings to investigate the third research question and explore potential differences in patterns of social engagement between players of Rosie the Fashionista and players of Build a House.

Chapter 2 Literature Review

Chapter two will provide a theoretical background for this dissertation and then discuss related work. First, I present an overview of the literature on the relationship between gender, sex and the computing culture with emphasis on computer games. Then I present an overview of the literature on computer games as a learning medium. Finally, I present related work that examines the practical use of computer games in education along with the educational programming languages developed.

2.1 Background

2.1.1 Gender and Computing

In reviewing the literature on gender and computing, it is first important to draw the distinction between gender and biological sex. Sex is what is ascribed by biology, such as anatomy, hormones and physiology, while gender refers to the socially constructed roles, behaviors, activities, and attributes that a given society considers appropriate for men and women (WHO.com). Gender is a concept of human production, just like culture, that depends on everyone constantly *doing gender* (West and Zimmerman, 1987). Gender is not the result of an individual's sex. Therefore, it is not something an individual 'is' or 'have' but rather is something that she/he 'does' or 'performs' (Butler, 1990). What it means to be male or female is not genetically inherent or defined similarly across all social groups, but rather situational and culturally variable. In the words of Barker and Aspray "Gender identity varies within particular contexts and forms, is reinforced within relationships and situations, and interacts with other types identities in ways that influence beliefs about who takes on those identities" (Barker and Aspray, 2006). In other words, gender is a set of social categories that shape implicit beliefs about how an individual believes he/she should behave, as well as beliefs about the way others treat individuals as gendered human beings. These categories also form expectations about the kinds of activities an individual 'will' and 'should' participate in (Barker and Aspray, 2006).

While the distinction between sex and gender has become increasingly popular in the West. This distinction is still blurred in the Middle East, and particularly in Saudi Arabia, where one of the studies reported in this dissertation was conducted. Saudi Arabian society follows a very traditional approach in gender construction. The cultural construction of gender is strongly based on perceived sex differences, heritage and local interpretations of Islamic laws. Women and men appearance, behavior and the acceptable range of their activities are defined by traditional binary gender roles. For example, men are always considered the breadwinners and women should always be the nurturers. In Saudi, men and women are commonly segregated in educational settings and in the workforce and the educational system restricts women access to certain areas of study such as engineering and journalism (El-sanabary, 1994; Baki, 2004).

Research on gender and computing often conflates gender with sex, with a substantial amount of research over the past three decades devoted to the relationship between gender/sex and computing. One strand of research focused on finding and documenting sex differences in computer use, interests, experience, confidence, and self-efficacy (e.g [Bain and Rice, 2006;

Barron, 2004; Beyer, 2004; Irani, 2004; Colley and Comber, 2003; Whitley, 1997; Busch, 1995; Durndell et al., 1995; Dyke and Smither, 1994;]). For example, Durndell et al. (1995) study of secondary school students showed that girls reported less experience using computers at school, while boys reported using computers out of school contexts more frequently than did girls. In addition, sex differences in positive orientation toward computers were found to be statistically significant, favoring boys over girls. Similarly, Whitley (1997) showed that male students, especially high school students, had higher computer self-efficacy, and more positive affect about computers than did female students. However, the differences in computer uses among male and female students were not statistically significant. Dyke and Smither (1994) reported that, when controlling for prior experience, no significant sex differences were found in computer anxiety or positive attitudes. Busch (1995) assigned simple and complex computer tasks to 147 college students after a computer course and reported sex differences in perceived self-efficacy regarding the completion of complex tasks.

Moreover, Colley and Comber (2003) conducted a study of sex differences among secondary school students with respect to computer use and attitudes and compared their findings to earlier studies in the 1990s. They suggest that while they saw an evidence of reduced sex gap in the use of some computer applications (such as word-processing), the sex attitude differences have largely remained. Boys were still more interested and more confident in using computers than girls. In addition, boys used computers out of school contexts more frequently, particularly for playing computer games. However, they found no significant sex differences in the frequency of accessing the internet or the use of email. Barron (2004) found that boys were more likely to participate in technological fluency building activities than did girls. These activities include multimedia programming, starting news group, building of robots, using CAD program to design, among other activities. To investigate why this was the case, Barron examined the history of classes taken in school and found that four times as many males as females took programming and advanced computing classes. Another study by Bain and Rice (2006) compared attitudes toward and uses of computers, among sixth graders and found that there were no sex differences in students' attitudes or uses of computers. But boys usually indicated they were better than girls in using computers.

Studies of sex differences also examined college computer science major and non-major students. For instance, Irani (2004) showed that female students at Stanford University taking computer science class have lower self –efficacy than male students, even when they have a similar level of achievement. This was due to social factors such as gendered self-presentation rather than object measures of abilities. In addition, Beyer et al. (2003) found that female computer science major students had less computer confidence than did male non-majors.

This approach of searching for sex differences and conflating sex with gender dominated the first wave of research. However, recent research argues against this approach as it promotes essentialist thinking. "Essentialism is the belief that people have properties that are essential to their composition. In this sense, all members of a particular demographic group (e.g., gender, race) share common and finite characteristics. Hence, at the core of essentialism is the belief that since men and women are inherently different in their physical bodies, they are also different in the ways in which they act, behave and think" (Frieze et al., 2011).

While some research endorse the notions of essentialism and attribute *perceived* differences between men and women to biological differences (Baron-Cohen, 2003; Pinker, 2002; Benbow and Stanley, 1983; 1980), other research has challenged this idea and provided evidence that undermining contextual factors can impede our understanding of such phenomenon (e.g. Miller and Halpern, 2013; Eliot, 2010; Barnett and Rivers, 2004; Eccles et al., 1990; Epstein, 1990; Eccles, 1987; Caplan et al. 1985). Specifically, research shows that the human brain is affected by the surrounding culture and experience (Eliot, 2010) and that different socialization practices between girls and boys contribute to perceived sex differences (Eccles et al., 1990; Eccles, 1987). Early differences between boys and girls in their math abilities were attributed to biology (Benbow and Stanley, 1983; 1980). However, Hyde et al. (2008; 1990) showed that there is no longer any difference in standardized test scores between boys and girls. In fact, girls are now receiving better grades than boys in their high school and college math courses (Stout et al., 2011; Bridgeman and Wendler, 1991). Cheryan (2012) suggests that as academic achievement became compatible with the female gender role, girls have caught up in their math performance. In addition, Frieze et al. (2011) suggest that the math performance gap have been eliminated after more positive attention was paid to girls and math, where efforts to encourage girls, and give them more practice and experience were applied.

There are a number of studies that attempted to avoid the sex/gender conflation by using the psychological gender theory. For instance, Huffman (2012) showed that gender roles, specifically, masculinity, is a greater predictor of technology self-efficacy than the designation of biological sex. Similarly, Brosnan (1998) found that femininity correlated with poorer attitude toward technology and Charlton (1999) found that greater masculinity correlated with greater engagement with computers.

The attempt to understand how and why participation in computational activities is often dramatically shaped by sex have reached a consensus that it has less to do with biological sex differences and more to do with cultural, psychological, and societal factors that intertwined together to shape the experience of gender in relation to technology (e.g. Cheryan et al., 2015; Leslie et al., 2015; Fine et al., 2014; Patitsas et al., 2014; Stout and Camp, 2014; Abbate, 2012; Cheryan, 2012; Abbis, 2011; Frieze et al., 2011; Jenson and de Castell, 2010; Misa, 2010; Blum et al., 2007; Cohoon and Aspray, 2006; Blum and Frieze, 2005; Margolis and Fisher 2002; Elkjaer, 1992). Some researchers argue that many girls resist participating in the computing culture because it is associated with stereotypes that are inconsistent with the female gender role (Cheryan et al., 2015; Cheryan, 2012; Jenson and de Castell, 2010; Misa, 2010; Cohoon and Aspray, 2006), which could threaten their social identities as females (Schofield, 1995; Cockburn, 1992; Wajcman, 1991). Jenson and de Castell argue that “women lack technological competence to the extent that they seek to appropriately perform femininity; correlatively, men are technologically competent by virtue of their performance of masculinity.”(Jenson and de Castell, 2010).

In fact, examining the history of computing reveals that in the 19th and early 20th century, computing was actually considered “women’s work” (Luker, 2008). Women were stereotyped as better programmers than men (Gurer, 2002; Little, 1999), as “programming requires lots of patience, persistence and a capacity detail and those are traits that many girls have" (cited in

Gurer 2002). The Electronic Numerical Integrator and Computer (*ENIAC)* women are commonly celebrated as the earliest computer programmers (Gurer 2002; Ensmenger, 2010). These women were recruited to setup the ENIAC machine to perform "plans of computation". The male engineers usually planned algorithms and the women translated the algorithms into code. During that time in the 1940s, coding was largely thought of as handicraft, mechanical and feminine work that didn't require the intellect of a man (Ensmenger, 2010). Coding was expected to be a straightforward process of simply translating an algorithm into a form that a computer can understand. However, in the late 1950s, when computers started being used for commercial purposes, labor shortage have emerged and to the surprise of engineers and managers, coding turned out to be much more difficult and time consuming than they had originally thought. This discovery of inherent programming complexity that requires planning, testing and debugging created a serious intellectual challenge. As a result of the labor shortage, and the emergence of computer programming as an intellectual activity, programming gradually became masculinized (Ensmenger, 2010; Todd et al., 2005).

Two other influential women have always been cited in the reviews of the history of women's participation in computing: Augusta Ada Lovelace and Grace Hopper (e.g. [Gurer 2002; Little, 1999; Ensmenger, 2010]). Augusta Ada Lovelace was the first conceptual programmer, she developed the "loop" and "subroutine" concepts long before electronic computers appeared, and collaborated with Charles Babbage on the Difference and Analytical engines which form the theoretical foundations for modern computers (Gurer, 2002). Grace Hopper was the third programmer on the world's first large-scale digital computer. She contributed to tools and techniques for programming and compiling and supervised the work that produced the first compiler (Gurer, 2002).

Patitsas et al. (2014) examined a historical sociology of female participation in computing and identified four types of barriers that historically affect women's participation in computing from a social point of view. Four intentional/unintentional barriers were identified on institutional and individual levels. The intentional barriers include 1) the *De jure discrimination* (an institutional barrier, such as policies barring women from studying computing and engineering) and 2) explicit sexism (an individual barrier, such as public sexual joking and negative stereotyping). Two other unintentional barriers were identified on the institutional and individual levels as well. The unintentional barriers include 1) the *De facto* discrimination (an institutional barrier, such as policies created without considering its effects on women (e.g. programming experience as an admission requirement to computer science schools) and 2) implicit sexism (an individual barrier, such as unconscious bias against women). While *De jure discrimination* has largely diminished (particularly in the US and western countries), efforts are still being made to combat explicit sexism and *De facto discrimination* barriers. One remarkable example of eliminating *de facto* barriers faced by women is Margolis and Fisher (2002) successful interventions to reach gender parity in the computer science department at Carnegie Mellon University. In their ground breaking research that diagnosed reasons for the gender gap in computer science classes, they discussed that the prevailing cultural messages about computing and how it is often claimed as a male territory were also found in the micro-culture of the computer science department. In the micro-culture, curriculum and teachers' expectations reflect males' pathways into computing, thus, they sought to develop curricula to exploit connections between computer science and other disciplines to ensure that computing is also considered in its social context. For example, adding an undergraduate concentration in human computer interaction. Moreover, admission requirements emphasized prior programming experience, favoring male students. However, they found that prior programming experience was not correlated to student performance, so this criteria was much lessened to admit students who show promise, even without prior experience and provide them with appropriate curriculum which lead them to the same place as experienced students. Other computer science departments implemented parallel policies and interventions to help improve the recruitment and retention of female students (Murphy et al., 2011; Alvarado and Dodds, 2010; Powell, 2008; Townsend et al., 2007).

While a majority of researchers argue that the sex composition of computing is a consequence of the computing culture, Blum et al. (2007) and Blum and Frieze (2005) argue that the causality goes in the opposite direction, that is, the culture of computing is a consequence of sex composition. From their interviews with students from Carnegie Mellon University, they suggest that as the sex composition of the department became more balanced, the culture has changed. Blum and Frieze (2005) and Frieze et al. (2011) question the contextual approach in changing the computer science curriculum to promote gender equity and argue that changes should be based strictly on pedagogical purposes. They argue that “the experiences and perspectives of the women in these other studies were in part shaped by their minority, and sometimes token, status rather than by gender” (Blum et al., 2007). They conclude that there is no need for “female friendly” curriculum in order to attract and retain female students into computer science departments and that attempts to change the culture of computing might be unnecessary or even counterproductive if these changes are based on presumed gender differences.

Whether the underrepresentation of women in computing is a consequence or a cause of the computing culture is an open question. I believe that evidence exists in both directions. On one hand, research has shown that changing stereotypes of an academic field to be less masculine increases women's motivation to participate in that field (Cheryan et al., 2009; Ridgeway, 2011). On the other hand, stereotypes associated with a field become more feminine as more women enter that field (Misa, 2010; Phillips and Austin, 2009). In this regard, Cheryan (2012) suggest that "the male-dominated domains could begin the process of welcoming women by altering their masculine stereotypes, and the process would perpetuate itself as more women enter the domain."

Patitsas et al. (2014) and Fine et al. (2014) argue that implicit sexism and unconscious bias against women has become the dominant barrier for women entering computer science (and STEM fields in general). Empirical studies have shown how implicit sexism against women can constrain their participation and success in STEM fields. In one study, Steinpreis et al. (1999) showed that simply changing the name, from a female name to a male one, on the same CV for a position as an assistant professor of psychology significantly affected the competence ratings and the chances of being accepted, favoring male applicants. This finding is consistent with a more recent study (Moss-Racusin et al., 2012) where science faculty from both public and private research universities were asked to evaluate an application for a lab manager position from an undergraduate student. The applications were randomly assigned to either a female or a male name. When the name on the application was female, faculty rated the application as less competent and they were less likely to hire the applicant than when the name on the application was male. Moreover, Budden et al. (2007) found a significant increase in female authorship of research papers in the journal of Behavioral Ecology after the double-blind review policy was enforced. The prevalence of the gendered assumptions and stereotypes about men and women in society usually lead more people to evaluate women as less competent, especially in domains typically associated with men (Eagly, 2002).

Moreover, research shows that students are significantly influenced by their teacher's expectations, and these expectations are internalized by students (Bamburg 1994; Raffini 1993). Teachers' beliefs about technology, along with their beliefs about appropriate roles and behaviors for boys and girls can influence girls not to pursue computing. For example, research shows that females in mixed gender classes report significantly less teacher support with technology use than females in all-female classrooms (Crombie et al., 2002; Crombie and Armstrong, 1999). These behaviors convey implicit messages to girls that their learning and participation is less important than that of boys. More importantly, parent's relationship with their children communicates implicit and explicit beliefs about appropriate roles and behaviors for girls and boys. It is common for parents to treat their children in gendered ways by the virtue of their sex, which is evident in the ways parents often encourage boys and girls to take different educational paths and prepare for different careers. Margolis and Fisher (2002) study revealed that male students often reported that their fathers provided them with computers and spent time tinkering on the machine with them. They also often reported their mothers as computer-phobic or incompetent. The female students reported much less frequent bonding experience with the computer with their parents. Similar findings were reported by Busch (1995), where boys reported getting significantly more support and encouragement from their parents and peers than did girls.

In addition to social factors, research suggests that cultural factors produced by society can affect women participation as well. The image, stereotypes, and culture of computing have been studied as factors contributing to female underrepresentation in computing. Kiesler et al. (1985) and Wajcman (1991) noted the strong overlap between the computing culture and the masculine culture. For example, they indicate that the language of computing incorporate many violent terms such as hacking, brute force, and blue screen of death. Similarly, early computer games usually feature competition and destruction. This culture and image of computing contributes to women underrepresentation as they may reject it as an unappealing activity and conform to the stereotype that it is a male appropriate activity (Cohoon and Aspray, 2006).

In addition, the lack of perceived similarity between the female gender role and people in the computing field was shown to be an important factor contributing to women's lack of interest in computer science (Cheryan et al., 2011; Cheryan et al., 2010; Cheryan et al., 2009; Margolis and Fisher, 2002). For instance, researchers argue that stereotypical identities associated with computer science professionals can have an enduring negative effect on girls' interest and anticipated success in computer science and that this negative effect is mediated by perceived dissimilarity (Cheryan et al., 2011; Cheryan et al., 2010). In addition, a study by Cheryan et al., (2009) revealed that when a computer science classroom contains objects stereotypically associated with computer science (e.g. Star Trek poster), female undergraduates expressed less interest in computer science than their male counterparts. However, simply redesigning the classroom to include objects not stereotypically associated with computer science (e.g. art, phone books), significantly increased female interest in computer science. This study show how the design of educational environments influences student's sense of "ambient belonging."

Margolis and Fisher (2002) show that stereotypes about computer scientists as geeks who narrowly focus on technical work can be more damaging for women than men. In their interviews with students, they reported that one third of male students said they differ from the stereotype while more than two thirds of female students felt different from this stereotype. Additionally, 20 percent of women questioned whether they belong in computer science as they felt they do not share the same interests as their male peers and do not “dream in code”. To address this issue, they advocate broadening the perception of the field by promoting multiple valid ways to be in computer science and explain how computer science is more multi-dimensional than the standard “Boy hacker” symbol.

Cohoon et al. (2011) interestingly analyzed gender authorship for all conferences in the ACM digital library from 1966 to 2009 and suggested that “*alignment with gender stereotypes predicts the extent of women’s authorship*”, where a greater proportion of women authors was associated with conferences such as Human Factors in Computing Systems, while a greater proportion of men authors was associated with conferences on Algorithms.

A number of studies have examined the effects of *stereotype threat* on women’s interest and performance in STEM fields (Shapiro, 2012; Markus, 2011; Good et al., 2010; Koch et al. 2008; Davies et al., 2002; Steele, 1997). Stereotype threat refers to “being at risk of confirming, as self-characteristic, to a negative stereotype about one's group” (Steele & Aronson, 1995). The fear of being treated or judged based on a negative stereotype about one’s group has been empirically shown to impair one’s ability to perform their full potential (e.g.[Steele, 1997]) as well as to pressure *disidentification* from the domain where this group is negatively stereotyped (Steele, 1997).

Women's and girls' disidentification with computing can be attributed, in part, to their susceptibility to stereotype threat (Patitsas et al., 2014; Koch et al., 2008; Peckham et al., 2007; Cohoon and Aspray, 2006; Todd et al., 2005). Koch et al. (2008) investigated whether stereotype threat can influence women's attributions of failure in a computer task. A number of college female and male students were asked to work on a computer task and were divided into three groups. The first group was told that men usually perform better than women do (negative threat condition). The second group was told that women usually perform better than men (positive condition) and the third group was not told anything (control group). The task was intentionally designed so that completing it was actually impossible due to a faulty USB device given to participants. Results of this study suggests that there was a stereotype threat effect on women's attribution of failure, where women in the negative threat condition attributed the failure to their own lack of ability while men attributed the failure to the USB device. In the positive and control conditions, there were no significant differences between women and men in their attribution of failure.

In addition, studies have shown that the mere underrepresentation in a domain can activate stereotype threat concerns (Murphy et al., 2007; Dasgupta and Asgari, 2004; Sekaquaptewa and Thompson, 2003; Inzlicht and Ben-Zeev, 2000). Murphy et al. (2007) created two versions of a video advertisement for MES (math, engineering and science) conference. One version had an unbalanced gender representation and another had a balanced gender representation. They found that women who watched the unbalanced video reported lower sense of belonging, and were less willing to participate in the conference compared to women who watched the gender balanced video. While watching the unbalanced video, women also showed faster heart rates, greater skin conductance and greater sympathetic activation of the cardiovascular system.

Another relevant study by Good et al. (2010) examined the effect of stereotype threat on students' comprehension of science lessons by using stereotypic and counter-stereotypic textbook images. In this study, three student groups were assigned to read a section of chemistry textbook illustrated with either images of only male scientists, only female scientists or with both male and female scientists together. In a later exam on the section, girls scored higher than boys in the female scientists only condition; boys scored higher in the male scientists' only condition; and in the mixed gender condition, the scores for both girls and boys fell between their scores in the stereotypic and counter-stereotypic conditions. Interestingly, this study provides evidence that "the mixed gender condition didn't simply represent the absence of stereotype threat. Instead, the condition seems to equalize the performance of girls and boys" as there was no significant difference in the scores between girls and boys.

In a similar fashion, I am interested in investigating whether a gender-neutral design might still hold a degree of stereotype threat to girls who are interacting with a computer programming game, in which case we would expect girls' learning and attitude scores in this condition to be significantly lower than the scores of girls in the girl-oriented design condition.

Intriguing work (Buechley et al., 2010; Buechley et al., 2008; Horn et al., 2009, Kelleher et al., 2007) suggests that the nature of the programming environment and of the activities can dramatically change girls' interests, motivation, and engagement with computer programming. Recent studies show that e-textiles (Kafai and Burke, 2014; Weibert et al., 2014, Buechley et al., 2008) can promote female interests in electronics and computer science and "disrupt binary gender roles" by leveraging girls' cultural practices and traditions of play and incorporating them creatively with advanced computing activities. For example, Horn's work on programming systems in museum setting's showed that girls were significantly more likely to use a tangible programming exhibit than a graphical programming exhibit. In addition, Buechley developed an e-textile construction kit, called LilyPad Arduino, which enables novices to build soft interactive clothing. This construction kit was especially appealing to an unusual community of developers; it was successful in engaging a large number of women in designing and engineering technology. Buechely and Hill compared LilyPad community to the traditional electronics community who used Arduino and found a strong relationship between user's gender and the type of board they purchased and used. The difference between the proportion of females and males who bought and used LilyPad and the proportion of females and males who bought and used the traditional Arduino was highly statistically significant. In addition, Weibert et al. (2014) study on e-textiles in computer clubs for children in mixed gender groups showed how children's thematic choices were initially influenced by conventional binary gender roles. However, these choices were changed and did not seem to matter later, in the practical context of the e-textile project work. Weibert et al. argue that e-textile can "disrupt normative binary gender allowing for the development of feminine technical identities, masculine creative identities, and everything in between. In addition, it alleviates girls from feeling gender inauthenticity when engaging in technical skills, which has been argued to be key barrier to the inclusion of women in computing".

Kelleher's et al. (2007) work on 'Storytelling Alice' also shows how changes to the programming environment itself can promote girls' interest programming. In her study, Kelleher added a support for story creation to the programming environment 'Alice' and compared groups of middle school girls who used Alice and Storytelling Alice. Kelleher found that girls who used Storytelling Alice were more motivated to program than girls who used Alice and they also showed stronger evidence of engagement with programming. These studies paint more of a picture of why we should be interested in the programming environment itself. It also shows how we can support new cultures of computing and open new directions to broaden participation.

2.1.1.1 Gender and Computer Games

Computer games are frequently seen as "*children's first and most compelling introduction to digital technologies*" (Hayes, 2005) and often considered a gateway into computer science and information technology careers (Tillberg and Cohoon, 2005; Margolis and Fisher, 2002; AAUW, 2000). Several studies found gaps between college female and male students in their computer and programming experience and that this experience is often acquired informally through game playing, hacking, and unguided exploration (Murphy et al., 2006; Margolis and Fisher 2002; Kersteen et al. 1998; Busch, 1995; Taylor and Mounfield 1994).

The Girls' Game Movement in the 1990s was, in part, a political response to the national concern about the gender gap in technological fields (among other goals well documented in Jenkins and

Cassell, 2008). Developing games targeted specifically toward girls was thought of as the best way to encourage girls to participate in the computer gaming culture. This movement's reliance on targeting stereotypical girl interests created a considerable concern (controversy) among researchers and feminists as only another tool to reinforce existing gender stereotypes (Brunner, 2008; Lazzaro, 2008; Taylor, 2008; Yee, 2008; Flangan, 2005; Cassell, 2002). These so-called 'pink' games were often shallow, and did not allow for sophisticated features that enable the acquisition of advanced computing skills (Hayes, 2008). Debates about contextual formulations around computer game play and how they matter more than the game mechanics in understanding the issue of gender and gaming have spurred, resulting in a call for more gender-neutral games (Ray, 2004; Cassell, 2002). For instance, Taylor points out that how people know about a game, get their hands on it, are taught how to play it, is deeply informed by their social networks and quite often, women gamers inhabit a kind of closeted gamer identity. Likewise, Lazzaro caution against designing games that appeal to a single sex because it ignores the fact that both men and women could enjoy the same game.

A community of female gamers called 'Grrl Gamers' opposed this movement as well, arguing that female gamers can have similar preferences and level of engagement in games as males, and challenging cultural positions and definitions of femininity.

The huge success of some of the Girls' Game Movement products, such as Barbie Fashion Designer, requires a deeper understanding of why many girls were drawn into playing these games. In this regard, I find Yates and Littleton (2001) broad conceptualization of engagement with computer games particularly useful. They argue from a sociological and psychological standpoint that both positions, the Girls' Game Movement and Grrl Gamers, "can be theoretically encompassed and understood if computer gaming is viewed as contextually situated and socially constructed activity that draws heavily upon the cultural position of the gamers themselves." Specifically, they view computer games as a medium to be read, just like any other media text, and that Girls' Games Movement utilized girls' cultural subject positions to create new kinds of computer games. These games contained elements that can afford girl-oriented preferred readings. On the other hand, "the Grrl Gamers who make criticism of such software are able to negotiate the male-oriented preferred readings inherent in contemporary games. In doing this, some Grrl Gamers have taken up subject positions which are critical to some of the ideological positions that they perceive in the Girls' Games Movement. These ideological positions derive from the ways in which Girls' Games draw upon and reflect society's current dominant discourses and ideologies of femininity." In other words, the cultural and subject position of women and girls, who embrace their cultural definitions of female, prevented consequent interaction with mainstream computer games, as these games had inherently male-oriented affordances and preferred readings. At the same time, some women and girls had subject positions that challenge their cultural definitions of female, which liberated them from any anxiety or concern regarding possible interaction with these games. In making that argument, Yates and Littleton draw on studies that emphasize the importance of content and context in understanding children's engagement with computer games. For instance Littleton et al. (1998) conducted a series of studies to investigate the influence of different game designs on boys and girls performance. They developed two versions of a problem solving adventure game where one was called *Kings and Crown* and included male –oriented characters and metaphors such as pirates and captains. The other game was called *Honeybears* and had gender-neutral representation and metaphors. They compared the performance, measured by successful moves, of 11 and 12 year old boys and girls on the two versions and found that girls' performed significantly better in the gender-neutral version. On the other hand, boys' performance was not affected by the version of the game. This study highlight the importance of content on player's reading of the game. The images and metaphors used to represent the game were particularly relevant to how girls' oriented and interacted with it, despite the identical underlying structure of the two versions.

Additionally, Littleton et al. (1999) conducted another study to examine the effects of different contextualization of a computer based perceptual-motor skills task on children performance. They developed software called "Electric Eel" which consisted of a double cursor framing an irregular line (Figure 9), which moved from right to left across the screen at a regular speed.

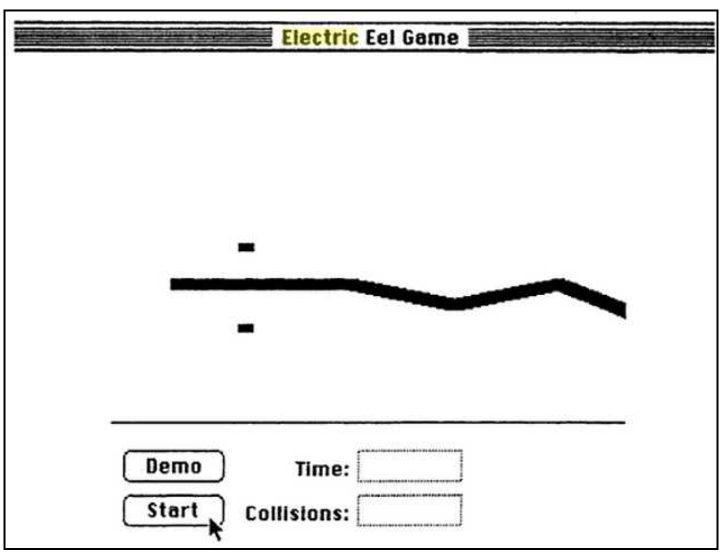


Figure 9. Electric Eel software

The objective was to use the mouse in order to raise and lower the cursor so that the line would pass smoothly through the gap, without hitting the edges of the cursor frame. They introduced the software to children in two different contexts. In one context, children were told that the software is a computer game. In the second context, the software was represented as a skills test. In analyzing the performance of children in the two context conditions, they found that when the software was represented as a skills test, there were no gender differences in children's performance. However, when the software was represented as a computer game, boys' performance was significantly better than girls' performance. Moreover, girls performed significantly better in the skills test context condition than in the computer game context condition. This study highlights the importance of social and cultural contexts on players' reading of the game.

In discussing these two studies, Yates and Littleton argue that what makes games 'boring' or 'exciting' for children is not only the underlying structure of the game, but equally important the content and metaphors of the game through which this is activated. These studies also undermine essentialist thinking, as perceived differences in skills and preferences between boys and girls were not innate, but rather the result of cultural forces.

Additionally, scholars and serious game designers Heeter and Winn suggest that educational games used in the context of classroom learning will trigger player's cultural expectation about gender (Heeter and Winn, 2008). Together they created a game called Life Preservers to study the effects of rewarding speedy play versus rewarding exploration on play style and learning and found that when speedy play was rewarded, girls played faster and made more mistakes while when exploration was rewarded, boys slowed down and made fewer mistakes. Interestingly, the sex of the player was a more significant predictor of play style than how often the player played games. They conclude that taking a gender blind position in designing games might feel appropriate but is, in fact, risky as it overlooks the power of cultural expectations and the performance of gender.

To this end, I was interested in possible effects of different game designs on the ability to learn computer programming, where one design takes a gender blind position and the other builds on a more feminine cultural form of dress up dolls.

A recent report by the Entertainment Software Association (2013) shows that 45 percent of game players are female. While the number of females who play computer games is continually increasing, the type of computer games preferred and played can be usually predicted based on player's sex. Females consistently reported preferences for virtual worlds and puzzle-like games, while males reported preferences for first person shooter, sports and action games (e.g. Homer et al., 2012; Markus, 2012; joiner et al., 2011; Hartmann & Klimmt, 2006; Lucas and Sherry, 2004). The bestselling video game *The sims*, a life simulation game, has attracted a large number of females (Gee and Hayes, 2010). Part of this success is attributed to the fact that the design team of the game included women (Gee and Hayes, 2010). In fact, Heeter et. al. (2005) asked two same sex-groups of girls and boys to design educational games for space exploration. They later showed the two games to 145 middle school children without revealing information about the design team and found same sex preferences to the games. Girls preferred the game designed by girls and boys preferred the game designed by boys. Consistent with Huff and Cooper (1987), they reveal that designer's gender and gender-based stereotypes can influence the design outcome of the game.

Nowadays, women's access to digital technologies and computers is no longer a concern. The gap between males and females in online access has largely closed; in fact, women's use of the computer for certain practices (e.g. e-mail and blogging) has actually exceeded that of men (Roberts et al., 2005). But women are *still* underrepresented in computer science and technology related fields. The National Center for Women and Information Technology (2013) reports that 57 percent of 2012 undergraduate degree recipients were female but only 18 percent of 2012 Computer and Information Sciences undergraduate degree recipients were female. They also report a 79 percent decline in the numbers of first year undergraduate women interested in majoring in Computer Science between 2000 and 2013. Hayes (2008) argues that young people's attitude toward computers, as well as their aptitude and interest in computer science are highly influenced by their informal experiences with computers and that girls need to play games that have the most potential for developing identities associated with IT expertise. In this regard, she stresses that girls must be given the opportunity to discover their talents, never forced into technology, but to make it possible for them to develop a stronger bond between computers and their career choice. To this end, I am interested in how can we do a better job motivating girls to explore activities related technology and computer science? And if 'gender neutral' is always the best way?

2.1.2 Computer Games in Education

Developmental psychologists have long argued for the importance of play in children's development and learning (Bruner, 1976; Vygotsky, 1976; Piaget, 1937). For example, Jean Piaget discussed how the stages of child intellectual development are reflected by the forms of playing. Bruner argued that playing in itself is a form of learning. According to Bruner, combinations of actions can be carried out during play that would otherwise never be tried. The experiences with these actions then can serve as the foundation for later learning. Lev Vygotsky discussed how playing has a significant impact in children's social and emotional development. In his article Play and Its Role in the Mental Development of the Child, Vygotsky states: "The play-development-relationship can be compared to the instruction-development relationship, but play provides a background for changes in needs and in consciousness of a much wider nature. Play is the source of development and creates the zone of proximal development."

Computer and video games are relatively a new form of play that has emerged following the emergence of personal computing. Computer games refer to games which are played on a PC while video games refer to games which need a special console. In this dissertation, I will use the term computer games to refer to the two types for short since I am interested in their shared concept rather than how they operate. Computer games were first developed in the 1940s as a form of entertainment, but their popularity exploded after arcade games, personal computers, and gaming consoles were introduced to the general public in the 1970s and 1980s.

According to the Entertainment Software Association (2013), 58 percent of American households play computer or video games, and 51 percent of U.S households own a dedicated games console. Females compromise 45 percent of the total number of gamers, while 55 percent are males. 52 percent of parents believe games are a positive part of their children's lives. A recent study by NPD Group, a leading marketing research company, reports that around 91% of children aged 2-17 play computer games. This suggests that computer games could be a potentially valuable way to engage a large and diverse audience.

The "edutainment" movement for computer games that are design to both educate and entertain at the same time followed shortly after observing game players exhibiting problem solving skills and persistence which are key characteristics to a successful learner (Gee, 2007). The edutainment market rose dramatically until the 1990s to the point that 'The Learning Company' was considered the world's second largest software company after Microsoft (Shuler, 2012). Best-selling video games like 'Where in the world is Carmen Sandiego?' which was developed to get children interested in Geography, and 'The Oregon Trail' which teaches the realities of the 19th century pioneer life, are examples of games that can be simultaneously fun and educational. However, the edutainment industry declined in the late 1990s due to economic factors including the emergence of mass market retailers and the downward pricing pressure which left little to invest in innovation and shifted to licensing new popular characters over the same content over and over again. An equally important factor contributed to this downfall was the focus on mostly drill and practice games (e.g. Math Blaster and Reader Rabbit), which were assumed to only improve school performance. While drill and practice can have positive effects in learning especially teaching lower order thinking skills, narrowly focusing on it leaves us with just a little of what computer games has to offer (Hayes, 2008; Gee, 2007). Papert (1998) referred to edutainment as Shavian reversal —offspring that keep the bad features of each parent and lose the good ones— where he explain that edutainment is mostly the combination of drill and practice (one of the lowest forms of education) with less than entertaining game play.

Today, educational researchers and literacy scholars led by James Paul Gee, Kurt Squire and David Williamson Shaffer among others are passionately advocating a new powerful movement in educational games. They argue that games offer rich learning opportunities and can promote understanding in highly motivating contexts (Gee, 2007; Shaffer, 2006; Squire, 2006). They argue that games can work as a vehicle to spark children's interest around topics they never would have considered relevant or of interest before. And while games are usually not sufficient as a course of study, they can help many students familiarize themselves with facts beyond temporary memorization. Gee (2007) outlines ways in which he sees the design of video games imbed effective learning principles in highly motivating context. For example, the 'practice principle' in learning, where learners need a great deal of practice in a context where they are engaged in the material, not bored with it, is embedded in most video game designs by creating a challenging yet engaging context. In addition, the 'incremental principle' in learning, where learners create connections in earlier, easier stages that aid them in later, more difficult stages, is also embedded in most video game designs where games start off relatively easy to allow the player the explore and gradually increase in complexity and challenge.

Shaffer's and others views of using technology to change education for the better is consistent with Papert's discussion about children and computers in his book "The Children Machine." In this book, Papert invites readers to imagine a party of time travelers from an earlier century consisting of a group of surgeons and a group of school teachers where each group is eager to see how much things have changed in their profession a hundred or more years into the future. If the group of surgeons is put in the operating room of a modern hospital, they would most likely be unable to figure out what the newer generation of surgeons is trying to achieve or what is the purpose of the many strange devices used, it would be totally and absolutely unfamiliar situation to them. On the contrary, the teachers group, when put in a classroom, might be confused about a few strange objects, but they would fully understand what the teachers are trying to accomplish and most importantly, could simply take over the class. Papert uses this example to clarify how the progress of some areas of human activity has been uneven. He confirms that there has been a change in the schooling system, but argues that it was not in significant ways or at a comparable rate to other areas such as telecommunications and transportation among other areas.

Papert also interestingly demonstrates that we care too much about the role of the teacher to the point that our language has a bias toward giving the teacher (rather than the student) control over the learning process, to explain this interesting thought, he uses the sentence: The teacher teaches object. Papert also explain that this bias is evident that the word pedagogy means the art of teaching, while there is no parallel word for the art of learning in the dictionary.

Shaffer (2006), in his book 'How Computer Games Help Children Learn' advocates using the power of computer games as part of the key to solve the current crisis in education by giving children access to experiences that build interest around the subject matter which leads players to explore further, outside the computer game context. He discusses how games can embody some of the influential ideas about progressive education by the famous education reformer John Dewey.

Progressive education pedagogy suggests that people should be free to learn by exploring their own interests. According to Dewey, the process of moving from interest to understanding is learning by doing, or to be specific, learning by trying to do something, making mistakes, and then figuring out how to fix them. This is typical of what a game player does while playing a computer game.

In the world of computer games, quite contrary to conventional formal schooling, Gee points out that challenges are welcome where easy is not so good and hard is actually not bad. Games can provide players with embodied experiences that can help them in developing situated understanding (Gee, 2007). Players immersed in personally meaningful experiences learn facts more easily and use these facts to achieve desired ends within that situated domain (Shaffer et al., 2004). In using dress-up dolls, presumably meaningful cultural form for many girls, as a basis for designing one of my games, I was interested in finding whether that would potentially provide an advantage in the comprehension of computer programming concepts over more gender-neutral design.

Shaffer's studies shows how students', from diverse age range, engagement in epistemic games (epistemic games are a type of computer games that help players learn to think like engineers, urban planners, journalists, lawyers and other innovative professionals) help them better achieve in school and motivate them to develop knowledge, skills and attitude that they need to succeed in the digital age. He goes on to show how the epistemic games he used in his research highly impacted the students' perceptions about the subject matter. Shaffer envisions epistemic games as a third place, or perhaps, as he noted: "more appropriately a third space" between formal schooling and traditional commercial games. My design shares some characteristics with epistemic games in that it helps players learn to think like programmers.

Furthermore, Squire's research with low-income African American students in high school and in an after school program showed that students who were underachieving or uninterested in history classes have "developed new vocabularies, better understandings of geography, and more robust concepts of world history" after engaging them with Civilization III, a highly complex history-based commercial game simulation (Squire, 2004). Squire reports that engagement in this strategy game, inspired some students to ask questions like, "Why is it that Europeans colonized the Americas, and why did Africans and Asians not colonize America or Europe?" (Squire, 2006.)

Literacy scholar, James Paul Gee (2007) reports findings from his research that "a number of young people who have used the domain of video games as a fruitful precursor domain for mastering other semiotic domains tied to computers and related technologies. Indeed, several of these young people plan to go to college and major in computer science or related areas." He then continues to explain how computer games have the potential to encourage players to explore themselves with new and different identities. When players take on different identities within a semiotic world, their pre-supposed perceptions about the world might be either reinforced or challenged (Gee, 2007).

Gee explains that a game player exhibits three identities while playing some kinds of computer games (mostly role-playing games): virtual identity, real identity and projective identity. The virtual identity is the "player's identity as a *virtual character"*, where virtual character is italicized to indicate that the stress is on the virtual character acting in the virtual world of the game. The real world identity is the player's identity, a non-virtual player playing the computer game. This identity is represented as "*player* as a virtual character," where player is italicized to indicate that, in this identity, the stress is on the real-world character playing the computer game. The third identity is called the projective identity, playing on two senses of the word "project," meaning both "to project one's values and desires onto the virtual character" and "seeing the virtual character as one's own project in the making, a creature whom the player fill with a certain trajectory through time defined by his aspirations for what he want the character to be and become, of course, within the limitation of the virtual character's capacities." The third identity is the most important one for understanding the power and potential of computer games but the hardest to describe. This identity is represented as "player *as* virtual character" where the word "as" is italicized to indicate that, in this identity, the stress is on the interface between – the interactions between— the real world person and the virtual character. Gee further discusses that if learners in classrooms carry learning so far as to take on a projective identity, something magic happens:

> *A magic that cannot take place in quite the same way when playing a video game. The learner comes to know that he or she has the capacity, at some level, to take on the virtual identity as a real world identity. (p. 66)*

Gee goes on to explain that he is not making the argument that what people are learning when they are playing video games is always good, but rather, what they are doing when they are playing good computer games is often good learning.

Gee's discussion of how identities work in learning and using learning to play computer games as a crucial example is also discussed by Squire and other researchers in this domain. For example, Squire explain that computer game players can inhabit roles otherwise inaccessible to them, which help them in developing new identities through not only game play but also through the broader gaming communities (Squire, 2006). Epistemic games for the most part play on the identities argument in that it invites players to take on the identities of experts and gives them access to their ways of thinking with the goal of producing a deep fluency within a semiotic domain (Shaffer et al., 2005). This inspiring discussion about identities provides a sound and convincing argument to push this movement forward.

Research has shown that computer games can also have unintended outcomes. For example, improving perceptual skills was one of the findings from Green and Baveliar study (cited in Vorderer and Bryant, 2012) where they found that people who play video games show better attention to cues across the visual field and attend to more visual cues overall than people who do not play video games. Another study by Rosser et al. (2004, cited in Vorderer and Bryant, 2012) found that surgeons who have some experience playing video games perform laparoscopic surgery faster and make fewer mistakes; laparoscopic surgery is a type of surgery in which a tiny camera is inserted through an incision to the abdomen and other surgical instruments are inserted through other small incisions and then the surgeon uses keypads and joystick to operate while watching his performance on the monitor.

Accepting the fact that computer games teach something, whether intentional or not, leads us to question if we can design better games to promote more effective education.

While the type of puzzle games I developed differ from immersive, epistemic, and fast reflex-based games, I believe they can all share some effective learning principles (Gee, 2007).

Finally, it is worth acknowledging that computer games may not be suitable for some academic subjects or even some elements of a certain subject, so it is also worth investigating what is fundamentally engaging about the subject and put players in touch with it and to shift the focus from delivering content to designing meaningful experiences.

2.2 Related Work

2.2.1 Educational Computer Games

2.2.1.1Computer programming games

Code.org lists a number of computer programming games/tutorials in their website. None of these games leverages cultural traditions of girls' play. However, they recently included a game featuring Disney's *Frozen* characters, Anna and Elsa, as part of their efforts to attract more girls to try coding (Figure 10).

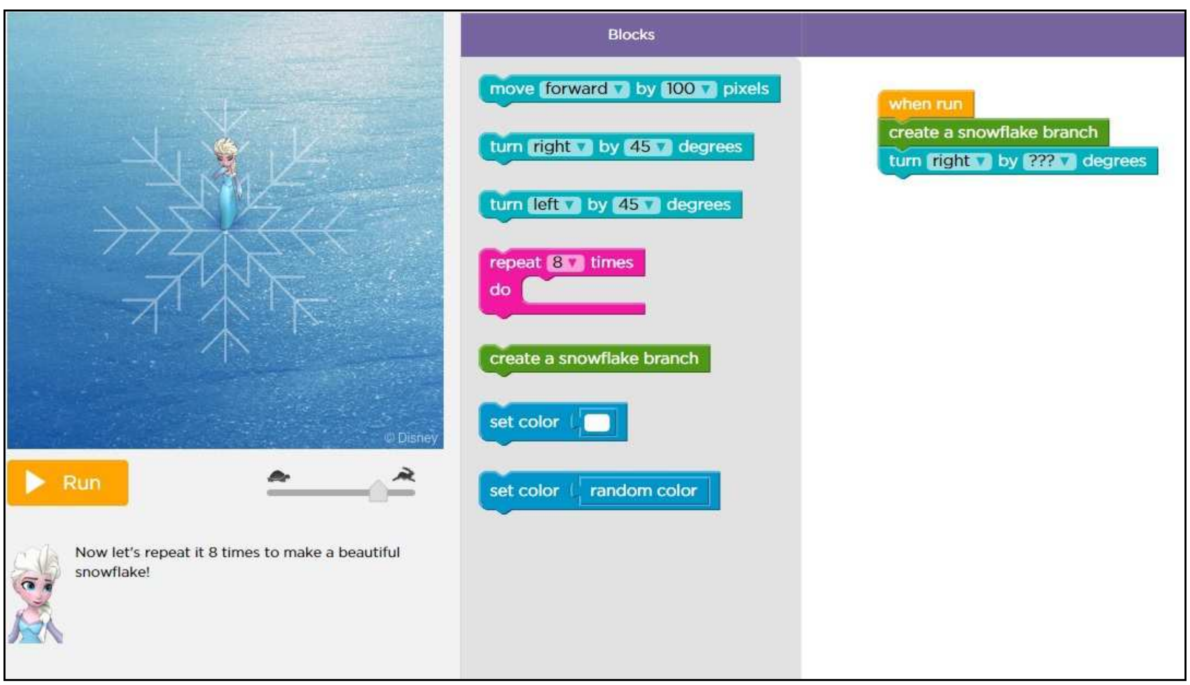


Figure 10. Frozen activity screenshot from code.org

A number of older computer games were also developed to teach programming. For example, Karl the Robot and Robocode are computer games where the player exercise programming by writing code to control robots (see Figure 11).

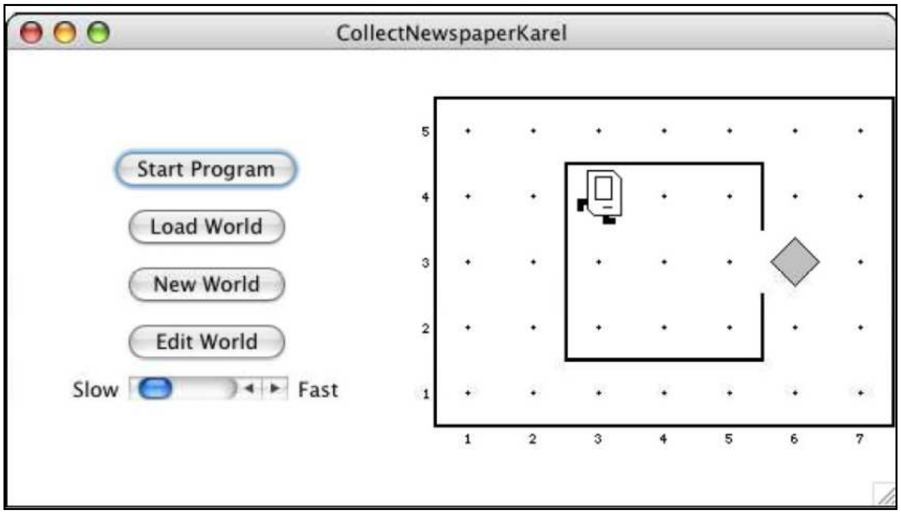


Figure 11. Karel the Robot screenshot

Of a particular interest, RAPUNSEL (Flanagan et al., 2005) and Virtual Family (Duplantis et al., 2002) are games that introduce programming within contexts that may be more motivating for girls. For instance, RAPUNSEL (Flanagan et al., 2005) is a dance 3D - game designed for 10-12 year olds with the goal of empowering young people to learn about computer science. In RAPUNSEL, the player program dance moves and can participate in dancing competitions to win rewards (see Figure 12).

Figure 12. RAPUNSEL game screenshot

Virtual Family (Duplantis et al., 2002) provides a completely functioning game that players can extend by altering or adding to the game existing code, it is specific to Java programming and targets high school students.

Neither RAPUNSEL nor Virtual Family employ a graphical programming language, instead the player needs to program actions using text. Graphical programming languages can eliminate syntax errors, a major source of frustration while learning to program. In the next section, I highlight the Direct Manipulation paradigm as a motivator for visual programming.

While these two games targets middle and high school students, Rosie the Fashionista and Build a House targets both elementary and middle school children.

2.2.1.1Other Educational Games

Recently, there has been an emerging paradigm of game-based learning and training used in the military, health care, business, public policy and education.

The military is one of the largest groups that have embraced the use of computer games for training but other sectors are catching up quickly. Examples include McDonalds where they use video games in employee training seminars (business), MayoClinic also uses video games like Name That Congenital Abnormality to train residents (health care). Marcom Group teaches employees how to handle hazardous waste and similar tasks uses "jeopardy" style games (Buckley and Anderson, 2006). In education, quite a lot of computer games have been utilized whether in a classroom context or as an informal learning tool. For example, Life Preserves (Figure 13) is a computer game that teaches adaptation and evolution and was used in the classroom settings (Heeter and Winn, 2008).

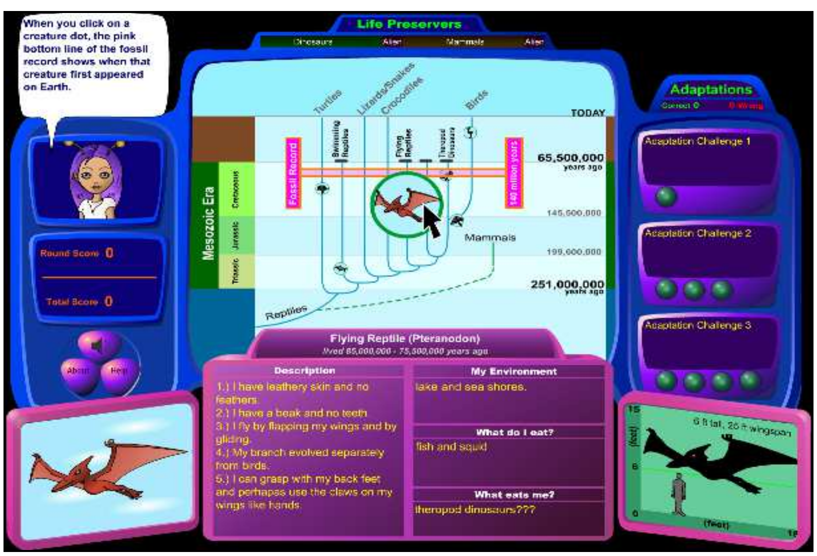


Figure 13. Life Preserves screenshot

Museums, zoos and botanical gardens have also shifted from being merely repositories for display to more of informal learning environments, where visitors come to learn about things of interest. Build-a-Tree (Horn et al., 2012) is a tabletop, multi-level puzzle game that also teaches evolution and was used at the Harvard Museum of Natural History (Figure 14). In analyzing visitor engagement with this game, Horn et al. argue that visitors brought to the museum their existing social practices around game play, which contributed substantially to their collaboration and engagement. In a similar fashion, I was interested in finding whether Rosie the Fashionista game would cue existing patterns of social engagement around dress-up dolls as a way to create a more productive learning experience for young girls.

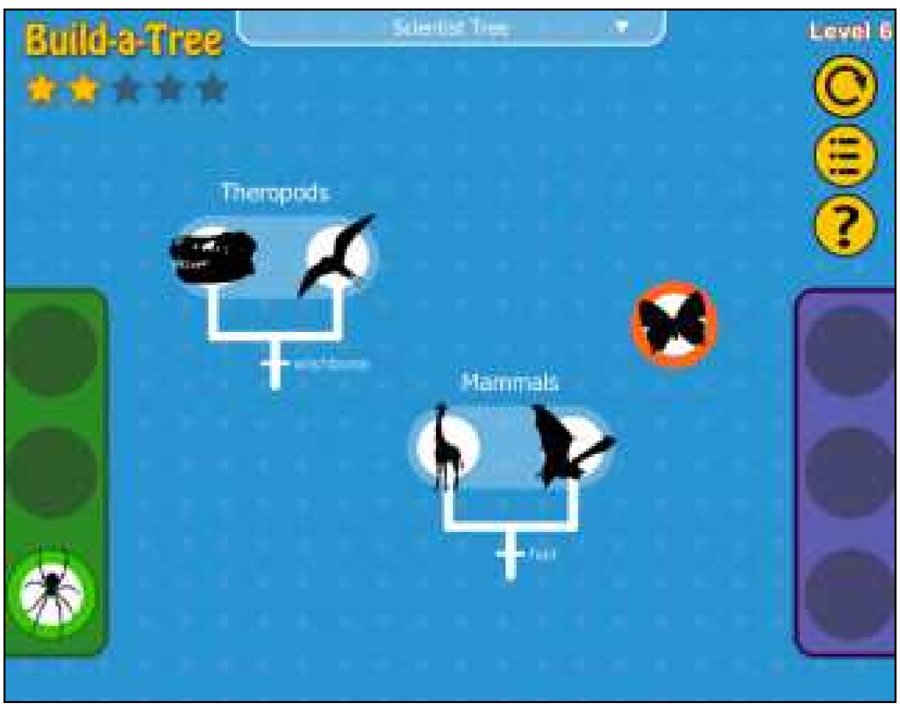


Figure 14. Build-a-Tree screenshot

Computer games were also used to teach geometry and algebra (Corbett et al., 2001), physics (Squire et al., 2004), Urban planning (Shaffer, 2006), Journalism (Shaffer, 2006), and engineering design (Svarovsky and Shaffer, 2006). These games were successful in engaging students in the subject matter and motivated them to learn more. In particular, Svarovsky and Shaffer (2006) developed an engineering design game called Digital Zoo, where middle school girl's work as engineers by engaging in activities modeled after an undergraduate engineering design course. They found that the Digital Zoo game helped girls in developing an engineering identity.

Additionally, Joiner et al. (2011) developed Racing Academy, a racing car simulation/video game that supports the learning of mechanical engineering concepts to undergraduate students (Figure 15).

Figure 15. Racing Academy screenshot

They found that the game helped students (both females and males) learn mechanical engineering concepts and there were no gender differences in the beneficial effects of the game. It was particularly interesting in this study to find that female students found the game more motivating the male students, given that a car racing game theme might be described as male-oriented. In discussing their findings, they suggest that "females will benefit as equally as males regardless of the type and design of the digital game". Additionally, DigiQuilt (Lamberty and Kolodner, 2004) is an example of a digital learning environment for mathematical principles such as symmetry and fractions.

Whyville (Figure 16) is a virtual world where players can explore topics in science, economics and citizenship. Whyville have more than 1.2 million registered users and girls represent over 68% of all players (Kafai, 2010). In analyzing gender play patterns, Kafai et al. (2009) noted that "social norms of what it means to be a girl were evident in this virtual world, with heavy emphasis on avatar representation that indicate status and tenure". Virtual worlds and casual games were found to be especially popular among women and girls. Several studies found significant differences between boys and girls in the types of games played and preferred. Girls played virtual worlds and puzzle-like games more than boys, while boys played action and sports game more than girls (e.g. Homer et al., 2012; Markus, 2012; joiner et al., 2011; Hartmann & Klimmt, 2006; Lucas and Sherry, 2004).

Figure 16. WhyVille screenshot

2.2.1 Educational Programming Languages

A variety of programming environments have been developed by researchers to introduce computer programming to novices, especially children. Logo is one of the first educational programming languages and was created by Papert in the 1970s. Logo is a powerful language for exploring mathematical problem solving. Logo combines a physical (and virtual in later editions) turtle as a new way to teach geometric concepts to children. Logo has influenced many other educational programming languages including Boxer, EToys, NetLogo, StarLogo and Scratch, to name a few.

Fields of related research examine the creation and evaluation of visual (e.g. Kelleher et al., 2007; Resnick et al., 2003; Pane et al., 2002) and tangible programming languages (e.g. Chawla et al., 2013; Sipitakiat et al., 2012; Wyeth, 2008; Horn and Jacob, 2007).

Visual programming is a class of programming languages that offers a different interaction style than traditional textual programming. Visual programming provides Direct Manipulation (Schniderman, 1983) interaction style to users, where they can drag and drop visual blocks to create programs rather than typing purely textual commands. Visual programming emphasizes recognition over recall to minimize user's memory load by making objects, actions and options visible. Visual programming can also reduce syntax errors, a major source of frustration while learning to program.

Novice and beginner programmers might find visual programming relatively easier to learn. Previous studies (Stefik, 2013; Denny et al., 2011) have shown that syntax was found to be a major barrier to students learning to program. In addition, studies (Dann et al., 2012; Hundhausen et al., 2009) found that visual programming provided a positive transfer to textual programming. Hundhausen et al. (2009) showed that a visual interface significantly supported better initial programming outcomes than an equivalent textual interface. By constraining syntax and providing concrete visual representations, visual programming can work as a *way-in* (Hundhausen et al., 2009) to traditional textual programming. Informed by the philosophy and capabilities of visual programming languages, I decided to employ a visual programming editor within Rosie the Fashionista and Build a House games.

One popular example of a visual programming language is Scratch. Scratch is intended to promote computational ideas through playful experimenting, such as creating interactive animations and games (Figure 17). Scratch is based on a building-block metaphor, in which learners build scripts by snapping together graphical blocks much like pieces in a jigsaw puzzle.

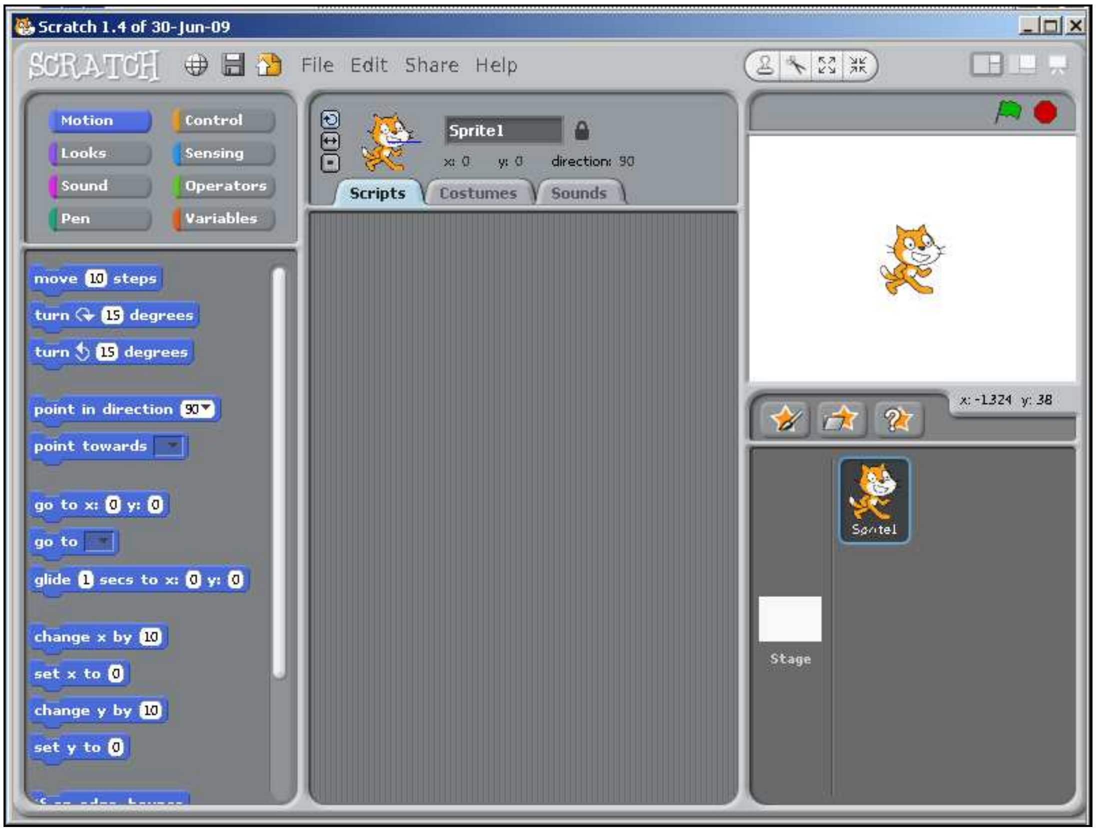


Figure 17. Scratch screenshot

ScratchJr (Louis et al., 2013) is a version of Scratch designed for children between the ages of 5 and 7 to address the lack of powerful technologies for computer programming in early childhood education. Snap! is an adaptation of Scratch that introduces additional features such as lists and procedures in an effort to create a serious introduction to programming for high school and college students.

Other visual environments include Alice and Storytelling Alice which support the creation of 3D animations. Storytelling Alice (Figure 18) is an extension of Alice designed to engage middle school girls in the creation of interactive narratives with 3D virtual characters. Kelleher et al. (2007) compared girls' experiences learning to program using Alice and Storytelling Alice and found that girls who used Storytelling Alice and girls who used Alice were equally successful at learning computer programming concepts. However, girls who used Storytelling Alice spent 42% more time programming, were more than 3 times as likely to sneak extra time to work on their programs and expressed stronger interest in future use of the software than girls who used Alice. It appears that adding storytelling support to the environment motivated girls to program more, as it significantly affected the level of engagement with the programming environment.

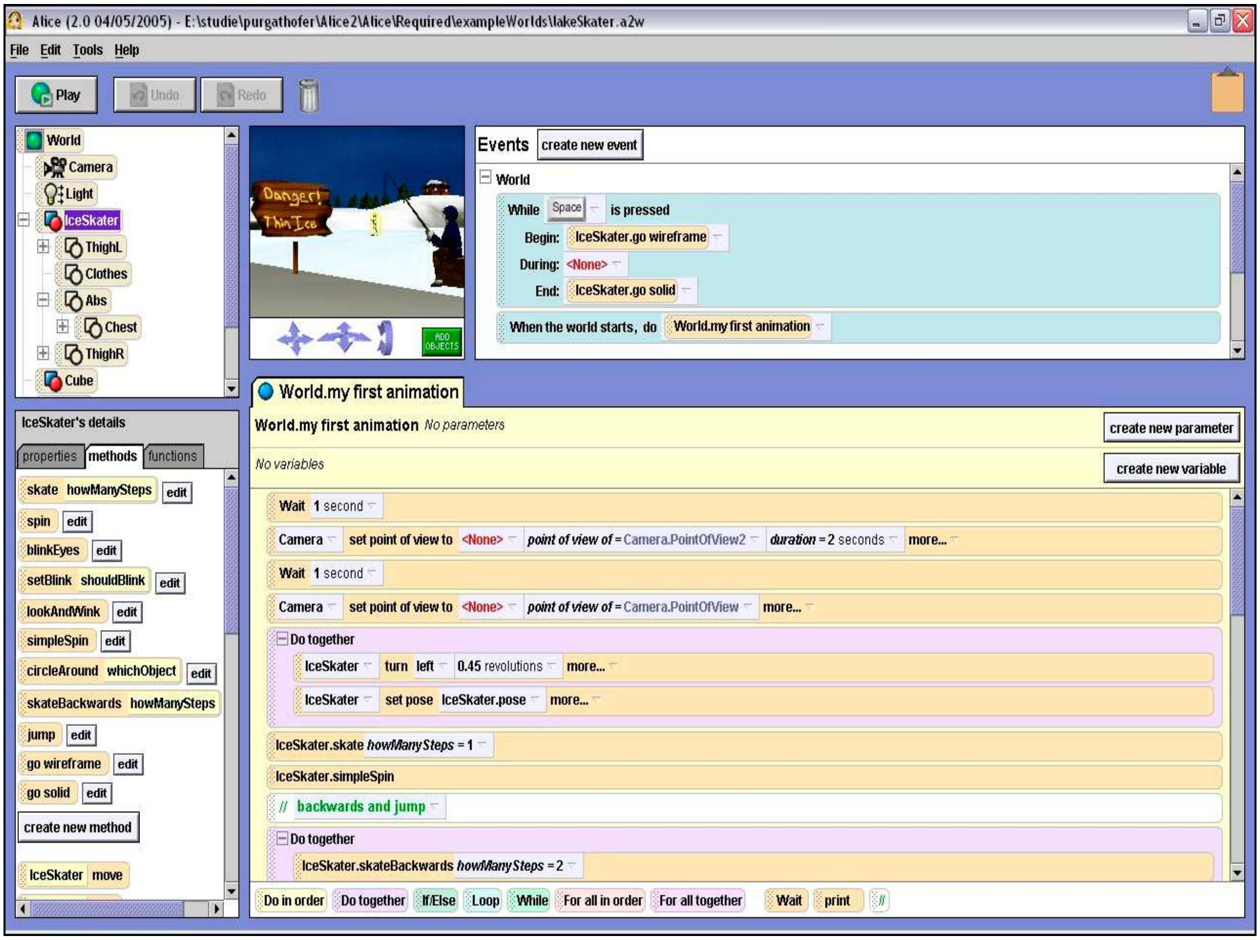


Figure 18. Storytelling Alice screenshot

There's also a class of tangible programming languages that involve construction of computer programs with physical objects (Figure 19). Examples include Tern (Horn et al., 2007), Electronic Blocks (Wyeth, 2008), Dr. Wagon (Chawla et al., 2013) and Robo-blocks (Sipitakiat et al., 2012).

Figure 19. Tangible programming languages

2.3 Summary

This chapter critically reviews the literature on the relationship between gender, sex and the computing culture with emphasis on computer games. A large body of scientific research supports the hypothesis that cultural and societal factors contribute dramatically to women's underrepresentation in computing. These factors include gendered expectations about the abilities and interests of women and men from parents, teachers, peers and others (Cheryan et al., 2015; Moss-Racusin et al., 2012; Cohoon and Aspray, 2006; Margolis and Fisher, 2002; Eccles et al., 1990), the lack of perceived similarity with people in the field (Cheryan et al., 2013; Margolis and Fisher, 2002), stereotypes that are inconsistent with qualities typically valued in women, such as femininity and being people-oriented (Cheryan et al., 2015; Jenson and De Castell, 2010; Schofield, 1995; Cocburn, 1992; Wajcman, 1991), stereotypes about the culture of computing (Cheryan et al., 2015), and stereotype threat (Patitsas et al., 2014; Koch et al., 2008; Peckham et al., 2007; Cohoon and Aspray, 2006; Todd et al., 2005).

Many societal barriers to female participation in computing opportunities have been identified and efforts are underway to combat these barriers. However, cultural stereotypes about computing still constrain females' learning opportunities and career aspirations toward technology and computing (see Figure 20). In particular, the stereotypes about the people, the work, and the values in the computing culture can be more damaging for women than men as these stereotypes are perceived as incongruent with the female gender role (Cheryan et al., 2015; Margolis and Fisher, 2002). The need to broaden and diversify the stereotypes and the image of computing is necessary so that individuals who might be interested in those fields do not get pushed back because they think they do not fit with the current stereotypes. It is important to note, however, that the current stereotypes sometimes steer individuals (even some women) *into* these fields; so instead of altering the current stereotypes all together, it would be more practical to try to diversify these stereotypes to create a more inclusive culture (Cheryan et al., 2015).

Chapter 3 Design and Implementation

In this chapter, I describe the design and implementation of the two games that I developed and evaluated for this study. The first game called *Rosie the Fashionista* was designed with an intentional gender orientation (Figure 20). The second game called *Build a House* was intended to be gender-neutral (Figure 21). The two games offer identical programming activities, but the first game is built around the cultural form of dress-up dolls, while the second around building and decorating houses. Players of the two games manipulate graphical elements, instead of text, to write computer programs.

Figure 20 Rosie the Fashionista game screenshot

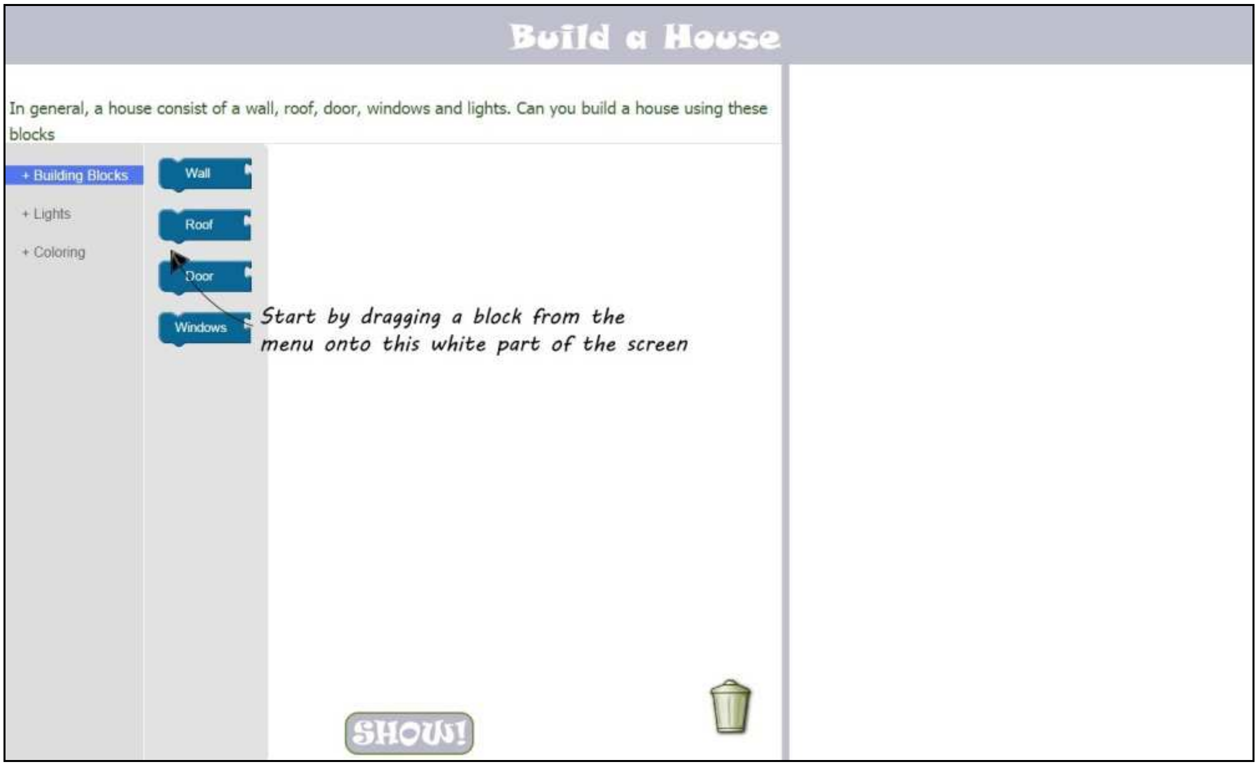


Figure 21. Build a House home screen

I employed Blockly library to build the visual programming editors for the two games. The computer programming concepts introduced in the games include sequential execution, conditionals, loops, and functions. Based on Horn (Horn et al., 2007) and Wyeth (Wyeth, 2008) work on programming curriculum for early elementary school children, we attempted to introduce children to a series of powerful ideas (Bers, 2008;Papert, 1980) from computer programming through these two computer games. Following (Horn et al., 2012) we selected programming activities to build on one another conceptually while remaining developmentally appropriate for children in our target age range.

3.1 Rosie the Fashionista Design

Rosie the Fashionista game follows the story of a young girl named Rosie who needs help in figuring out what to wear on several occasions. Each occasion prompts a programming activity that the player needs to solve as shown in Figure 20. The programs that the players create specify the outfit that Rosie will be wearing on that specific occasion. Figure 22 shows a sample of the programming blocks that players can use in this game.

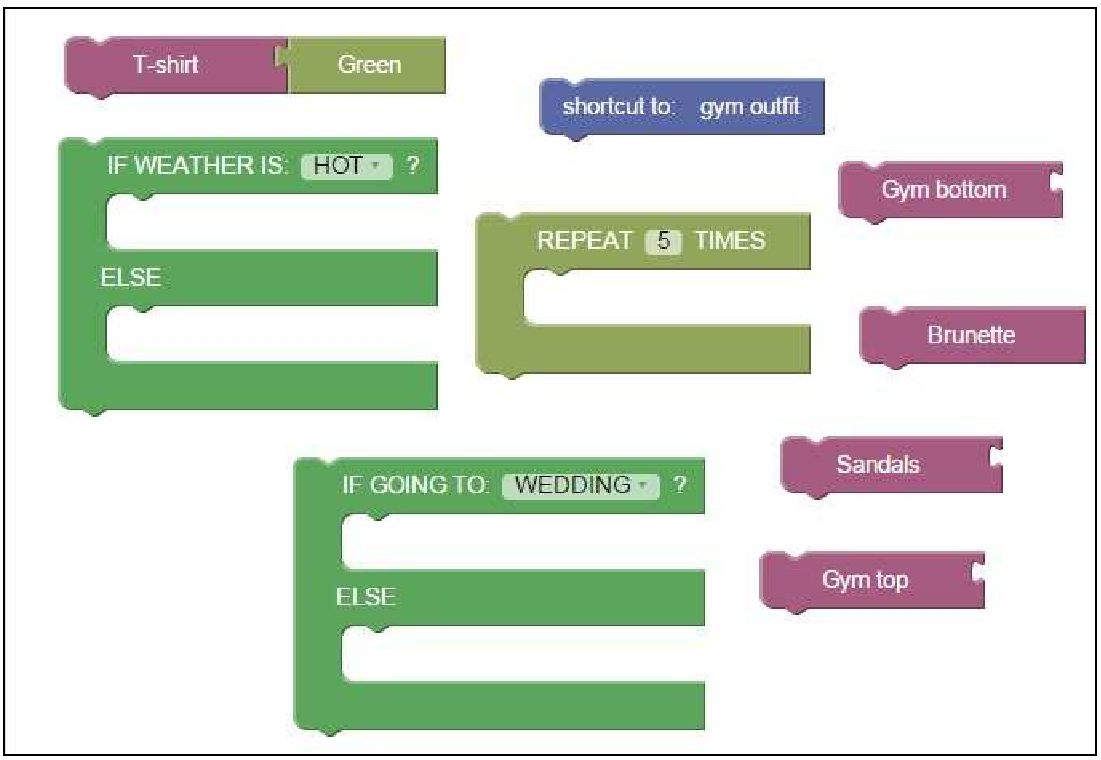


Figure 22. Sample of programming blocks in Rosie the Fashionista game

Table 1 shows the programming activities for Rosie the Fashionista.

<table>
<tr><th>Activity</th><th>Sample Program</th></tr>
<tr><td>

Activity 1: Sequence of actions

(prompt: Rosie is going to a restaurant with her friend Jasmin. Help her decide what to wear)

⇨ **Children create a program consisting of a Top, Bottom, Hair, and Shoes blocks of their choice.**

</td><td>

</td></tr>
<tr><td>

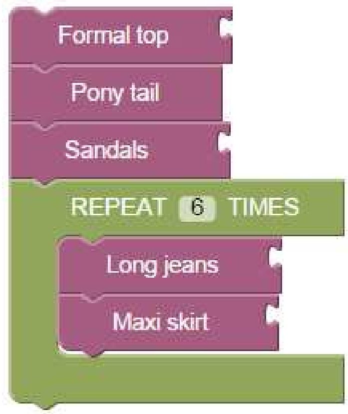
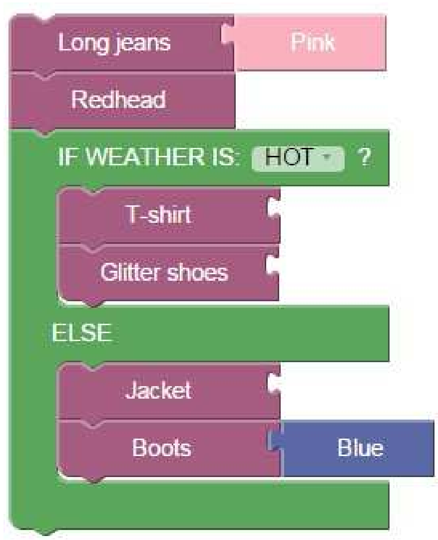
Activity 2: Manual repetition

(prompt: Jasmin is daring Rosie to wear a sequence of [long jeans then change to a long skirt] 3 times in a row. Can you help Rosie do this?)

⇨ **Children create a program consisting of a sequence of six alternating long jeans blocks and long skirt blocks**

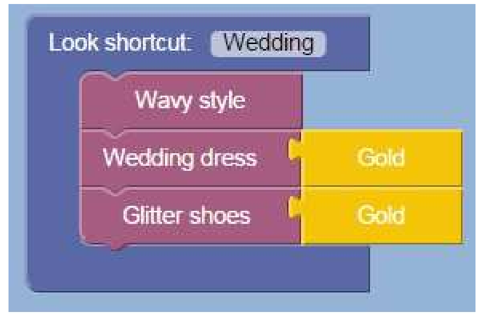
</td><td>

</td></tr>
</table>

Activity 3: Counting Loop (prompt: Jasmin is daring Rosie to wear a sequence of [long jeans then change to a long skirt] 6 times in a row. Can you help Rosie do this using only six blocks?) ⇨ **Children modify the program structure of activity 2 to include only one (instead of three) jeans block and only one skirt block and use REPEAT block. This level limit the number of draggable blocks in the work space to only six blocks, which constrains player's ability to accomplish the goal without using the REPEAT block.**	
Activity 4: Conditional (prompt: Rosie wants to go for a walk. You don't know whether it's hot or cold outside but can you tell Rosie to wear t-shirt when it's hot, and wear a jacket when it's cold?) ⇨ **Children create a program consisting of a IF-ELSE block along with a t-shirt block and jacket block and specify the appropriate top block based on the condition selected [hot outside or cold outside]**	

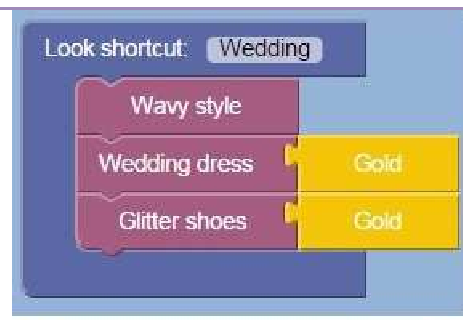
<table>
<tr>
<td>
Activity 5: Function

(prompt: Now, instead of choosing a new look for Rosie in each level, you can create a shortcut to some look and use it in later levels. Can you give this look a name? You'll be able to use it later.)

⇨ Children are presented with a function definition for a pre defined wedding outfit and are asked to name it in order to use it in the next level.
</td>
<td>


</td>
</tr>
<tr>
<td>
Activity 6: Function and Conditional

(prompt: Rosie will go out soon. You don't know whether she is going to a wedding or a gym but can you tell Rosie to get the look “prev_level_func_name” when she's going to a wedding and wear gym clothes when going to a gym?)

⇨ Children create a program consisting of IF-ELSE block along with gym appropriate clothes blocks and a “CALL” for the function definition created in the previous activity.
</td>
<td>


</td>
</tr>
</table>

Activity 7: Open-ended prompt (prompt: Play with the blocks as you like!) ⇨ **Children are invited to play with all available blocks to construct the outfit they desire.**	

Table 1. Programming activities for Rosie the Fashionista game

3.2 Build a House Design

The Build a House game is structurally equivalent to the Rosie game, which allows players to build and decorate a house with different colors. Just as Rosie game, each level prompts a programming activity that the player needs to solve in order to build a house. Figure 23 shows a sample of the programming blocks that players can use in this game.

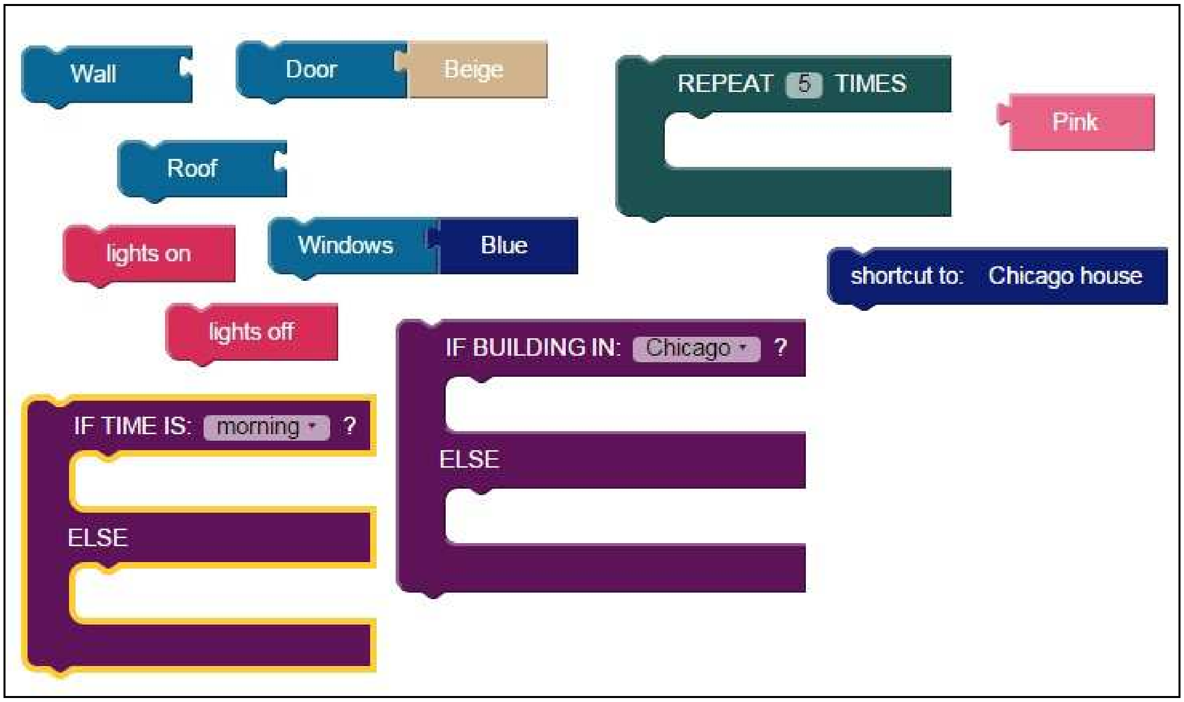
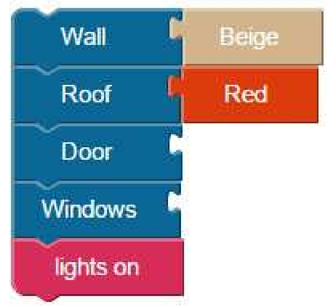
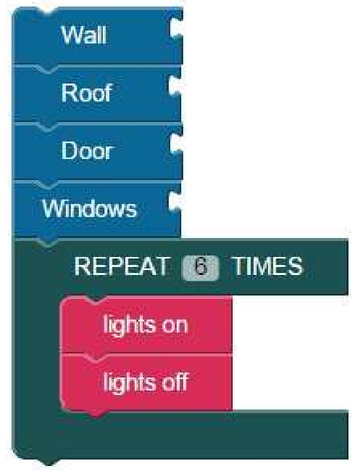
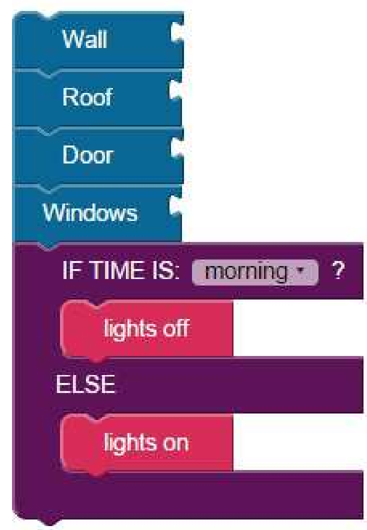


Figure 23. Sample of programming blocks for Build a House game

Table 2 shows the programming activities for Build a House game.

Activity	Sample Program
Activity 1: Sequence of actions (prompt: In general, a house consists of a wall, roof, door, windows and lights. Can you build a house using these blocks) ⇨ **Children create a program consisting of a wall, roof, door, windows and lights blocks of their coloring choice.**	
Activity 2: Manual repetition (prompt: Can you build a house with different colors and turn the lights on and then off 3 times in a row?) ⇨ **Children create a program consisting of a sequence of six alternating 'lights-on' blocks and 'lights-off' blocks.**	
Activity 3: Counting Loop (prompt: A flashing house will keep turning the lights on and off over and over again. Can you build a flashing house that will keep turning the lights on and off 6 times in a row using only seven	

blocks?) ⇨ **Children modify the program structure of activity 2 to include only one (instead of three) 'lights-on' block and only one 'lights-off'block and use REPEAT block. This level limits the number of draggable blocks in the space to only use seven blocks, which constrain player's ability to accomplish the goal without using the REPEAT block**.	
Activity 4: Conditional (prompt: You don't know whether it is daytime or nighttime, but can you program a house so that when it is daytime, the lights are switched off and when it is night time, it will be switched on?) ⇨ **Children create a program consisting of a IF-ELSE block along with a 'lights-on' block and 'lights-off' block and specify the appropriate light block based on the condition selected [morning or night]**	
Activity 5: Function (prompt: Now, instead of building a new house each level, you can create a shortcut to a house and use it in later levels. Change the colors of this house and give it a name and you'll be able to use it later) ⇨ **Children are presented with a function**	

<table>
<tr><td>

definition for a pre defined house and are asked to name it in order to use it in the next level.

</td><td></td></tr>
<tr><td>

Activity 6: Function and Conditional

(prompt: you don't know whether the next house will be built in Chicago or Boston, but can you build the house "…" when the city is Chicago, and build a different house when the city is Boston?)

⇨ **Children create a program consisting of IF-ELSE block along with house appropriate blocks and a "CALL" for the function definition created in the previous activity.**

</td><td>

</td></tr>
<tr><td>

Activity 7: Open-ended prompt

(prompt: Play with the blocks as you like!)

⇨ **Children are invited to play with all available blocks to construct the house they desire.**

</td><td></td></tr>
</table>

Table 2. Programming activities for Build a House game

3.3 Implementation

In implementing the two games, I was interested in providing platform independent and installation-free games; thus, I decided to build web-app based games using HTML5, Javascript, jQuery, and Dart programming languages. I also employed Blockly library to build the visual programming editor for the games to allow players to manipulate graphical blocks instead of text to create programs. Dart code was later compiled to Javascript to allow the game to be run on standard web browsers (e.g. Chrome, FireFox). The game is 100% client-side, and there is no need for additional software installations or plug-ins other than a web browser. Rosie the Fashionista and Build a House share about 75% of the codebase, while the remaining 25% is tailored for each game individually.

3.3.1 Blockly Library

Blockly is relatively a new library created by Google to allow developers to build customized visual programming editors for their applications. Blockly was a good fit to my design because it is open source and allows extending to custom blocks, so I decided to utilize it to build my visual programming editors.

3.3.1.1 Blockly core code modifications

I made some changes to the core Blockly code to adapt it to my needs in the game. Below are the main modifications that I applied to Blockly core code:

1- **Trash can behavior:**

pilot testing revealed usability issues in placing blocks inside the trash can. Blockly behavior was set to dispose a block only when the cursor intersects with the trashcan. Users expected the block to be disposed whenever one of its edges touched the trashcan. The hand doesn't have to be in the same radius as the trashcan to dispose something, it's sufficient for the disposable item to be in that radius. So instead, I computed the block X and Y coordinates along with its height and width to determine if they intersect with the trashcan coordinates at any given time. Figure 24 (left) shows Blockly standard behavior, in which the trashcan lid won't open until the cursor itself intersects with the trashcan, regardless of the block location. Figure 24 (right) shows the modified behavior of the trashcan, where the lid will open once the block intersects.

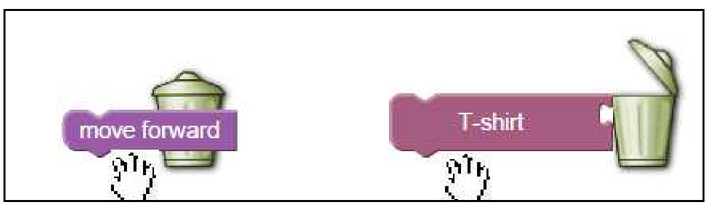


Figure 24. Blockly standard behavior and modified behavior for the trashcan

2- **Scrollbars issues:**

Blockly forces the workspace to have scrollbars whenever the toolbox has categories. This created a troubled experience for children as they would place blocks somewhere and move the scrollbars and then forget about them. I decided to remove the scrollbars and make all blocks visible at all times by bumping back any block that was dragged beyond the visible workspace.

3- Blockly uses a Hue-Saturation-Value (HSV) color model. Saturation and Value are hardcoded into Blockly, while the Hue can be defined in each block. Hard coding the Hue and Saturation to specific values severely limits the range of allowable colors for blocks in the workspace, so I decided to write additional code to allow each block to construct its own unique Hue, Saturation and Value color model, independently from other blocks.

4- In Blockly, the blocks for the main code must be all connected to form a valid program; however, the function block should not connect to the main code (only a call block can connect to the main code). Thus, the function block can be placed on any random place on the workspace. However, pilot testing revealed that this process was not intuitive and that players felt the need to attach the 'function block' to the main code somehow rather than leaving it on the side even though it doesn't have an upper and lower notch. So I added a colored virtual space in the workspace for functions to distinguish them from the main code. I also restricted the movement of these 'function blocks' so that they can only be dragged inside the blue virtual space. I also allowed previously defined functions to appear automatically in the following levels. Figure 25 shows the virtual space to place the 'function blocks' inside.

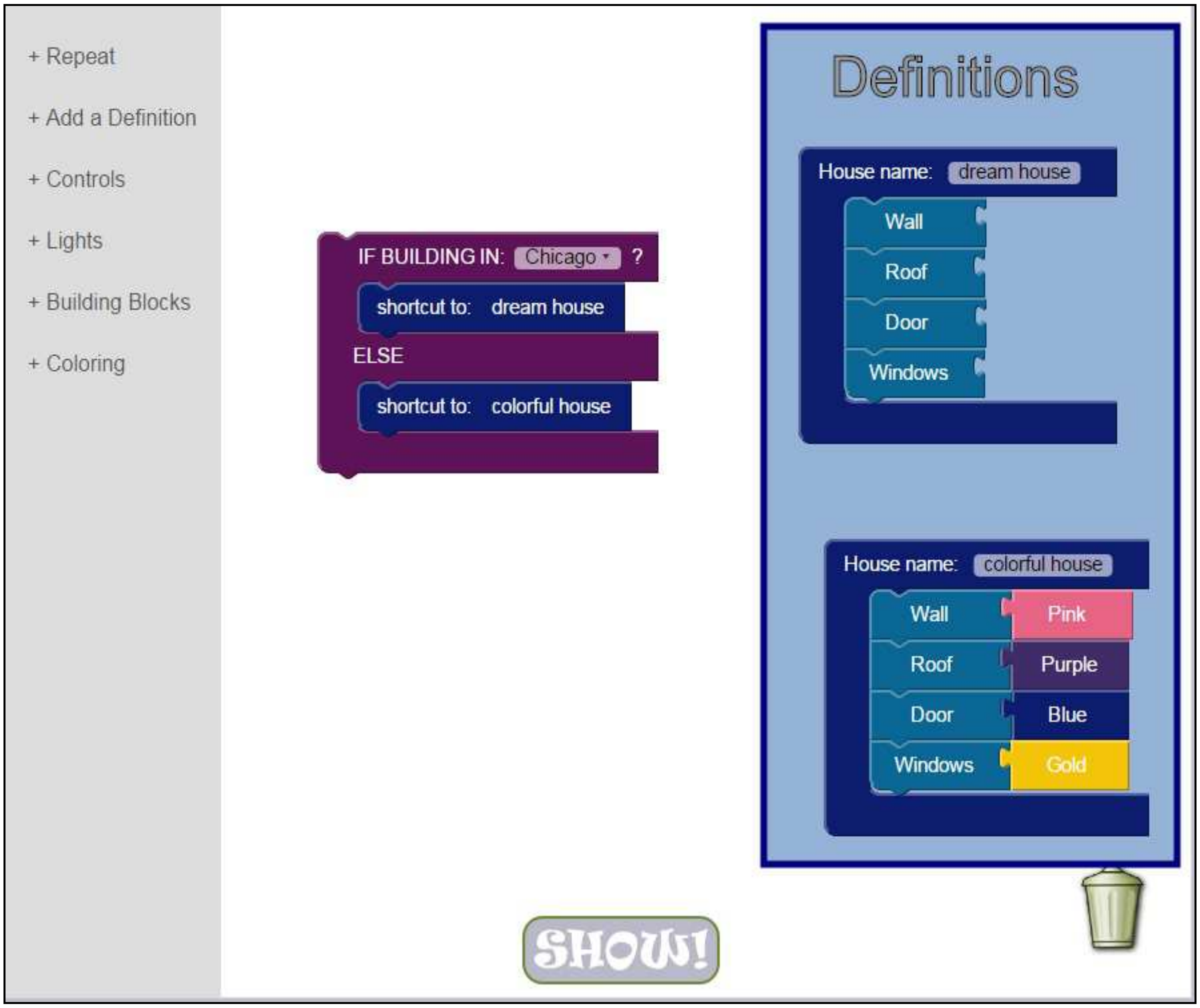


Figure 25. Virtual blue space to place function blocks

5- When users add a function block to the workspace, Blockly creates a "call" block to this function inside the toolbox, without any effect in the game to indicate that a new block was added, and users must browse the toolbox again to find the call block. So I decided to 'listen' for changes in the workspace, and whenever a change was determined as adding a new function, I initiate a "call" to this user defined function directly in the workspace. Figure 26 (left) shows Blockly standard behavior, where users must go back and browse the toolbox to find the call. Figure 26 (right) shows my modified behavior, where a call is immediately instantiated and added to the workspace after the user creates a function.

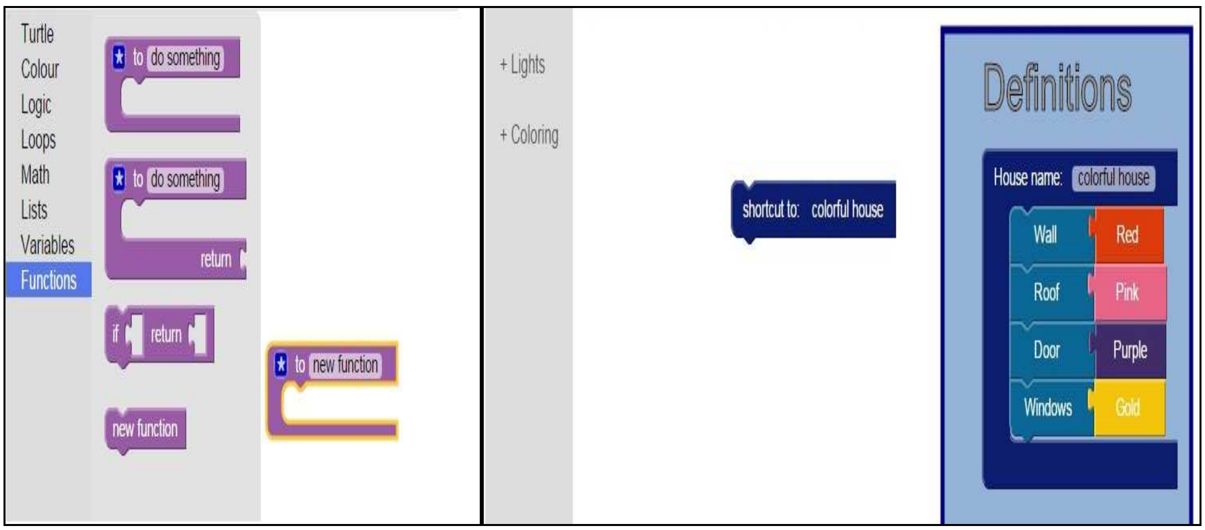


Figure 26. Blockly standard behavior and modified behavior for functions

6- Blockly allows users to define a function without an actual name (equivalent to an anonymous function in a language like JavaScript); this makes it counterintuitive to the goal of this feature, so I changed it so that a default name "Name" would appear as the function name whenever the user leaves it empty. In addition, to prevent duplicate function names, I added a variable counter to append a number to the function name if it already exists.

3.3.1.2 Custom Blocks

In order to build the visual programming editors for my two games, I needed to create new custom blocks that players will play around with. So I created new "language" blocks and code generators for these blocks. A language block code defines the properties for this block (e.g. color, title, whether it has a top/bottom/left or right connection, constrains on block connections, etc.) An example language block is shown in Figure 27.

```
//------------------------------------------------------------------------
// roof
//------------------------------------------------------------------------
Blockly.Language.roof = {
  helpUrl: '',
  init: function() {
    this.setColour(200, .93, .58);
    this.appendValueInput("color")
        .setCheck([String, "var"])
        .appendTitle("    Roof     ");
    this.setPreviousStatement(true);
    this.setNextStatement(true);
    var thisBlock = this;
    this.setTooltip( function() {
      var color = Blockly.JavaScript.valueToCode(thisBlock, 'color', Blockly.JavaScript.ORDER_NONE) || '0';
      if (color == '0')
        return 'roof-red';
      else {
        color = color.replace(/"/g, "").replace(/\(/g, "").replace(/\)/g, "");
        return 'roof-'+ color;
      }

    });
  },
};
```

Figure 27. An example of Language block

In the above code snippet, I have defined properties for the "Roof" block. For example, I assigned the color Teal to this block, indicated that it can have an upper and lower connections along with a side connection. I have also restricted the allowable blocks that can connect to the right-side to only color blocks (so that the user can change the color of the roof image to any of the given color blocks). The upper and lower connections can connect to any other block. In addition, I allowed the user to preview the output of this block on *mouse hover* using the *setTooltip* function. This function checks, in real time, whether the current block is connected to a color block or not. If the block is not connected, the roof that will be previewed will have a red color, otherwise, the roof will have the color of the connected color block. Figure 28 shows the behavior of this function.

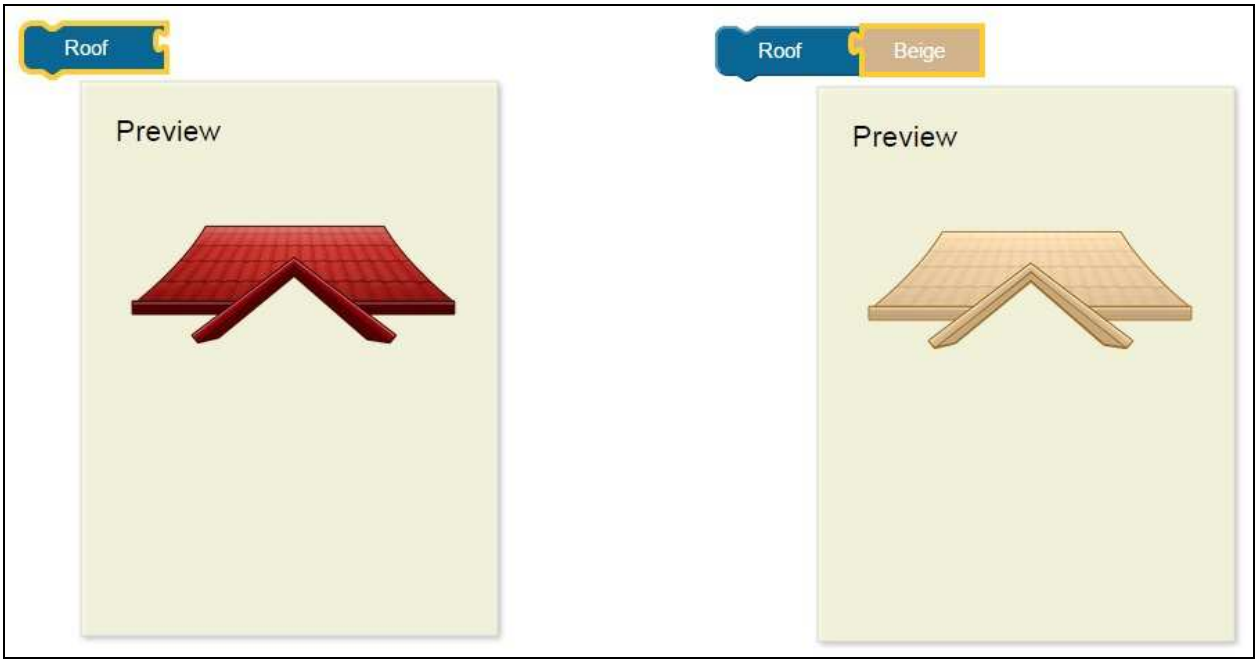


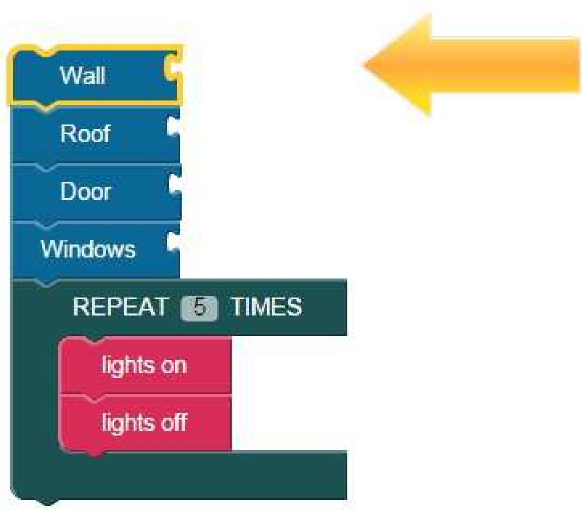
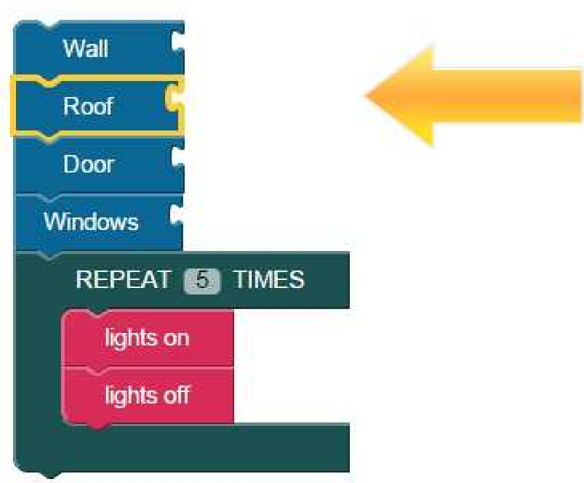
Figure 28. Previewing by hovering over blocks

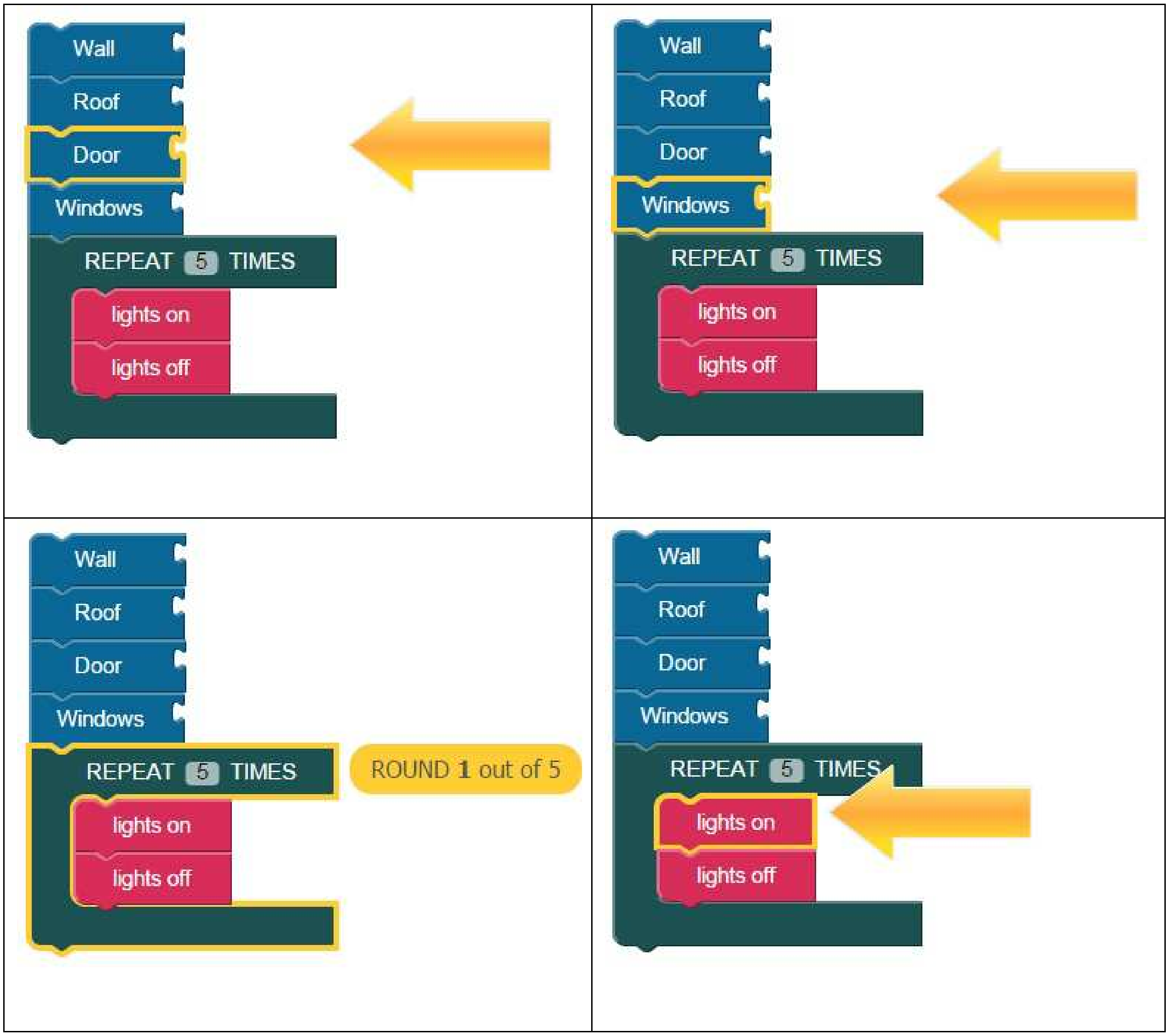
A code generator for each language block must specify the code returned by this block. I wrote the code generators for my games to return JSON data that are interpreted later. A sample generator for the previous language block is shown in Figure 29.

```
Blockly.JavaScript.roof = function() {
        var color = Blockly.JavaScript.valueToCode(this, 'color', Blockly.JavaScript.ORDER_NONE) || '0';
        if (color == '0')
                return '[ "roof-", "red", ' + this.id + ']';
        else
                return '[ "roof-",' + color + ', ' + this.id + ' ]';
};
```

Figure 29. Code generator for the roof block in Build a House game

Each block is assigned a unique ID once it is dragged to the workspace; I embedded this ID in the code generator to allow me to identify which block is being executed at any given moment. In addition, I used block's ID to allow visual tracing while the program is running by highlighting that block and placing a yellow arrow next to it. Table 3 shows how tracing is preformed during the program execution to indicate the current block being executed.


Wall
Roof
Door
Windows
REPEAT 5 TIMES
lights on
lights off
ROUND 1 out of 5

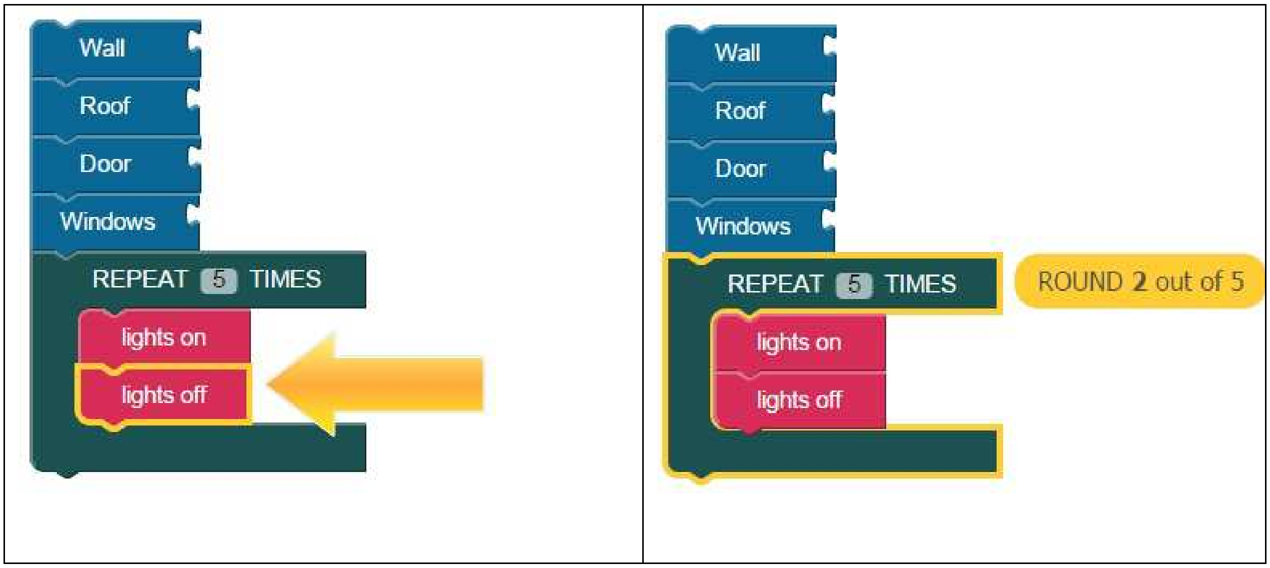


Table 3. Sample program execution tracing

Whenever the player press the “show” button, custom code generators for each block in the workspace return the appropriate JSON code, which is then combined into a larger, single JSON code that represent the whole program. Then, JSON code will be internally checked to see if blocks are all connected. If blocks aren’t connected, or there were no blocks in the workspace, appropriate feedback is displayed to the user. Figure 30 shows two message feedback for the user, (top) the user press “show” button, without dragging blocks to the workspace, (bottom) the user press “show” button while one block (or more) is not connected.

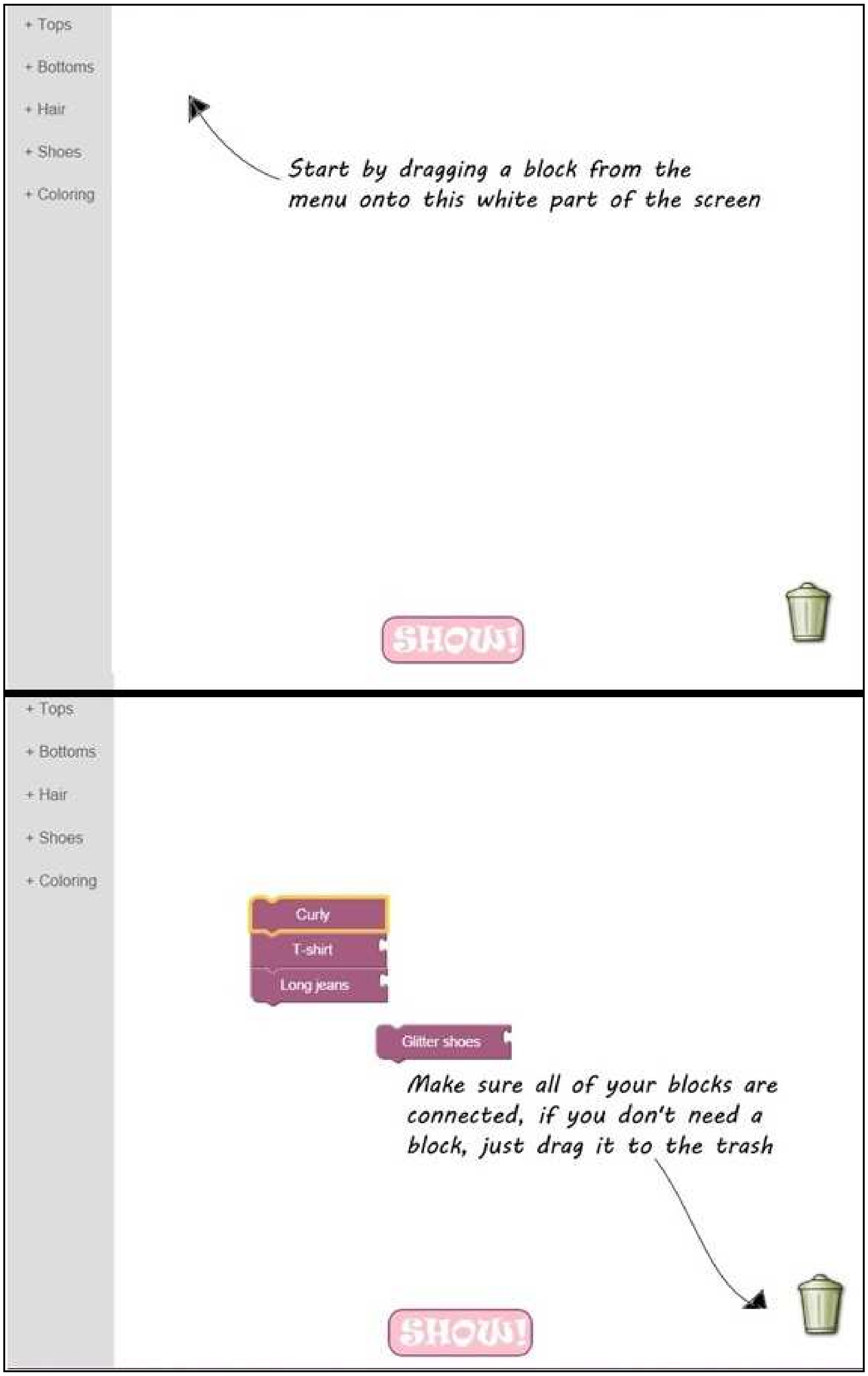


Figure 30. Feedback messages to players

If the user drags blocks into the workspace and connects them all together, pressing the “show” button will send the generated JSON code for processing and execution. An example of visual code and generated JSON code snippet is shown in Figure 31.

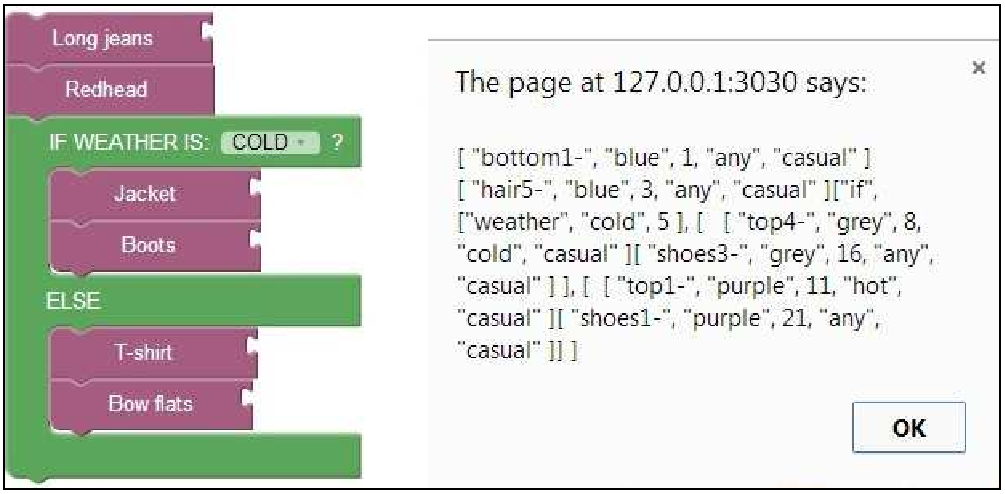


Figure 31. Visual code and its JSON generated code

The conditions built in the games are randomized for each run. For example, the weather (in Rosie the Fashionista game) on a random run could be either cold or hot depending on the result of the randomization function. Similarly, the time (in Build a House game) could be either morning or night depending on the result of the randomization function.

After processing the JSON code, a list of commands is generated. A command usually ‘shows’ an image or displays a message on the screen. An image can be, for example, a ‘sandal’ image or a background image (e.g. winter background), while a message can be a hint shown while tracing the program, for example, round X out of Y in a loop. Images are shown and hidden during the program using a javascript code to control the CSS ‘element visibility’ and ‘z-index’ properties.

3.3.2 System Diagram

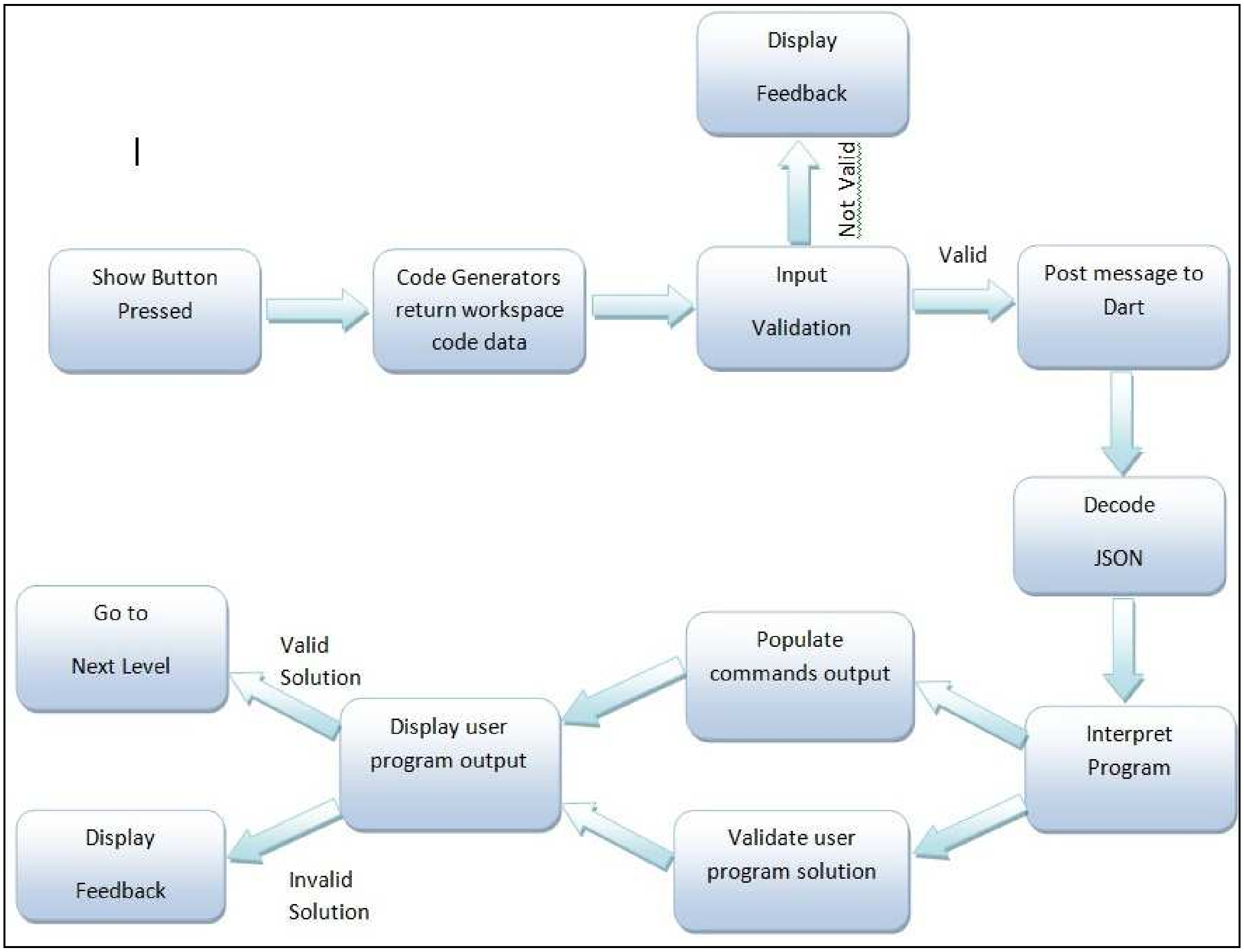


Figure 32. System diagram

Chapter 4 Study Methodology

In this chapter, I provide a description of the study methodology, data collection and data analysis.

4.1 Methodology

My study was conducted in two phases. The first phase was carried out in the Middle East, Saudi Arabia and the second phase in North America, United States. In each phase I used a quasi-experimental design in which I randomly divided participants into two groups. One group played Build a House and the other group played Rosie the Fashionista. Participants took part in a total of four sessions over a two-week period (each session lasted approximately 40 minutes). In the first session, participants completed a pre-assessment and a pre-survey about computer programming. The second and third sessions were devoted to playing the game. In the fourth (and last) session, participants completed a post-assessment and a post-survey. Figure 33 shows a diagram of my study design.

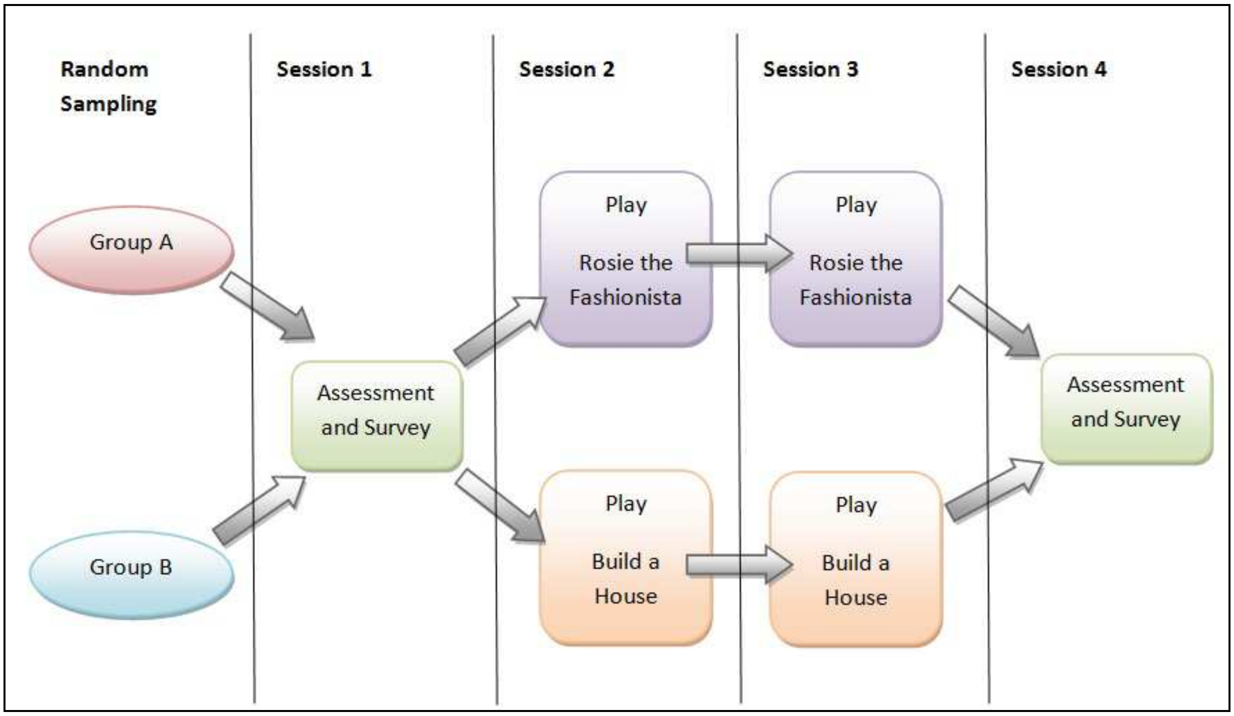


Figure 33. Study flowchart

The survey included fifteen statements about participants' game play preferences, attitudes toward computer programming, and their assigned version of the game. I adopted most questions from the computer science attitude survey (Weibe et al., 2003) with a focus on simplifying the questions for my target age rage. The assessment included fourteen questions divided into code generation and code prediction sections. The surveys and assessments used in this study are included in the appendix. The purpose of the assessments and surveys was to detect possible shifts in learning and attitudes after playing the game. The pre and post assessment/surveys were identical except that the post survey had three additional scales for game play preferences, game perception and enjoyment ratings (see Table 4).

Scale	Example Question	Cronbach Alpha
Confidence (2 Likert items)	I am not the type to do well in computer programming	0.67
Programming Enjoyability (2 Likert items)	Programming can be fun	0.77
Future interest (2 Likert items)	I am interested in learning more about programming	0.81
Relevance (2 Likert items)	Programming is of no relevance to my life	0.83
Game Gender preference (3 Likert items)	Games designed for girls are my favorite	0.61
Game enjoyment (2 Likert items)	I had fun while playing this game	0.62
Game perception (2 Likert items)	I think girls will enjoy this game more than boys	0.83

Table 4. Survey scales and example questions

4.1.1 Measures formulation

4.1.1.1 Assessment Formulation

In formulating the assessment questions, we were interested in measuring the ‘transfer of learning’ from the specific game context to a similar, yet different context. In particular, we were interested in exploring whether students can 'transfer out' what they learned from the games to common target transfer problems. Instead of creating test questions based on the same context as the games, we developed a short written assessment with the same block methodology for programs, but in a context of drawing different shapes and colors. The assessment context is independent of the two games and was tested on players of both games.

The assessment includes fourteen questions divided into code generation and code prediction questions. The format of the code generation section was multiple choice questions where participants choose the correct code snippet that produces the shown output (there could be more than one correct answer). Figure 34 shows an example of code generation question used in this study. In this question, both A and B are correct answers.

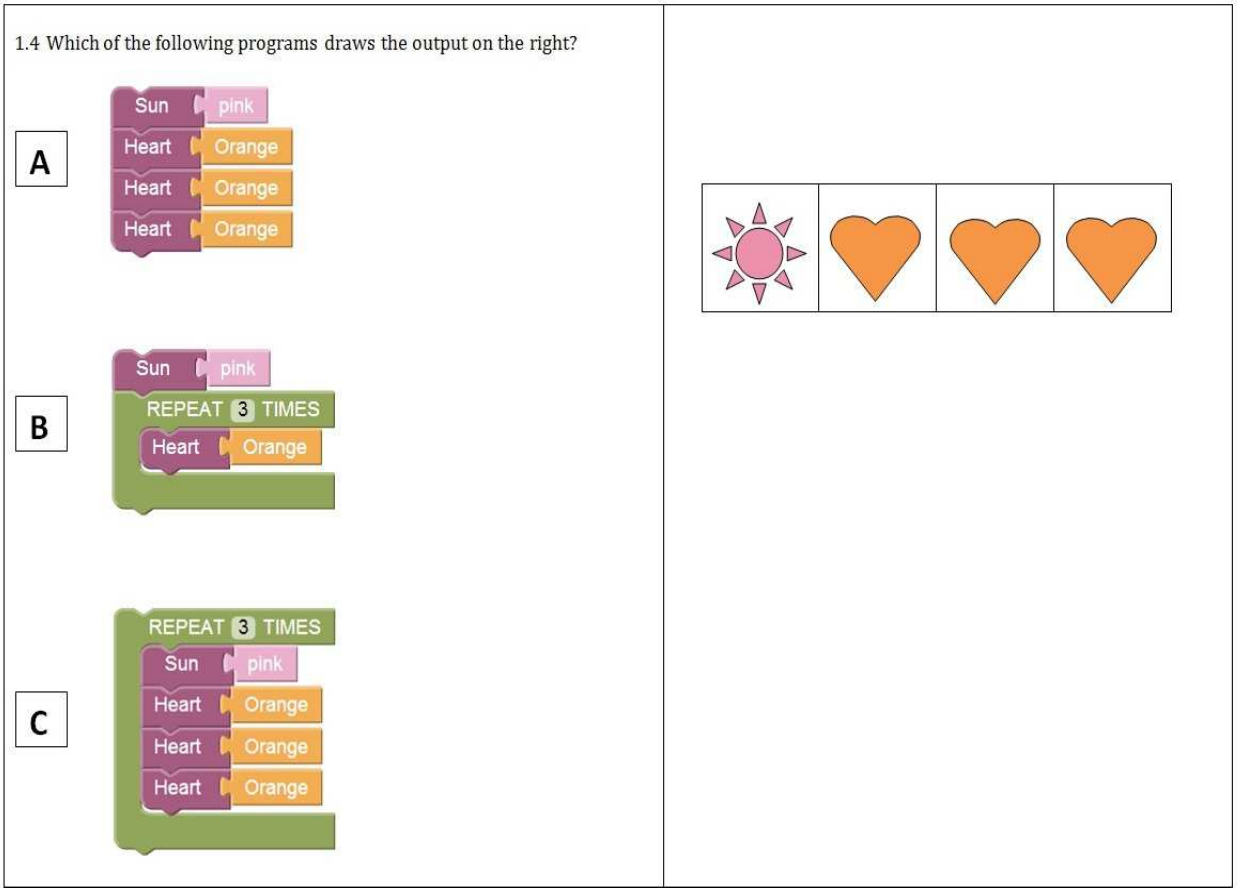


Figure 34. Code generation question example from the assessment

The format of the code prediction questions was to show a sample code snippet, and participants write (draw) the corresponding output to such code. Figure 35 shows an example of code prediction question used in the study.

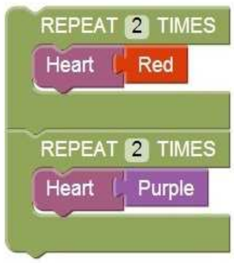
2.6 What will this program draw? 	

Figure 35. Code prediction question example from the assessment

A copy of the full assessment can be found in the appendix. The questions were formulated to cover the same fundamental concepts introduced in the games: sequential execution, loops, conditionals and functions. Some questions tested the comprehension of one concept at a time, while other questions combined two or three concepts together.

4.1.1.2 Survey Formulation

In formulating the survey items, we were interested in the general attitudes and perceptions of computer programming. We adopted most questions from the computer science attitude survey (Weibe et al., 2003) with a focus on simplifying the questions for our target age rage. The survey consisted of five-point Likert- scale items (from strongly disagree to strongly agree). We created six subscales for the pre-survey that included: confidence, programming enjoyability, future interest, relevance, self-image and difficulty. However, we eliminating the last two subscales (self-image and difficulty) as their concept validity (Cronbach's Alpha) measures were below the acceptable levels. In the post survey, we had three additional scales for game play preferences, game perception, and enjoyment ratings. Enjoyment ratings were included to see if players of Build a House would enjoy the game just as much as players of Rosie the Fashionista (or vice versa), it was also important for us to include this measure to determine if any observed differences in the attitudes after playing the game could be attributed to how much players actually enjoyed their assigned version of the game. The questions for each subscale is listed below (Table 5), a copy of the pre/post survey can be found in the appendix.

Subscale	Questions
1) Confidence	• I am not the type to do well in computer programming • I could get good grades in a programming class
2) Programming enjoyability	• programming is boring • programming can be fun
3) Future interest	• I am interested in learning more about programming • I would love to take a programming class in school
4) Relevance	• programming is of no relevance to my life • I can't think of any way that I will use programming in the future

5) Game enjoyment	• I had fun while playing this game • I would love to play this game again in my free time
6) Game gender preference	• Games designed for girls are my favorite • Games designed for boys are my favorite • I think girls and boys like different kinds of games
7) Game perception	• I think girls will enjoy this game more than boys • I think this game is designed for girls

Table 5. Questions for each survey scale

4.1.2 Study Phases

As I mentioned earlier, my research was conducted in two phases. The first phase was conducted in the Middle East, Saudi Arabia and the second phase in North America, United States

4.1.2.1 Phase One

In phase one, I could only have access to a girls' school (boys and girls are strictly segregated in schools), and I was allowed to conduct the study in a school during computer lab time. Sessions were conducted for each grade separately. Some sessions had one game condition only, while some sessions had both conditions playing in the same room, but they were on separate sides of the room with conditions facing opposite sides of each other and they were instructed not to talk to the other group, but they could talk to participants from the same condition.

4.1.2.1.1 Phase one participants

In phase one, fifty-four girls, aged 8-11 participated in the study (N= 54, M_{Age}= 9.5, SD_{Age}=1.2). Twenty-nine girls were randomly assigned to Build a House (N=29, M_{Age} = 9.3, SD_{Age} = 1.1) and twenty-five girls were randomly assigned to Rosie the Fashionista (N=25, M_{Age} = 9.6, SD_{Age}=1.2).

4.1.2.2 Phase Two

Phase two was conducted in the United States, in a Chicago public school summer camp. The camp was a general activity summer camp and included science, sports, dance, and outdoor activities. The camp was run by Youth Guidance (www.youth-guidance.org). We contacted Youth Guidance and got their approval to include our study as part of the activities in the camp.

4.1.2.2.1 Phase two participants

In phase two, sixteen children, aged 6-11 participated in the study (N=16, M_{Age}= 8.2, SD_{Age}=1.7). Seven children were randomly assigned to Build a House (N=7, M_{Age} = 8, SD_{Age}=1.8) three of them were girls and four were boys. Nine children were randomly assigned to Rosie the Fashionista (N=9, M_{Age} = 8.3, SD_{Age} =1.7) three of them were girls and six were boys.

4.2 Data Collection

Data was collected in the form of pre-post surveys and pre-post assessments to measure the impact of the computer games in changing attitudes and perceptions about computer programming and also assess learning outcomes. I also used field notes and observations during game playing sessions to investigate social activity around the two games. Due to privacy concerns among parents of participants in the first phase, we only video recorded game playing sessions in the second phase. In addition, I conducted audio and video interviews with randomly chosen participants from both phases after completing the study.

4.3 Data Analysis

4.3.1 Assessment Analysis

Assessments were analyzed quantitatively by computing the mean pre-score and mean post-score for players by game condition. Then, I conducted a paired *t*-test on the mean scores for each game condition individually to see if players had any gains in their programming comprehension as a result of playing any of the games. Then I conducted ANCOVA test on the post scores using *game condition* as the independent variable while controlling for the pre-scores and sex of the participant as covariates to see if there are any differences in the learning gains between the two game conditions.

4.3.2 Survey Analysis

As I did in the assessment analysis, to evaluate the impact of the two games on the attitudes and perceptions toward computer programming, I compared the pre and post scores on the first four scales in Table 1 using a paired *t*-test for each game condition individually. Then, I conducted an ANCOVA test on the post scores while controlling for the pre scores and sex as covariants to see if there were any differences in the attitudes between the two game conditions.

4.3.3 Game Play Sessions

In the first phase, we used field notes and observations to record patterns of social activity among players of the two games. Due to privacy concerns among parents of participants in this phase, we did not video record game playing sessions. However, we video recorded the game playing sessions in the second phase.

4.3.4 Post Interviews

After completing the study, we conducted audio interviews with randomly chosen participants from the first phase. In addition, we conducted video interviews with randomly chosen participants from the second phase. The purpose of these interviews was to gain more insight into how children perceived the games in relation to their gender identity. We also offered some children the opportunity to play the game that was not assigned to them during the study.

Chapter 5 Results

In this chapter, I present findings and results from the study reported in this dissertation. After presenting results from phase 1 and phase 2, I will discuss these findings in the next chapter. As I explained in the study methodology chapter (chapter 4), for each phase, I first compared the pre and post data for each game condition individually to assess the impact of the individual game condition on players' learning gains and attitudes. Then I compared the post data for all players using game condition as the independent variable while controlling for the pre data to check for differences in outcomes between players of the two games.

5.1 Phase One Results

Recall that phase one was conducted with *N*=54 girls (ages 8-11) in an all-girls school in Saudi Arabia. To determine the overall game gender preference for this sample, I used the **game gender preference** scale from the post survey. 48 out of 54 (88%) reported preference for girls' games, 3 reported preference for boys' games, and 3 reported no specific preference ($\chi^2(2)=75.67$, $p<.000$). Of those who preferred girls' games, 26 (90%) were Build a House players ($\chi^2(2)=39.11$, $p<.000$) and 22 (88%) were Rosie the Fashionista players ($\chi^2(2)=29.40$, $p<.000$). There are statistically significant differences in the preference of the type of games participants like to play, with more participants preferring girls' games.

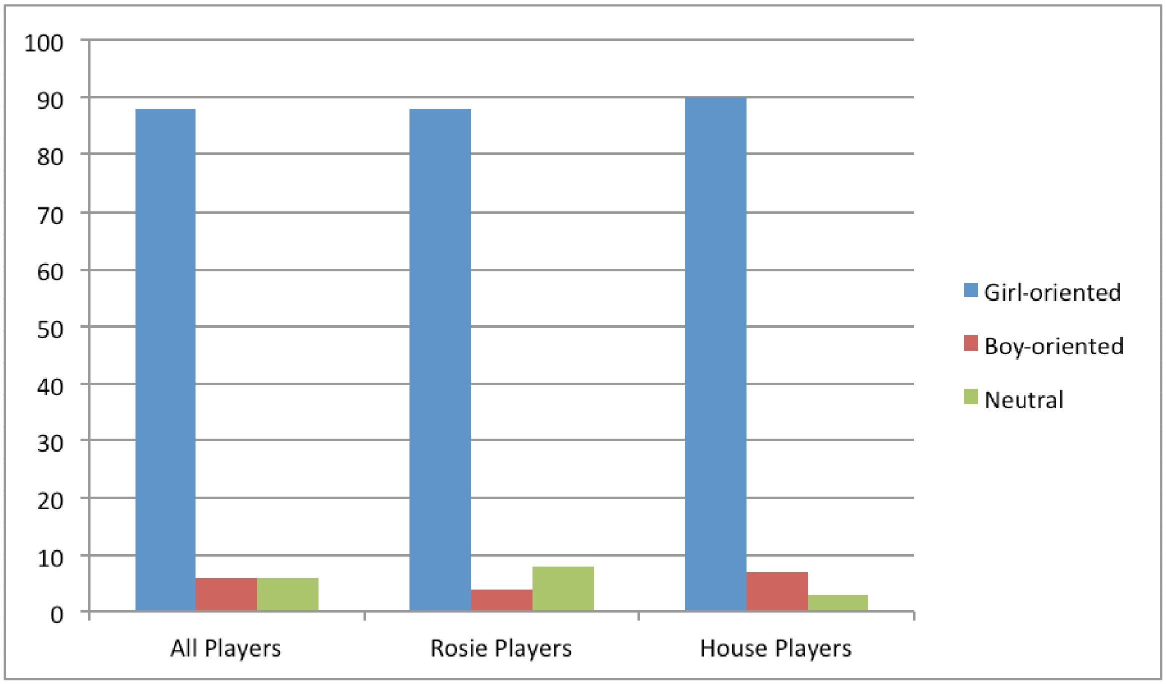


Figure 36. Significant preference for girl-oriented games among participants in phase one

5.1.1 Assessment Scores

I collected pre- and post- assessments from all participants in phase 1. These assessments were collected on the first and the fourth sessions of the study. Comparing results, I found a significant improvement in both game conditions on players' assessment scores (see Figure 37 and Table 6) However, learning gains did not differ between the two conditions (p=0.52).

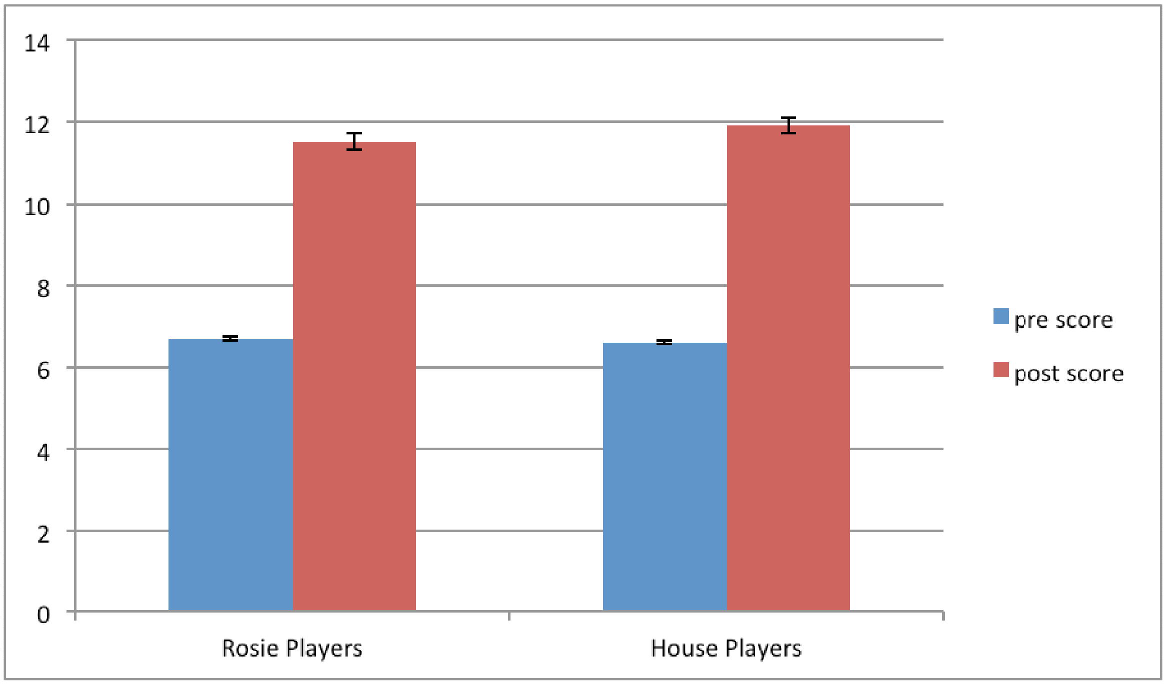


Figure 37. Post-assessment scores were significantly higher than pre-assessment scores for both game conditions (phase one)

		Mean	Std. Deviation	Std. Error Means	Sig.(2-tailed)
Pair 1	**Pre-House**	6.552	2.6671	.4953	$t(28) = 9.7$, $p = 0.000$
	Post-House	11.90	2.177	.404	
Pair 2	**Pre-Rosie**	6.7200	3.31059	.66212	$t(24) = 7.0$, $p = 0.000$
	Post-Rosie	11.5200	2.58392	.51678	

Table 6. Significance test values for assessment scores (phase one)

A comparison between the pre-score and the post-score for each concept is included in the following table (Table 7)

Concept	Pre-score	Post-score
Sequential execution	4.3	4.9
Loops	1.1	2.9
Conditionals	0.5	2.4
Functions	0.7	1.8

Table 7 Breakdown of assessment scores by concept (phase one)

5.1.2 Survey Results

5.1.2.1 Game Enjoyment

In the post-survey, I asked players to rate their enjoyment of the game, and I found that players of Build a House and players of Rosie the Fashionista did not differ significantly in their ratings of enjoyability ($F(1,53)=0.1$, $p=0.477$). A *t*-test showed that the mean enjoyment score for both game conditions was significantly different from neutral, that is from 6, the mid-point of the scale ($p<0.0000$).

Game	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed) From neutral (t=6)	*t*-test for Equality of Means
House	29	9.03	1.052	.195	$t(28)=15.54$, $p<.000$	$F(1,53) = 0.1$, $p= 0.477$
Rosie	25	9.24	1.052	.210	$t(24)=15.40$, $p<.000$	

Table 8. Mean enjoyment scores for both game conditions (phase one)

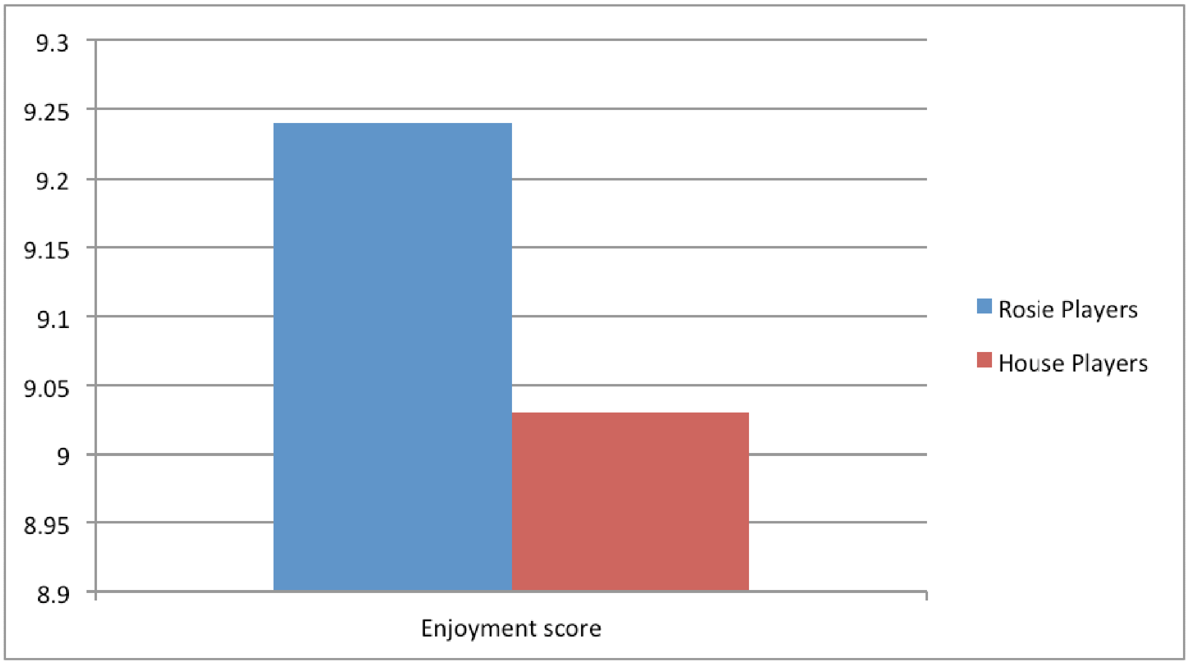


Figure 38.Rosie players' ratings of enjoy-ability was slightly higher than House players (phase one)

5.1.2.2 Game Gender Perception

In order to validate our assumptions about the gender orientation of the two games, we used the **game perception** scale that was administered as part of the post-questionnaire. 23 out of 29 (79%) players of Build a House did not think the game had a girl-specific bent ($\chi^2(1)=9.97$, $p=.002$). While 23 out of 25 (96%) players of Rosie the Fashionista thought the game had a girl-specific bent ($\chi^2(1)=17.64$, $p<.0001$). The two groups also differed significantly from one another in how they viewed the games in terms of their gender orientation ($\chi^2(1)=27.46$, $p<.000$). In doing so, we confirmed that players indeed perceived the two games differently: one as more gender specific and the other as gender neutral.

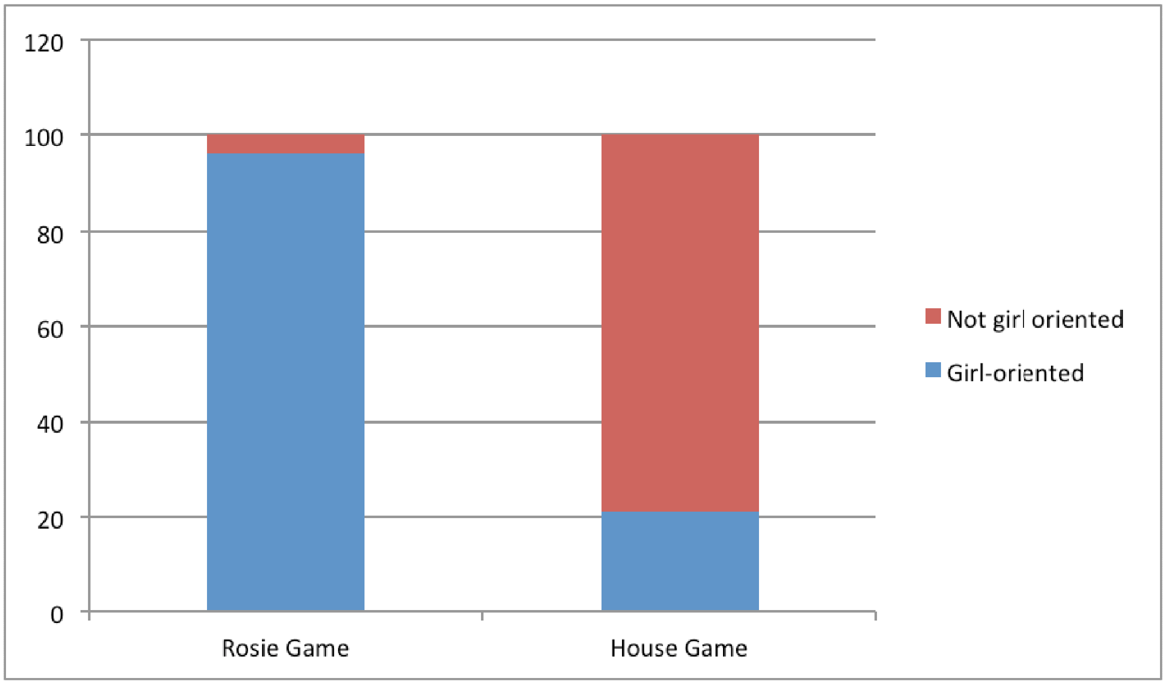


Figure 39. Players of Rosie perceived the game differently than did House players

5.1.2.3 Attitude Scores

5.1.2.3.1 Build a House Players Scores

Players of Build a House did not demonstrate a significant improvement in either the **future interest** scale (p=0.17) or the **relevance** scale (p=0.097). However, players of Build a House did show a significant improvement in both the **confidence** scale (p<0.000) and the **enjoyability** scale (p=0.003). Figure 40 and Table 9 show the mean attitude scores and descriptive statistics for Build a House players.

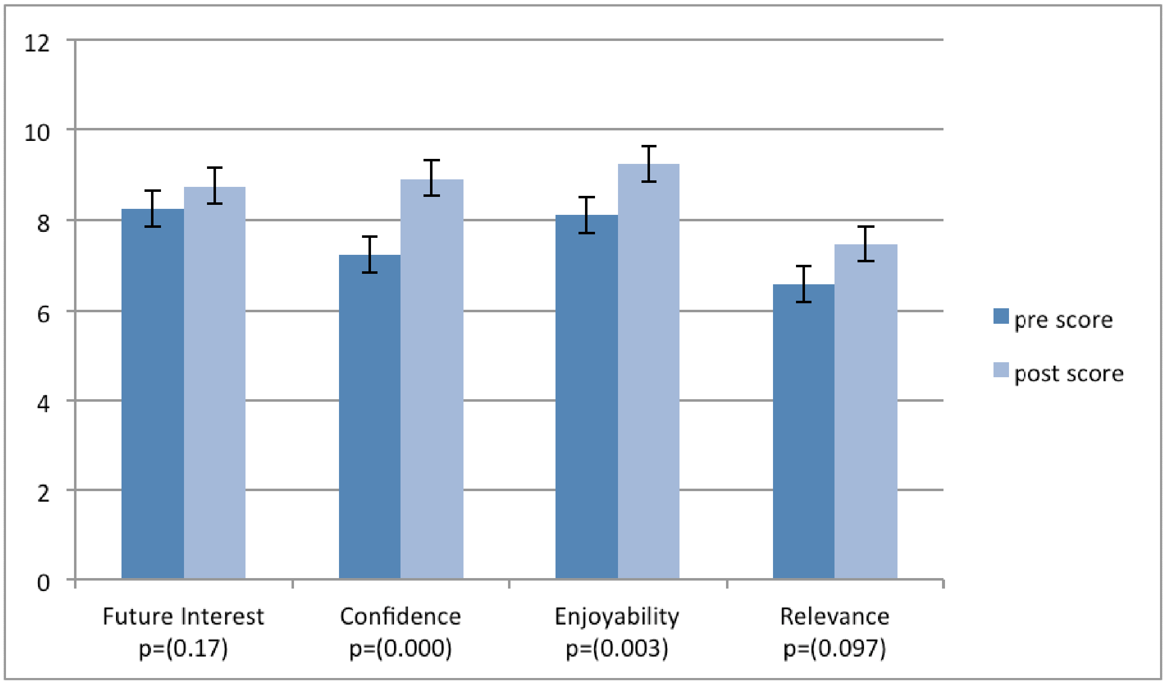


Figure 40. Survey pre-post scores for House players (phase one)

		Mean	Std. Deviation	Std. Error Mean	Sig (2-tailed)
Pair 1	preFutureH	8.28	1.601	.297	$t(28) = 1.41$, p=0.17
	postFutureH	8.76	1.550	.288	
Pair 2	preEnjoyH	8.14	1.457	.271	$t(28) = 3.30$, p=0.003
	postEnjoyH	9.24	1.405	.261	
Pair 3	preConfH	7.24	1.596	.296	$t(28) = 4.76$, p=0.000
	postConfH	8.93	1.486	.276	
Pair 4	preRelevH	6.59	2.212	.411	$t(28) = 1.72$, p=0.097
	postRelevH	7.48	2.681	.498	

Table 9. Mean attitude scores and significance values for House players (phase one)

5.1.2.3.2 Rosie the Fashionista Players Scores

Players of Rosie the Fashionista demonstrated a significant improvement in all attitude scales. They demonstrated a significant improvement in the **future interest** scale (p=0.001), **confidence** scale (p=0.002), **enjoyability** scale (p=0.002) and the **relevance** scale (p=0.048). Figure 41 and Table 10 show the mean attitude scores and descriptive for Rosie the Fashionista players.

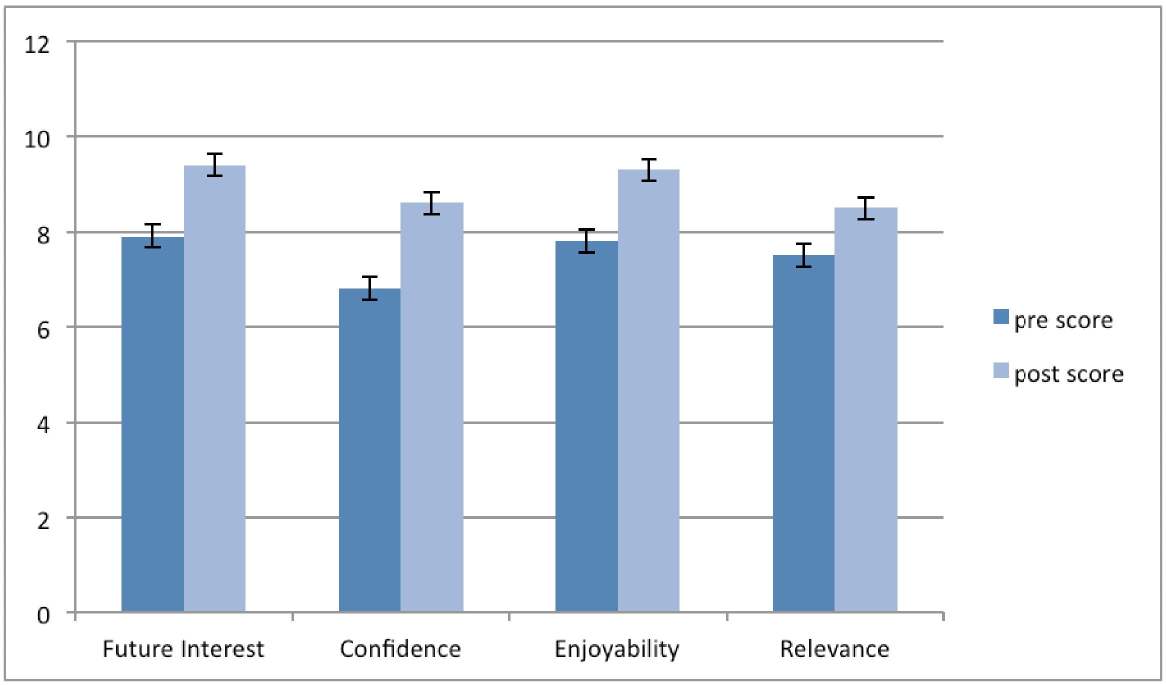


Figure 41. Survey pre-post scores for Rosie players (phase one)

		Mean	Std. Deviation	Std. Error Mean	Sig(2-tailed)
Pair 1	**FutureR**	7.9200	1.65630	.33126	*t*(24) = 3.94, *p*=0.001
	postFutureR	9.3600	.70000	.14000	
Pair 2	**EnjoyR**	7.7600	2.04695	.40939	*t*(24) = 3.55, *p*=0.002
	postEnjoyR	9.2800	1.24231	.24846	
Pair 3	**ConfR**	6.8400	2.09523	.41905	*t*(24) = 3.51, *p*=0.002
	postConfR	8.6000	1.47196	.29439	
Pair 4	**RelevR**	7.4800	1.96044	.39209	*t*(24) = 2.09, *p*=0.048
	postRelevR	8.4800	1.96044	.39209	

Table 10. Mean attitude scores and significance values for Rosie players (phase one)

5.1.2.3.3 House Players Versus Rosie Players

Players of Build a House and of Rosie the Fashionista did not differ significantly from one another in the **confidence** scale (*p*=0.750) and the **programming enjoyability** scale (*p*=0.482). However, the difference between the two conditions in the **future interest** scale approached significance (*p*=0.056). Additionally, although players of Rosie the Fashionista showed a significant improvement in perception of programming's **relevance** to their lives (*p*=0.048), while players of Build a House did not have a significant improvement in this scale (*p*=0.097), the difference between the two conditions was not significant after controlling for their pre-scores (*p*=0.291). Figure 42 and Table 11 show the difference in scores between the two conditions.

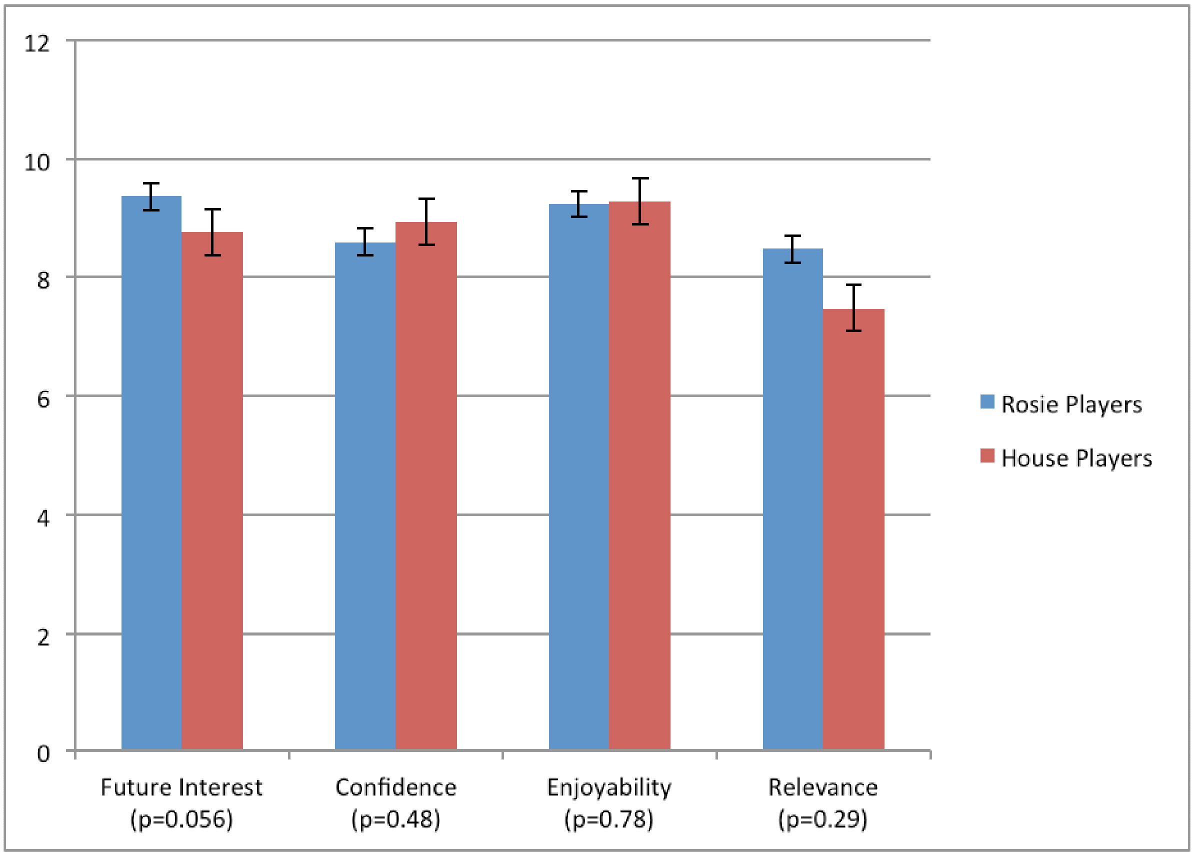


Figure 42. Difference between post-scores in the future interest scale approached significance

Scale	Build a House (paired test)	Rosie the Fashionista (paired test)	Between groups (ANCOVA)
Future interest	p=.170 $t(28) = 1.41$	p=.001 $t(24) = 3.94$	p=.056 $F(1,51) = 3.82$
Confidence	p=.000 $t(28) = 4.76$	p=.002 $t(24) = 3.51$	p=.482 $F(1,51) = 0.502$
Programming Enjoy-ability	p=.003 $t(28) = 3.30$	p=.002 $t(24) = 3.55$	p=.784 $F(1,51) = 0.08$
Relevance	p=.097 t(28) = 1.72	p=.048 $t(24) = 2.09$	p=.291 $F(1,51) = 1.14$

Table 11. Significance test values after comparing the two game conditions (phase one)

5.2 Phase Two Results

Just as I did on phase1, I used the **game gender preference** scale on this sample and I did not find evidence that the sample had any preference in games. We found that 4 players out of 16 (25%) reported preference for girls' games, 8 reported preference for boys' games, and 4 reported no specific preference ($\chi^2(2)=2$, $p=0.37$). Of those who reported girls preference, 2 players (29%) played Build a House game ($\chi^2(2)=1.84$, $p=.40$), and 2 (22%) played Rosie the Fashionista ($\chi^2(2)=0.67$, $p=.72$).

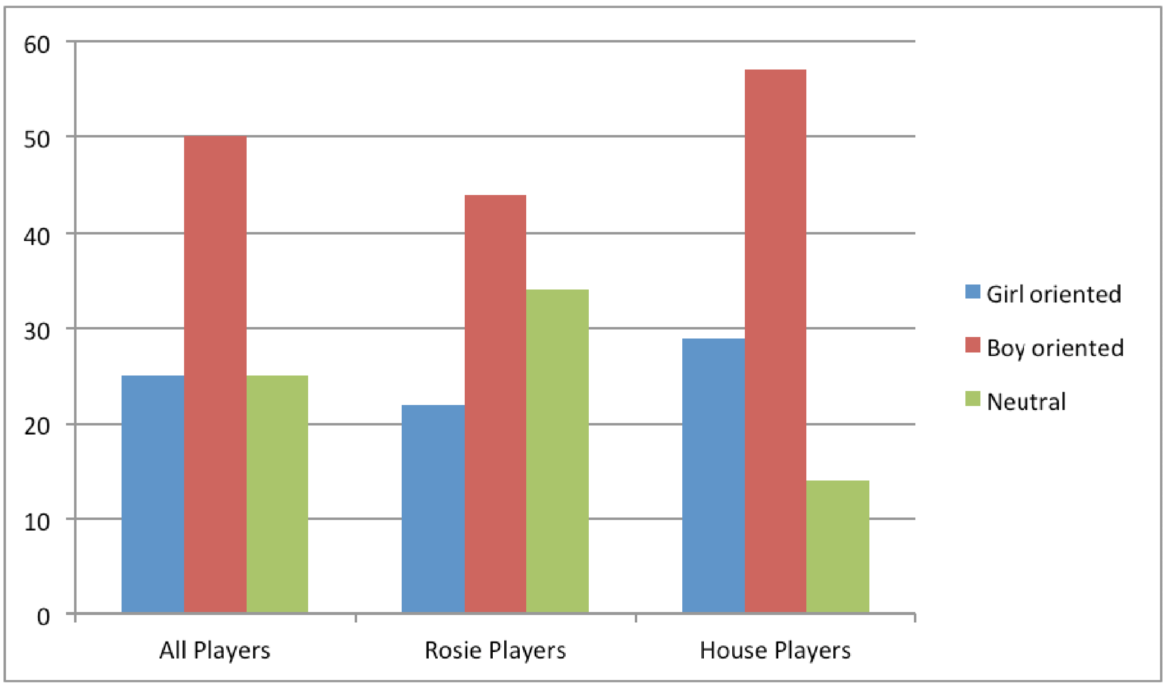


Figure 43. No significant differences in game play preferences between game conditions (phase two)

5.2.1 Assessment Scores

As with phase 1, players of Build a House and of Rosie the Fashionista demonstrated a significant improvement in computer programming comprehension (Table 12). However, there were no significant between-group differences ($F(1,13) = 1.27$, $p=.28$). See Figure 44 and Table 12 for more details.

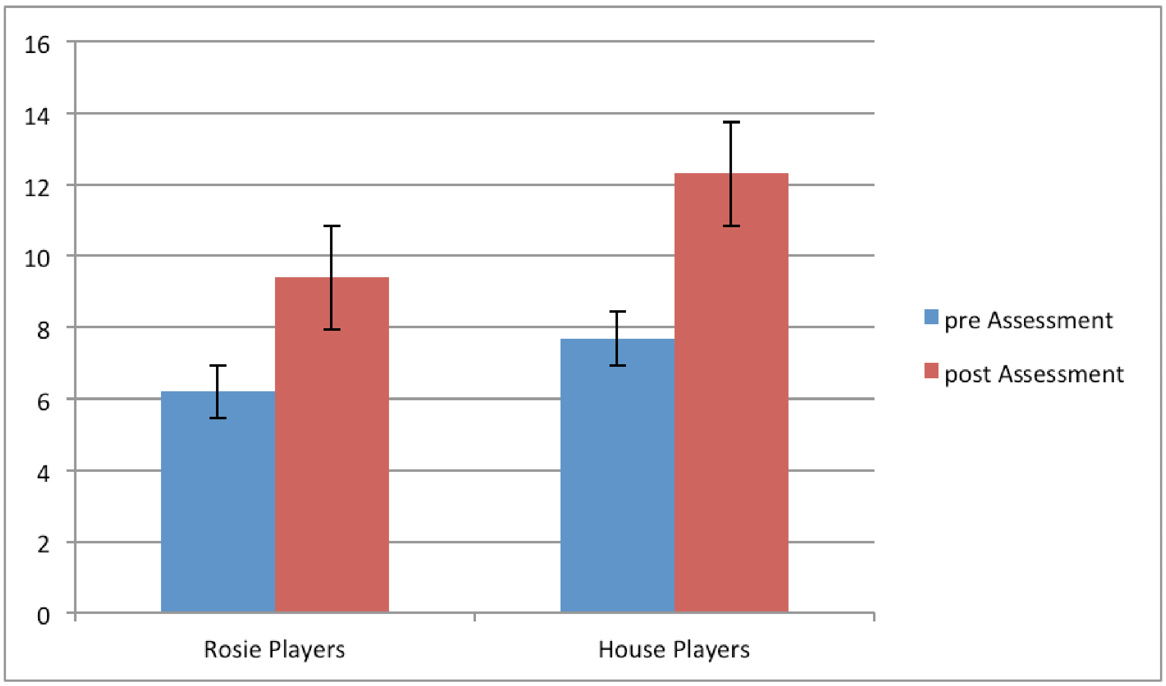


Figure 44. Post-assessment scores were significantly higher than pre-assessment scores for both game conditions (phase two)

		Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pair 1	**preH**	7.857	1.9518	.7377	$t(6) = 4.341$, $p = 0.005$
	postH	12.286	3.0394	1.1488	
Pair 2	**preR**	6.2222	2.38630	.79543	$t(8) = 5.409$, $p = 0.001$
	postR	9.4444	2.87711	.95904	

Table 12. Significance test values for assessment scores (phase two)

A comparison between the pre-score and the post-score for each concept is included in the following table (Table 13)

Concept	Pre-score	Post-score
Sequential execution	4.4	4.7
Loops	1.2	2.4
Conditionals	0.5	2.1
Functions	0.8	1.5

Table 13 Breakdown of assessment scores by concept (phase two)

5.2.2 Survey Result

5.2.2.1 Game Enjoyment

Players of Build a House and players of Rosie the Fashionista did not differ significantly from each other in how enjoyable they perceived the games ($F(1,14)=$, $p=0.749$). A *t*-test showed that the mean enjoyment score for both game conditions was significantly different from neutral, that is from 6, the mid-point of the scale ($p<0.0000$).

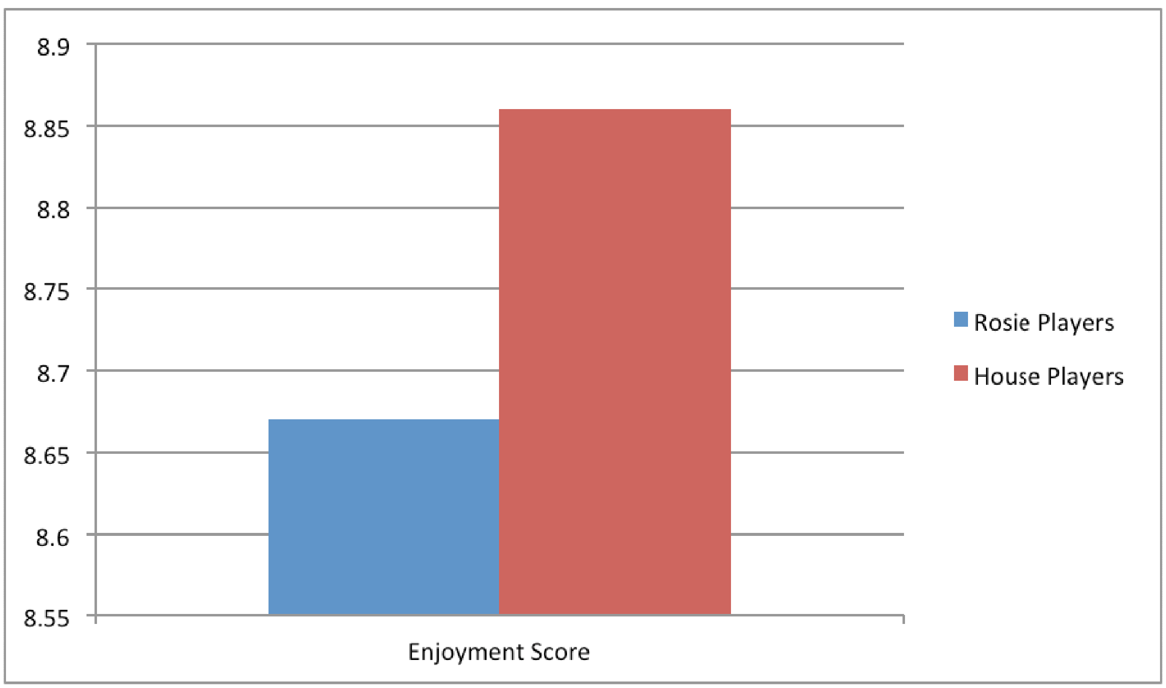


Figure 45. House players' ratings of enjoy-ability was slightly higher than Rosie players (phase two)

Game	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed) from Neutral (t=6)	Sig. (2-tailed) Equality of Means
House	7	8.86	.900	.340	$t(7) = 8.4$, $p<.000$	$F(1,14) =$, $p=0.749$
Rosie	9	8.67	1.323	.441	$t(7) = 6.05$, $p<.000$	

Table 14. Mean enjoyment scores for both game conditions (phase two)

5.2.2.2 Game Gender Perception

The same as we did on phase 1, we wanted to check if children saw a difference between the two games in terms of their gender orientation. None of Build a House players thought that Build a House would appeal to girls more than boys ($\chi^2(1)=7.00$, $p=0.008$). Seven players of Rosie the Fashionista (78%) thought the game had a girl-specific bent ($\chi^2(1)=2.78$, $p=.096$). Fisher's Exact Test revealed that the two groups differed significantly in how they viewed the games in terms of their gender orientation ($p=.003$).

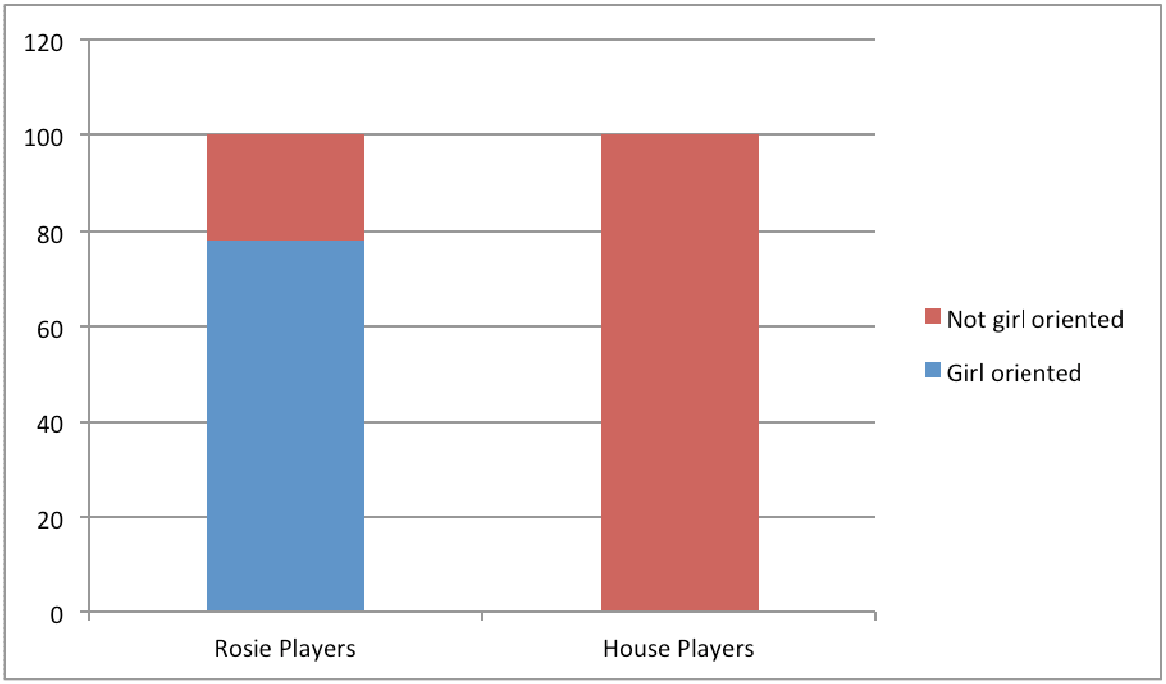


Figure 46. Rosie players perceived the game differently than did House players (phase two)

5.2.2.3 Attitude Scores

5.2.2.3.1 Build a House Players Scores

Players of Build a House did not demonstrate a significant improvement in all scales (**future interest** scale (p=0.095), **relevance** scale (p=0.089), **confidence** scale (p=0.251) and the **enjoyability** scale (p=0.569)). It is probably not surprising as the number of participants is low, making statistical significance unlikely. But as we can see from Figure 47 and Table 15 the mean attitude scores were consistently increasing in the post survey.

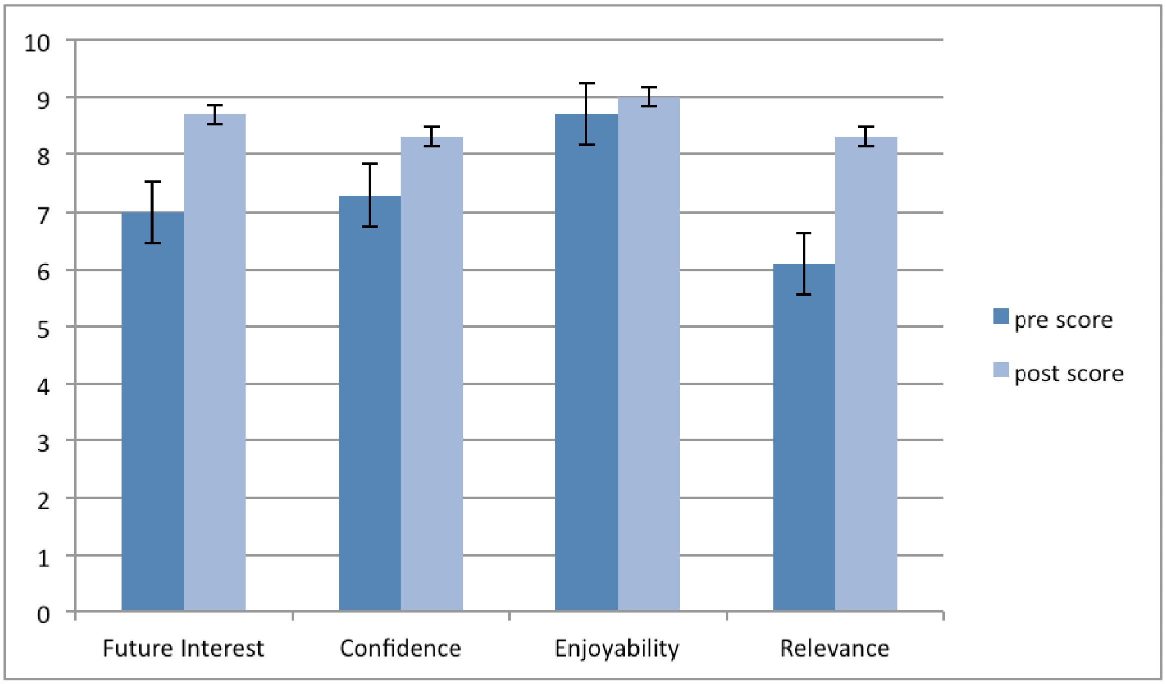


Figure 47. Survey pre-post scores for House players (phase two)

		Mean	N	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pair 1	**preFutureH**	7.000	7	2.5166	.9512	*t*(6) = 1.98, *p*=0.095
	postFutureH	8.71	7	.756	.286	
Pair 2	**preEnjoyH**	8.714	7	.7559	.2857	*t*(6) = .60, *p*=0.569
	postEnjoyH	9.00	7	.816	.309	
Pair 3	**preConfH**	7.286	7	1.6036	.6061	*t*(6) = 1.27, *p*=0.251
	postConfH	8.29	7	1.254	.474	
Pair 4	**preRelevH**	6.143	7	2.9681	1.1218	*t*(6) = 2.03, *p*=0.089
	postRelevH	8.29	7	.488	.184	

Table 15. Mean attitude scores and significance values for House players (phase two)

5.2.2.3.2 Rosie the Fashionista Players Scores

Players of Rosie the Fashionista demonstrated a significant improvement in the confidence scale (p=0.021). The players did not demonstrate a significant improvement in the remaining scales (**future interest** (p=0.347), **enjoyability** (p=1.0) and the **relevance** (p=0.395)). It is probably interesting in this condition to see the mean score for the relevance scale was decreased after playing Rosie the Fashionista, while the mean scores for the other scales were increased. However, it is also likely that this is just normal noise in survey data. Figure 48 and Table 16 show the mean attitude scores and descriptive for Rosie the Fashionista players.

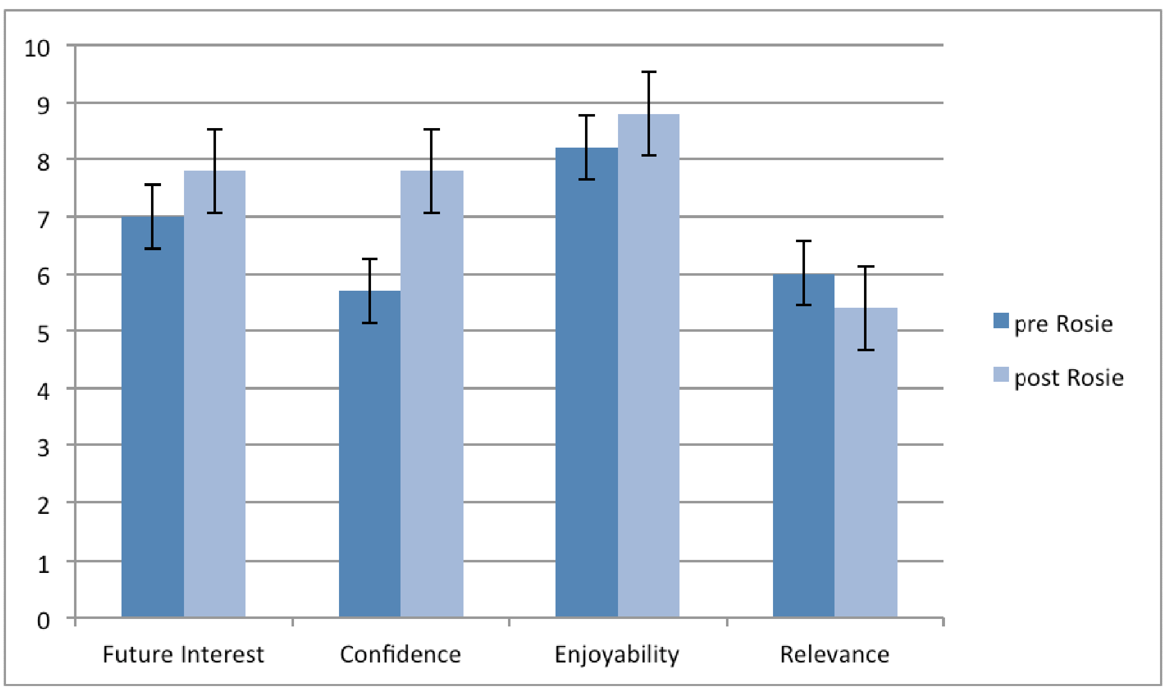


Figure 48. Survey pre-post scores for Rosie players (phase two)

		Mean	N	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Pair 1	**preFutureR**	7.0000	9	3.12250	1.04083	*t*(8) =1.0, *p*= 0.347
	postFutureR	7.7778	9	2.38630	.79543	
Pair 2	**preEnjoyR**	8.2222	9	2.04803	.68268	*t*(8) =0.0, *p*= 1.0
	postEnjoyR	8.7778	9	2.22361	.74120	
Pair 3	**preConfR**	5.6667	9	2.06155	.68718	*t*(8) =3.10, *p*= 0.021
	postConfR	7.7778	9	1.64148	.54716	
Pair 4	**preRelevR**	6.0000	9	2.44949	.81650	*t*(8) =0.92, *p*= 0.395
	postRelevR	5.4444	9	2.60342	.86781	

Table 16. Mean attitude scores and significance values for Rosie players (phase two)

5.2.2.3.3 House Players Versus Rosie Players

Players of Build a House and of Rosie the Fashionista did not differ significantly from one another in the **confidence** scale (*p*=0.544). Likewise, we found no significant differences between the two conditions in the **programming enjoyability** scale (*p*=0.933) or the **future interest** scale (p=0.258). However, the difference between the two conditions in the **relevance** scale was significant (*p*=0.014). Figure 49 and Table 17 show the difference in scores between the two conditions.

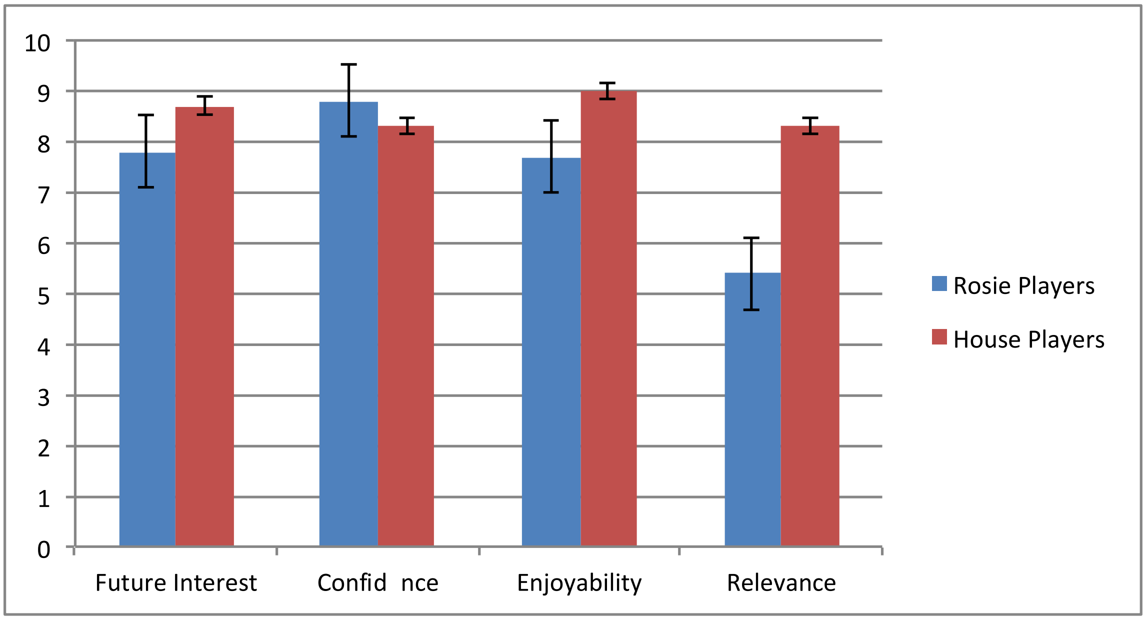


Figure 49. Difference between post-scores in the Relevance scale was significant (phase two)

Scale	Build a House (paired)	Rosie the Fashionista (paired)	Between groups (ANCOVA)
Confidence	*p*=.251 *t*(6) = 1.27	*p*=.021 *t*(8) = 3.10	*p*=.544 *F*(1, 14) = 0.39
Programming Enjoyability	*p*=.569 *t*(6) = 0.60	*p*=1.0 *t*(8) = 0.00	*p*=.933 *F(*1, 14) = 0.007
Future interest	*p*=.095 *t*(6) = 1.98	*p*=.347 t(8) = 1.0	*p*=.258 *F*(1, 14) = 1.41
Relevance	*p*=.089 *t*(6) = 2.03	*p*=.395 t(8) = 0.92	*p*=.014 *F*(1, 14) = 8.26

Table 17. Significance values after comparing the two game conditions (phase two)

5.2.2.3.4 Female Versus Male Attitude Scores

In the following two charts, I present a breakdown of the attitude scores for female versus male players for Rosie the Fashionista game (Figure 50) and Build a House game (Figure 51).

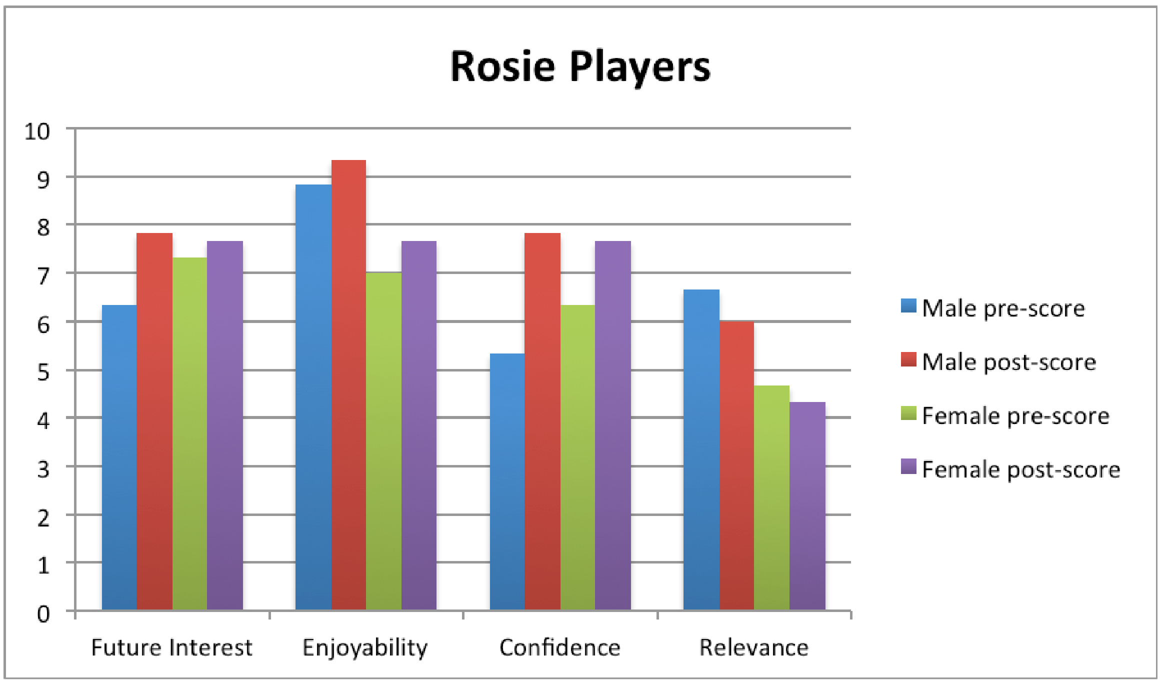


Figure 50 Breakdown of attitude scores by gender (Rosie game)

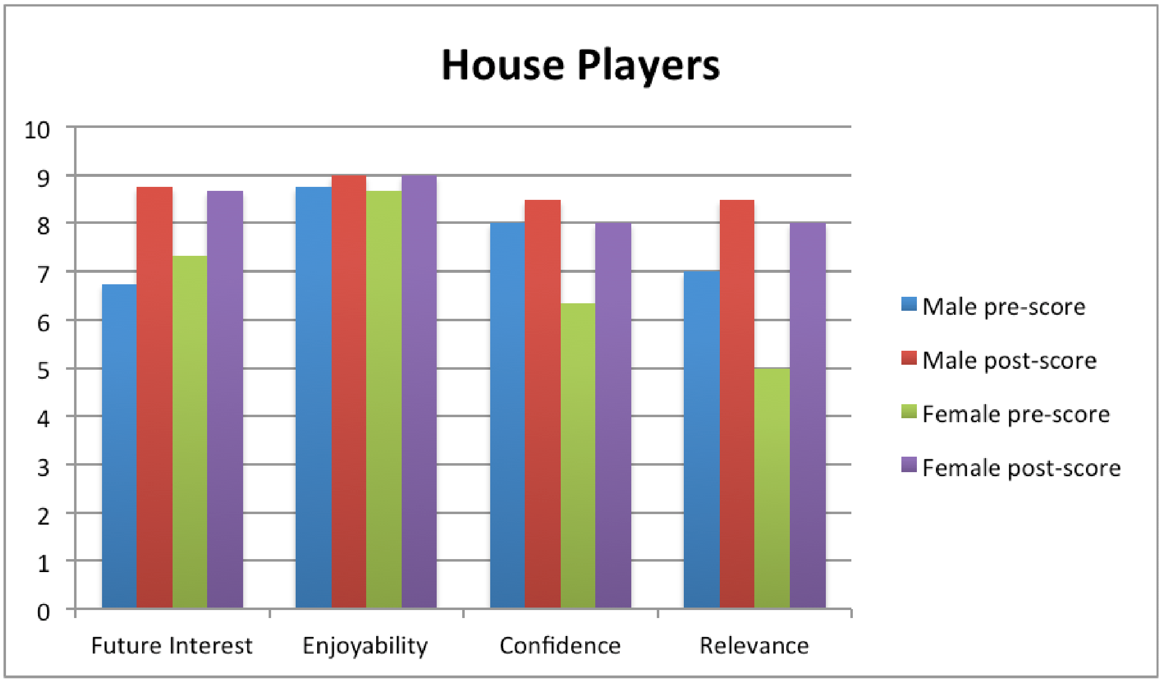


Figure 51 Breakdown of attitude scores by gender (House game)

5.3 Post Interviews

After completing the study, we conducted post interviews with some participants to gain more insight into how they perceived the games in relation to their gender identity. We also offered them the opportunity to play the game that was not assigned to them in the study. Most participants were able to quickly use the programming concepts they learned previously when playing the new game and expressed how similar the two games were. One child pointed out that the game is exactly the same as the one he played previously except that "*the wording is different*". Another child said "*well, it's kind of the same game, but not the same*."

Rob (7 year old boy) played Rosie the Fashionista in the post interview. When he finished the game, he commented:

> ***Rob:*** *I think you might wanna also make a boy's one, cause if boys don't like the House one, or Rosie one, then, and they wanna do computer programming, they're gonna go like 'ooh!, I don't wanna do computer programming anymore' and then we will lose people*
>
> ***Researcher:*** *Aha. So you want us to build something for boys. Can you give us an idea of what's the best, like, choice or theme for a game for boys?*
>
> ***Rob:*** *Well, I think it should be, umm, it should be kind of like this [pointing to Rosie's game on the screen]. Is there like a boy's name in this?*
>
> ***Researcher:*** *you mean a boy character in here?*
>
> ***Rob:*** *yeah*
>
> ***Researcher:*** *would that make it into a boy game?*

Rob: *yeah.*

Here, Rob proposes a simple change to the game to transform its gender orientation so that it could appeal to boys. Even though Rob confirmed that some boys might like either one of the two games, he seems to make a very important connection between players' gender and game gender orientation. When we asked Rob later about his plans for the future he said:

Rob: *I think I might be an army soldier*

Researcher: *why do you want to be an army soldier?*

Rob: *well, it would kind of be like, helping my mom's cousins. My mom has three cousins that are in the army, and my dad's dad he was in the army. He was a tank commander and he flew a jet*

Researcher: *Aha, and did you think about what you want to study in college?*

Rob: *I wanna go to college and study different wars, cause I'm really into wars, real wars not like Star Wars or different show wars. And I think that could be the boy one [referring to a possible design of our game to be themed in wars] cause a lot of boys like army stuff and then also I have a girl in my class and she likes Star Wars and stuff like that.*

In this excerpt, Rob was talking about his future plans and career aspirations then he spontaneously suggests an alternate design theme that represents his own interests. Rob did not suggest wars theme in the first place when we asked him for boys' game, it only came into his mind when he was expressing his own interests. He then continued to associate these interests with other boys in an act of conforming to stereotypes about boys' preferences.

We also interviewed Cynthia (10 year old girl) after the study and asked her which game she liked better. She said she liked Build a House because:

> *"I'm not really the type of, like, girl who likes dresses and everything so I'm more like, I like video games, like action figures, boys show TV shows pretty much all that".*

In this excerpt, Cynthia clearly distinguishes her biological gender from her constructed gender, and the masculine domain of interests seems to closely represent her own interests. In Cynthia's conversation, just as Rob, the importance of the connection between players' (constructed) gender and game gender orientation seems evident.

In addition, we interviewed Elena (7 year old girl) and had the following conversation with her:

> ***Researcher:*** *Why did you sign up for these game activities?*
>
> ***Elena:*** *because I like the games*
>
> ***Researcher:*** *what games do you like?*
>
> ***Elena:*** *girl games*
>
> ***Researcher:*** *how did you know that we have girl games? did you see the flyer?*
>
> ***Elena:*** *yes*
>
> ***Researcher:*** *what did you notice about it? [hands in the flyer]*
>
> ***Elena:*** *that it has these clothes [points to Rosie game photos] and then I thought I should do it because I like dressing up games.*

In the above excerpt, we tried to elicit Elena's motivation for joining the study, and it seems that photos of Rosie's game had influenced her decision to participate.

These interviews revealed the diversity in participants' preferences in game play and how these preferences relate to their constructed gender identity in one way or another.

5.3.1 Character Representation

In post interviews with children, we tried to elicit children's reasons for classifying the gender orientation of the games. We found that participants from the first phase (Middle East) considered Rosie the Fashionista to be a girl-oriented game despite our suggestion to change the character to a boy. In contrast, participants in the second phase felt that the sex of the main character played a bigger role in deciding the gender orientation of the game than other aspects of the game. We include some excerpts from interviews of the first (Middle East) phase below.

Researcher: *Do you think boys will like this game?*

Nora: *No… no they wouldn't like it because it's for girls*

Researcher: *why is it for girls?*

Nora: *because she is a girl*

Researcher: *what if we have a boy character; would that make it a boy game?*

Nora: *ummmm.. ma..maybe…*

Researcher: *Will boys enjoy playing the game then?*

Nora: *No, it's not appropriate for them to play it*

Researcher: *why is that?*

Nora: *because it's a dress-up!*

Researcher: *what kinds of games do you think they enjoy?*

Nora: *Cars.. and wrestling…*

In addition, Mona shared similar views about Rosie's game.

> ***Researcher:*** *Do you think boys will like this game?*
>
> ***Mona:*** *No*
>
> ***Researcher:*** *why?*
>
> ***Mona:*** *I don't know, they wouldn't like it because it's dress up, they don't like dressing up*
>
> ***Researcher:*** *what do they like?*
>
> ***Mona:*** *they like the games they really play [in real life]*
>
> ***Researcher:*** *like what?*
>
> ***Mona:*** *like soccer*
>
> ***Researcher:*** *what if we change the character to a boy, would they like it then?*
>
> ***Mona:*** *No, they wouldn't like it*
>
> ***Researcher:*** *why?*
>
> ***Mona:*** *because they don't like dressing up!*

In the second phase, Matthew (a 7-year-old boy) was just starting to play Rosie the Fashionista when he exclaimed!: "*I want to design my own person, how do I make it into a boy?!*" When we interviewed him after the game, he suggested that changing the character sex would make this game a '*boy game'*. In addition, Rob's example in the previous section echoes the same view. A third example from the second phase is Mia (9 year old girl), she played Rosie the Fashionista in the post interview and when we asked her about her opinion she said:

> ***Mia:*** *I think it's nice, it would be good for my little sister cause she likes to dress up, and Build a House is like a game for everyone*
>
> ***Researcher:*** *so dress up would be for little girls?*

Mia: *yeah, well, maybe for boys if you're interested in fashion*

Researcher: *what if we have a boy character; would that make it a boy game?*

Mia: *yeah! I think it would be a boy game because boys sometimes like, if you're going for a wedding you wanna dress nice, or if you're going to a fancy dance, you wanna look nice, so like, it depends.*

From our post interviews with children, it seems that interpretation and readings of Rosie's game were quite different between participants from the two phases. Nora and Mona, among many others, from the first phase were reluctant in considering the game suitable for boys after changing the character to a boy. However, Rob, Matthew and Mia were confident that boys would enjoy it after changing the character to a boy.

5.4 Social Activity Around the Games

One of my goals in this study was to investigate patterns of social activity surrounding a girl-oriented versus a gender-neutral game. From a cultural forms standpoint, the two different versions might invite different patterns of interaction on the part of students. In the first phase, I did not video record the game playing sessions due to privacy concerns among the parents, but I used field notes and observations during the sessions. In the second phase, I video recorded all game playing sessions and transcribed them. I describe the patterns of social activity for each phase below.

5.4.1 Phase One

In the first phase, I saw a clear distinction in the patterns of engagement between the two games. Upon entering the computer lab, players of Rosie the Fashionista started out with one player per computer, and then I told them that they could either play individually or as a group, whichever they preferred. Most girls decided to play in groups of two, but in a short while I observed signs of possession in groups in which one girl would take control over the mouse and not collaborate with her partner, which often resulted in conflict. One pattern of conflict would proceed like this (not an actual transcript):

> ***G1:*** *[drags a top block to the workspace] and now I want to match that with a jeans*
>
> ***G2:*** *[attempts to grab the mouse]*
>
> ***G1:*** *[maneuvers]*
>
> ***G2:*** *but look, the skirt looks very beautiful!*
>
> ***G1:*** *No! jeans is better [drags jeans block to the workspace]*

G2: *no! It's my turn, I want a skirt!*

G1: *No! this looks more beautiful*

G2: *[looks frustrated], now let's change that color to red, I love red*

G1: *I don't want red, I want purple*

G2: *Teacher, she won't listen to me or give me a turn! I want to go back to my computer!*

In this condition, girls seem to want to take control of the mouse. They were reluctant to give their partners a turn or to listen to their suggestions, despite their partner's insistence. The girls' exchanges suggest a struggle over creative ownership of the activity. But at the same time, girls appreciated playing together in the same room. They would often glance at one another's screen, seek and offer help to solve the puzzles, call (and be called) to look at the outfit one player created. This observation is consistent with earlier research studies (Inkpen et al., 1999) that found that girls often wanted to work collaboratively on puzzle software, but that they frequently had conflict over sharing the mouse. In Rosie the Fashionista game, girls contended over clothing choices as well as over sharing the mouse, but they enjoyed solving the puzzles together. In Build a House condition, just as Rosie condition, players started out with one player per computer and then quickly joined their friends to play together rather than alone. Groups of mostly two and some three were formed. However, unlike with the Rosie game, the context of this game seemed more inviting for collaboration and turn-taking between players. In Build a House, girls would switch over the mouse control between them and discuss which colors they would prefer their house to have. Conversations between players in this game usually included the phrase "our house" rather than "my house". In the fifth activity, where players are asked to name a house, younger girls created names like "dream house", "beautiful house", while older girls referred to their first names like "Sarah and Nora house". The pattern of possession with Rosie versus the pattern of turn-taking and collaboration with Build a House was observed over multiple and different sessions. This reinforced to our interpretation that the context of the game was the driving force behind this atmosphere rather than individual differences between the players.

5.4.2 Phase Two

In phase two, the number of girls participating in each condition was too low for us to determine whether or not similar patterns of engagement in phase one would emerge. However, participants' (both boys and girls) practices surrounding Rosie the Fashionista and Build a House differed in this phase as well. In Rosie the Fashionista, I observed players engaging in the context of the game, making either 'beautiful' or 'funny' looks for Rosie and calling friends to see how she looked to laugh at or admire her together. While in Build a House condition, players were more focused on achieving the goal of the game rather than spending time playing with the colors and accessories of the house they were building. After successive watching of the games sessions' videos and analyzing researcher's notes and transcriptions, I developed a coding scheme using a grounded theory approach (Strauss and Corbin, 1980). I repeatedly watched the videos to create and refine codes focused on how children reacted to and interpreted the different games. In analyzing the content of the videos and field notes, I also focused on differences between masculine and feminine interpretation and engagement around the same game. I coded the game playing sessions using the scheme shown in Table 18.

#	Code	Subcodes	Description
1	**Interact**	Ask	Asking researcher/friend for help explicitly [e.g. "I need help"- "can you help me?"]
		Help	Researcher/ friend providing help to players [e.g. "pick that", "put number 6", explaining the purpose of the activity]
		Answer	Answering a question from a researcher a friend/ replying to a comment
2	**Engagement**	eng	Engaging with game content by commenting on the content or program execution [e.g. "I want [something]", "show!", "6times!", "she needs to wear..", "she's supposed to go to the gym", "oh my god! [on execution]]
		look	Asking others to see one's screen [e.g. "look at my girl!", "look at my house"]
		Laugh	Laugh together (two or more students laughing together)
		feature	Talking about game features [e.g. "You can put on colors" , "you can change the number"]
		conflict	Disagreement over block choices or over the mouse control [e.g. "No, I wanna pick that", "No, I want wavy style!", refusing to hand in the mouse to a friend]
3	**Gender**	genderPreference	Expressing gender/sex preference [e.g. "I want a boy", "how do I make it into a boy?"]
		Genderize	Genderize stuff [e.g. "that's for girls", "lady color"]
		genderComment	General comments on gender [e.g. "she's ugly", "she's naked"] [This code applies to comments on Rosie basic appearance regardless of outfit choices]

4	**Appearance**	Appearance-admire	Admiring what's on the screen [e.g. "I like that", "this looks good"] [This code applies to sentences where players are admiring something they've created/previewed]
		Appearance-dislike	Disliking what's on the screen [e.g. "ewww", "I don't like that"] [This code applies to sentences where players are disliking something they've created/previewed]
		Appearance-fun	Laughing at/making fun of what's on the screen [e.g. "that's funny", [laughing and pointing to the screen]] [This code applies to sentences where players are making fun of/ laughing at something they've created/previewed]
5	**Name**	Name-sarcastic	Being sarcastic with function names [e.g. "fat head", "floppy head", and random typing]
		Name- personal	Naming functions after personally meaningful names [e.g. first or last name, a friend's name, "66 troopers"]
		Name- general	Naming functions general names [e.g. "prettiness", "nice house", "beautiful house"]
6	**Read**		Reading off the screen
7	**Reflect**		Reflecting on progress status [e.g. "I don't know how to do this", "I'm done", "I'm stuck", "I did it!"]
8	**Misc**		Any sentence that doesn't fall into the above categories

Table 18. Video Coding Scheme

Seven broad categories of social activity emerged from my data. *Interact* refers to instances of interaction during the session and includes asking the researcher/ a friend for help on the puzzle, help provided by the researcher/ a friend to players (such as reading game instructions, explaining the purpose of the activity and giving information on how to solve the puzzle) and answering questions from both friends and researchers. *Engagement* refers to instances of player engagement with the game and involves commenting on/ laughing at game content, inviting others to watch program creations, talking about game features and conflicts around the game. *Gender* includes references to gender, sex, or masculine/feminine terms. *Appearance* refers to sentences where players are reacting to the appearance of Rosie/house they've created/previewed. Reacting includes either liking, disliking or laughing at/making fun. *Name* refers to names chosen by players to define functions in the programming language. These names can either be *general* names, *personal* names, or *sarcastic* names. *Read* refers to instances in which players read instructions and block names directly from the screen. *Reflect* includes sentences in which players reflect on their progress status during the game.

5.4.2.1 Video Coding Findings

Many of the social activities around Rosie the Fashionista seemed quite different from those around Build a House, although they both shared general activities such as seeking and providing help, content engagement, reflecting on progress status, and so on. Rosie the Fashionista seemed to encourage a full range of gendered language and speech. For example, after only 30 seconds of starting the session, one of the boys was able to quickly *Genderize* the game and indicate that it was not of his interest. His remark, "*This is not for me at all!*", suggests that the activity he perceived in the game allowed him, in such a short time, to make gender-based judgments on the game and decide that it did not fit with his sense of gender (masculine) identity.

In addition, a number of boys expressed gender/sex preference while playing Rosie the Fashionista by explicitly stating that they wanted to play with a boy character rather than with Rosie; these gender preference comments include "*How can you make it into a boy*", "*Why do I have to get a girl?*", "*Can you change it into a boy?*", "*Why do we have to design a girl, not a boy?*". By expressing these gender preference comments, the boys seem to strongly identify with player characters of their gender.

Additionally, general gender related comments and gender mocking have arisen during the game. For example, in level five, where players are asked to type in function names, some boys who played Rosie the Fashionista game started teasing each other by typing their friends' names for Rosie. The following excerpt comes from three third grade boys playing Rosie the Fashionista. The boys, Max, Dennis and Rick were setting next to each other and Max and Dennis decided to write Rick's name for Rosie. Dennis started typing Rick's name and when he finished they both laughed and called for Rick's attention.

> ***Max:*** *Look! Rick, look! [laughing]*
>
> ***Dennis:*** *[laughing and looking at Rick]*
>
> ***Rick:*** *why did you put my name? [looking embarrassed]*
>
> ***Max:*** *I did ask. I asked him to put it on [pointing to Dennis]*
>
> ***Rick:*** *No! but that's not.. that's not a boy!*

In the above excerpt, Max and Dennis seem to deliberately mock Rick by typing his name for Rosie. By saying "*No! but that's not.. that's not a boy!*", Rick was consciously conveying that his name was not consistent with Rosie's sex/gender.

Moreover, since the boys genderized Rosie the Fashionista as a "girly" game, they intentionally used the color pink in various clothing choices likely because they also genderize that color as a "girly" color. For example, Max (8 year-old boy) was looking at the list of available colors when he decided to use a pink block and commented, "*Look! I'm gonna do lady color pink!*"

On the other hand, none of the boys who played Build a House chose the color pink to decorate their houses. This suggests that the cultural forms that players perceived in the game (the content and metaphors in the game) can have a great impact on how players oriented themselves and interacted with it.

Some instances of player's conflicts around clothing choices and over mouse control were also seen in Rosie the Fashionista game. An example is the following excerpt between Chris and Dennis (8 year-old boys) who were playing on the same workstation and fighting over the hairstyle they wanted Rosie to have.

> ***Dennis:*** *Now what color? Hair?*
>
> ***Chris:*** *Wavy style!*
>
> ***Dennis:*** *Wavy! [smiling]*
>
> ***Chris:*** *No! at the top, at the top!*
>
> ***Dennis:*** *No! I'll put it back!*
>
> ***Chris:*** *Nooo! Wavy style! I said wavy style!*

In addition, the pair also had a conflict over the mouse control as demonstrated in the following excerpt.

> ***Chris:*** *Let's play with the blocks as you like [pulling the mouse from Dennis's hand]*
>
> ***Dennis:*** *Chris! [pulling the mouse cord from Chris] you're gonna rip the cord!*
>
> ***Chris:*** *yeah! OK! You put one thing and then I put mine, OK?*
>
> ***Dennis:*** *No! not the repeat block!*
>
> ***Chris:*** *yeah, yeah, yeah [laughing]*
>
> ***Dennis:*** *where.. where should we go?*
>
> ***Chris:*** *Ummm. Add a definition [points to screen], the repeat block, and then put, you know it says we can do.. press it, press right there.. and look.. one [starts typing on the keyboard] zero, zero, zero, zero, zero…*
>
> ***Dennis:*** *[taking Chris's hand off the keyboard]*

In the above excerpt, the pair have just completed the last activity and started the open ended exploration level. Chris decided to experiment by adding many control blocks to the workspace, and then by saying "*you know it says we can do...*" and typing 100,000 on the repeat block, he was referring to the instruction of this activity "play with the blocks as you like". Dennis, on the other hand, wanted to have control over the mouse and was frequently pulling the mouse cord back and forth from Chris.

Moreover, Jose (10 year-old boy) and Cathy (10 year-old girl) were each playing on their own computers. Cathy was able to solve a puzzle that Jose was struggling on and then she commented:

> ***Cathy:*** *I did it, I did it! [singing and dancing] after passing the level*

Jose: *How? [asking Cathy]*

Cathy: *[reaching for Jose's keyboard]*

Jose: *[preventing Cathy from typing and starting to type on his keyboard]*

Cathy: *[inaudible] wedding look... and that's not how you spell wedding!*

Another two similar instances were seen between Cathy and Alice in following scenarios.

Cathy: *[helping Alice solve the puzzle by telling her what to do and pointing to the screen]*

Alice: *[follows Cathy's instructions]*

Cathy: *[trying to grab Alice's mouse to solve the puzzle for her]*

Alice: *[refusing the hand in the mouse to Cathy]*

Then, in a later level, the same scenario with the same girls have happened but by switching the roles.

Alice: *[trying to hold Cathy's mouse to help her with the puzzle]*

Cathy: *[shaking her hand off while holding on to the mouse]*

Finding these instances of conflict only in Rosie the Fashionista sessions supports the findings of phase one, where girls who played Rosie the Fashionista frequently contended around clothing choices and control of the mouse, while girls who played Build a House appeared to be more likely to collaborate and take turns while playing.

5.4.2.1.1 Masculine Versus Feminine

In analyzing the content of the videos, I was also interested in investigating whether there would be differences between masculine and feminine reactions to and interpretations of the same game. One of the things I noticed while coding the transcriptions is that boys who played Rosie the Fashionista reacted to the outfits of Rosie in two ways, either admire her appearance or laugh at her because they created a funny outfit. On the other hand, girls usually reacted to the appearance of Rosie in three different ways; admire her appearance, laugh at her funny clothes, and also dislike some outfits that were available for them. For instance, the following excerpt comes from a third grade boy Ethan setting next his friend Jim, and next to them is Tania, a 6 year old girl all playing Rosie the Fashionista. The session has just started and Ethan appeared to be amused by an outfit he was previewing.

> ***Ethan:*** *That just looks good! [after previewing an outfit]. What are you supposed to do right here?*
>
> ***Jim:*** *I don't know*
>
> ***Tania:*** *I know how to do it!*
>
> ***Jim:*** *I don't*
>
> ***Ethan:*** *oh my gosh, no! [laughing while previewing another outfit]*
>
> ***Jim:*** *gym bottom [reading off the screen]*
>
> ***Ethan:*** *I want this one, this one looks pretty! [after previewing another outfit]*

When Ethan started playing, he immediately began manipulating and previewing outfits without much attention to the instructions. By saying "*that just looks good*" and "*I want this one, this one* *looks pretty!*", Ethan was admiring the appearance of Rosie he was previewing and creating. In the same excerpt, Ethan appears to also laugh at the appearance of Rosie after previewing a different outfit. On the other hand, girls appear to look at the outfits of Rosie in one additional dimension. By disliking a certain outfit, girls seem to express their personal taste of clothing around the available outfits for Rosie. For example, Cathy, a 10-year-old girl playing Rosie was just beginning the game and was browsing the list of available outfits. She was slowly hovering her mouse over the blocks to preview the clothing and carefully inspecting them when she commented "*No, no, no, no, ewwww!*" This kind of reaction was only expressed by female players in this study. This finding also suggests that Rosie game seemed to encourage players to express themselves slightly more than the House game did.

One additional difference that I noticed between masculine and feminine engagement around the games was that, in level five, players are asked to type in function names for their own subroutines. Boys' chosen names were coded into three different categories: personal, general and sarcastic names. Girls' names, on the other hand, were coded into only two categories; either personal or general names. The boys seemed to be more sarcastic during Rosie game, which suggest that boys felt the need to be sarcastic to save face and legitimize their engagement in an overtly feminine game. For instance, one 7-year-old boy who played Build a House was passionate about the army and he had many relatives there. When he named his house, he chose the name "66 troopers", and while calling for his friend's attention to check out the name, he paused and said "maybe I should call it 67! Or 88!". This boy, Rob, decided to give his house a personally meaningful name. In addition, one third grade boy who played Rosie the Fashionista seemed to like his girlfriend, Abby, and he chose the name "Abby prettiness" for Rosie's wedding look.

Children also chose general names for their houses and for Rosie's look. For example, Megan (a third grade girl) was playing Build a House and chose the name "Nice" for her house. Similarly, Cathy was playing Rosie the Fashionista and typed "wedding look" for Rosie's wedding look. On the other hand, some boys seemed to take the opportunity of their ability to type their own names to act funny and show off their funny side, especially those who played Rosie the Fashionista game. Our interpretation of this is that posturing has a purpose for the boys. They have to put on a show of not taking it too seriously or their friends might think they are into a girly game. Again, this also suggests that the cultural forms that players perceived in the game (the content and metaphors in the game) can have a great impact on how they oriented themselves and interacted with it.

For example, the following excerpt comes from two third grade boys playing Rosie the Fashionista.

> ***Dennis:*** *Mine is gonna be floppy head [laughing]*
>
> ***Chris:*** *OK, mine is.. mine is [pausing for a while to come up with a name] mine is fat head [smiling] fat head!*

In addition, Michael and Aaron were playing Build a House each on their own computer and talking about the game.

Michael: *[connecting blocks and pressing show button] we got a beige, oh! I didn't put a name! and what should I do next?*

Aaron: *[typing randomly on the keyboard] that's my name! [smirking]*

Aaron, in the above excerpt was trying to be sarcastic with his house name when he randomly typed on the keyboard, after that, he called for his friends' attention and said

"*Look at my name.. my name is soo looooong! I made it so long!.. Michael, check out my name… check out my name!*"

Michael was engaged with his game and did not turn his head toward Aaron. Aaron then raised his voice saying "*MICHAEL!! CHECK OUT MY NAME!!*" but Michael didn't pay attention either. However, Nick, from the other side, heard him responded to Aaron by looking at his screen and smiling. Aaron seemed satisfied by getting a positive response to his name and repeated "*so long!*" while smiling.

5.4.2.1.2 Collaboration Versus Alone

In analyzing the videos, I was also interested in investigating the patterns of collaboration versus working alone between the two games. To achieve this, I coded participants' interactions using the following coding scheme (Table 19).

#	CODE	DESCRIPTION
1	ALONE	Student is working alone on his computer
2	ASK	Student is asking a friend a question about the game
3	INST	Student is instructing a friend on how to achieve something
4	REACT	Student is reacting collaboratively on something seen on the screen
5	TOGETHER	Student is collaborating on solving a puzzle with a friend
6	NA	Student was not available (e.g. went to the washroom)

Table 19. Coding Scheme

5.4.2.1.2.1 Method

For each one minute interval in the videos, I coded each and every participant status during a 15 second window of time (starting at the 30 second mark). A sample from this interval coding is included below (Table 20).

TIME	JADEN	CALEB	DENNIS	MAX	JADA
0-1	ALONE	ALONE	ALONE	ALONE	ALONE
1-2	ALONE	ASK	INST	ALONE	ALONE
2-3	ALONE	REACT	REACT	REACT	ALONE
3-4	REACT	ALONE	REACT	REACT	ALONE
4-5	ASK	ALONE	ALONE	ALONE	ALONE

Table 20. Sample from interval coding

The above table summarizes the status of every participant during the 30-45th second of a minute. For example, all students were working alone in the first interval. In the second minute, Caleb was asking Dennis a question about the game and Dennis instructed him how to do it.

For each game, the camera was able to capture the status of ten participants. I compiled the status of all participants for each game in Table 21.

VIDEO	ALONE	ASK	INST	REACT	TOGETHER	NA	TOTAL
ROSIE TOTALS	480	30	27	158	38	21	754
HOUSE TOTALS	582	16	17	59	5	37	716

Table 21. Players' status during both game conditions

I removed the NA instances from the total to get the adjusted total and compute the proportions. The adjusted values are included in Table 22.

VIDEO	ALONE	ASK	INST	REACT	TOGETHER	ADJUSTED TOTAL
ROSIE TOTALS	480 65.48%	30 4.09%	27 3.68%	158 21.56%	38 5.18%	733 100%
HOUSE TOTALS	582 85.71%	16 2.36%	17 2.50%	59 8.69%	5 0.74%	679 100%
Significance	Z=8.8 ***p*<0.000**	Z=1.8 *p*=0.067	Z=1.3 *p*=0.202	Z=6.7 ***p*<0.000**	Z=4.9 ***p*<0.000**	

Table 22. Players' statuses with adjusted values

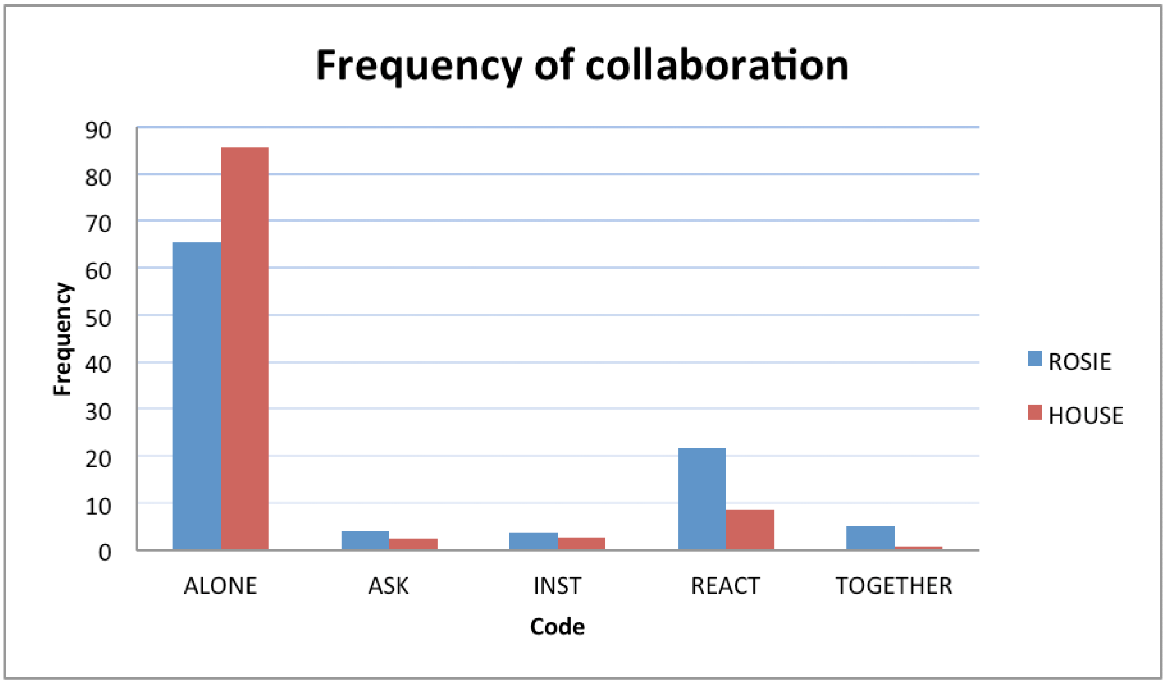


Figure 52. Frequency of collaboration between players (phase two)

5.4.2.1.2.2 Significance Testing

I used the z-test for two sample proportions to compare the frequency of collaboration between the two game conditions. The test revealed a significant difference in *working alone* between participants of the two games. Players of Build a House spent significantly more time working alone than players of Rosie the Fashionista. On the other hand, players of Rosie the Fashionista spent significantly more time *reacting collaboratively* on game content and *collaborating together* on solving the puzzles than players of Build a House. This result suggests that the two game conditions might have differently impacted the way players interact with them. In particular, Rosie the Fashionista game seemed to encourage more collaborative response than Build a House. Our interpretation of this outcome is that the cultural forms that players perceived in the game (the content and metaphors in the game) can have a great impact on how players orient themselves and interact with it. However, this result should be interpreted with caution, as other factors can affect the way players interact with these games, such as the particular set of kids in each group. Reflecting on our results from phase one, where we found that players of Build a House collaborated on solving the puzzles more than players of Rosie the Fashionista did, we can suggest that the different gender composition of these samples might have affected the way players interacted with the game.

Chapter 6 Discussion and Conclusion

6.1 Discussion

On a general level, the study reported in this dissertation explores the feasibility of designing computer games to support the comprehension of fundamental computer programming concepts for elementary and middle school students. Despite the limited game structure, I observed significant pre-post learning gains and increases in positive attitudes toward computer programming.

At a more specific level, the study explores the impact of designing games based on gender-specific cultural forms. My findings suggest that children's learning scores were not affected by the type of game played; however, the cultural form of dress up dolls positively influenced players' interest in computer programming in one context and negatively influenced players' attitudes in another context. Specifically, when participants reported preference for games designed for girls, they were more motivated to learn about the topic after playing Rosie the Fashionista game. One explanation of this result could be that the cultural form of dress-up dolls evoked a stronger identification between players and their gender identity. On the other hand, when participants did not prefer games designed for girls, they were not able to relate the topic to their own lives after playing Rosie the Fashionista game. This result suggests that for those participants, the game did not afford such identification as the cultural form of dress-up was not associated with their gender identity.

I also observed how social dynamics in the room can be affected by what is represented on the screen. Social activity surrounding Rosie the Fashionista differed from that surrounding Build a House. Particularly, Rosie game seemed to encourage a full range of gendered language and speech. My interpretation of this outcome is that the cultural forms that players perceive in games can have a substantial impact on the resulting activity between players in the same room. There were also differences between masculine and feminine reactions to and interpretations of the same game. Specifically, boys seemed more sarcastic while playing Rosie the Fashionista. My interpretation of this outcome is that boys were "performing gender" as they were being intentionally sarcastic to assert their own constructed masculine identities in front of their peers. In this regard, I refer to the findings of (Yates and Littleton, 1999) where boys and girls oriented themselves and interacted with the games differently, based on the content and metaphors they perceived in the games.

In addition, post interviews with children revealed the diversity in participants' play preferences and how these preferences relate to their constructed gender identity in one way or another. The post interviews also showed how changing the sex of the main character in the game changes players' readings of Rosie's game in one context, but not the other. In particular, participants from the first phase (Saudi Arabia) were reluctant in considering the game as suitable for boys even if we changed the character to a boy. On the other hand, participants from the second phase (United States) were confident that boys would pretty much enjoy the game if we changed the character to a boy. I reflect on this result from the perspective that gender is socially and culturally constructed and that for girls in the first phase, dress-up was not seen as appropriate for boys might be due to the culture (i.e. separated schools and practices).

Why does all of this matter? Why should designers consider the cultural forms that they draw on to create games for learning, particularly in computer science education? A number of studies have examined the effects of *stereotype threat* on women's interest and performance in STEM fields (Good et al. 2010; Shapiro, 2012; Koch et al., 2008; Markus, 2011; Davies, 2002; Steele, 1997). Stereotype threat refers to "being at risk of confirming, as self-characteristic, to a negative stereotype about one's group" (Steele & Aronson, 1995). The fear of being treated or judged based on a negative stereotype about one's group has been empirically shown to impair one's ability to perform to full potential (e.g.[Steele & Anderson, 1995]) and to pressure *disidentification* from the domain where this group is negatively stereotyped (Steele, 1997). Women's and girls' disidentification with computing can be attributed, in part, to their susceptibility to stereotype threat (Peckham, 2007; Koch et al., 2008; Patitsas et al., 2014, Todd et al., 2005; Cohoon and Aspray, 2006). A relevant study (Good et al., 2010) examined the effect of stereotype threat on students' comprehension of science lessons by using stereotypic and counter-stereotypic textbook images. In that study, three student groups were assigned to read a section of chemistry textbook illustrated with either images of only male scientists, only female scientists, or with both male and female scientists together. In a later exam on the section, girls scored higher than boys in the female scientists only condition; boys scored higher in the male scientists' only condition; and in the mixed gender condition, the scores for both girls and boys fell between their scores in the stereotypic and counter-stereotypic conditions. Interestingly, this study provides evidence that "the mixed gender condition didn't simply represent the absence of stereotype threat. Instead, the condition seems to equalize the performance of girls and boys." In a similar fashion, focusing exclusively on gender-neutral designs for computational learning environments, especially in domains typically considered as masculine, might not represent the absence of stereotype threat for some girls. Providing counter-stereotypic designs might be one way to assemble new images of computing and dismantle the widespread stereotypes of computing masculinity.

When I chose to focus on gendered cultural forms, I was aware that preferences among girls can vary as much as it can vary between girls and boys. My goal was to create a culturally relevant experience to one group of children rather than to reinforce existing stereotypes. Designing exclusively gender-neutral environments can artificially narrow the design space and might actually work against leveling the playing field. A more effective strategy might be to support and encourage a full range of youth interests, including gendered ones. Diversifying the design of learning environments can help in diversifying people who engage with them. As Cheryan et al. (2015) argue, the current stereotypes steer women away from the field and constrain their learning opportunities and career aspirations. Thus, it is particularly important to diversify the stereotypes about the culture of computing, but not alter them all together, as the current stereotypes actually steer some men (and women) *into* the field. The aim is that people should not think they have to fit a specific stereotype to be successful in computing fields.

The findings of this study do not imply that utilizing female-oriented cultural forms in the design of programming games will turn girls into programmers, nor does it mean that female-oriented designs work better than neutral designs (or male-oriented designs). Rather, I propose that employing female-oriented cultural forms can provide a group of children with an opportunity to engage in personally meaningful learning experiences and might be a useful way to spark future interest and to influence career trajectories. Just as Hour of Code is not intended to make everyone a programmer, female-oriented games might only serve as a positive early experience for some children. In addition, providing counter-stereotypic designs for computer programming learning environments, without compromising the content, can allow children to retain aspects of their feminine identities while simultaneously challenging their prior assumptions about the masculinity of the domain (Hayes, 2011). Such strategy can engage girls with games that have the potential to develop IT expertise and would enable them to create new identities as feminine technical youths.

This study raises two questions that I think worth asking 1) Are we fighting the right battle (diversity in computing) with the wrong tools (limiting ourselves to gender-neutral designs)? And 2) By restricting the design, are we unconsciously implying that femininity and computer programming can't be related? A fuller exploration of these questions will require future work.

6.2 Limitations and Future Work

The results of the study reported here should be interpreted with caution; the sex composition of the samples aligned with gender stereotypes in terms of the kinds of games participants typically engage with. The sample from the first phase (Saudi Arabia) was all girls, and the game gender preference scale indicated that the sample preferred girl-oriented games. Similarly, the sex composition of the second phase sample (United States) was mixed between girls and boys, and we were not able to associate a specific gender identity to this sample in relation to the games they engage with. Thus, we were not able to perform cross-cultural comparison in terms of the effect of the two games on participants' attitude toward computer programming.

In addition, we were not able to recruit boys as participants in the first phase. It would be interesting to measure the impact of the two different games on boys in that particular context and compare that to boys in phase two. I expect most boys from Saudi would refuse to play Rosie the Fashionista, especially the older ones. If the character was changed to a boy, I expect that the degree of rejection to the game would be lessened, although not dramatically. The boys' perception on the femininity of a dress-up game might be greatly impacted if the boy character was a popular superhero or action figure. I would like to explore the impact of these various design options in future work.

Another limitation of this study is the number of participants in the second phase; broader participation in terms of the total number and gender representation is needed to gain a better understanding. We would like address these two limitations in future work. Moreover, the games offer only six activities to players, and while participants manifested a significant gain in their programming comprehension after playing the games, the long term retention of such short activity need to be measured.

Additionally, requiring children to fill out long surveys is a challenging procedure, thus, we tried to minimize the number of items in each scale as possible, but a comprehensive survey with more items per scale would be more reliable. Another limitation include sample self-selection bias as evident from one of the girls in the second phase who explicitly stated that she participated in the study after seeing the dress-up images in the flyer.

Finally, we are also interested in changing the female character *Rosie* to a male one *Peter*, and see how this would impact the results of such study.

References

AAUW. (2000). *Tech savvy: Educating Girls in the Computer Age.* Washington, D.C.: Educational Foundation of the American Association of University Women.

Abbate, J. (2012). *Recoding gender: women's changing participation in computing.* Cambridge, MA: MIT Press.

Abbis, J. (2011). Boys and machines: gendered computer identities, regulation and resistance. *Gender and Education* , 601-617.

Alvarado, C., & Dodds, Z. (2010). Women in CS: an evaluation of three promising practices. *Proceedings of the 41st ACM technical symposium on Computer science education.* New York, NY: ACM Press.

Anderman, L. H. (2003). Academic and social perceptions as predictors of change in middle school students' sense of school belonging. *The Journal of Experimental Education* , 72, 5–22.

Appel, M. (2012). Are heavy users of computer games and social media more computer literate? *Computers & Education* .

Appel, M., Kronberger, N., & Aronson, J. (2011). Stereotype threat impairs ability building: Effects on test preparation among women in science and technology. *European Journal of Social Psychology* .

Aschbacher, P. (2003). *Gender Differences in the Perception and Use of an Informal Science Learning Website.* Arlington, VA: National Science Foundation.

Baina, C. D., & Riceb, M. L. (2006). The Influence of Gender on Attitudes, Perceptions, and Uses of Technology. *Journal of Research on Technology in Education* .

Baki, R. (2004). Gender-Segregated Education in Saudi Arabia: Its Impact on Social Norms and the Saudi Labor Market. *Education Policy Analysis Archives* , 28.

Bamburg, J. (1994). *Raising expectations to improve student learning.* Oak Brook, IL: North Central Regional Educational Laboratory.

Bandura, A. (2006). Adolescent development form an agentic perspective. In F. Pajares, & T. Urdan, *Self-efficacy beliefs of adolescents.* Greenwich, CT: Information Age Publishing.

Barker, L. J., & Aspray, W. (2006). The state of research on girls and IT. In J. Cohoon, & W. Aspray, *Women and Information Technology: Research on Underrepresentation.* Cambridge, MA: MIT Press.

Barnett, R., & Rivers, C. (2004). *Same difference: how gender myths are hurting our relationships, our children, and our jobs.* New York, NY: Basic Books.

Barron, B. (2004). Learning ecologies for technological fluency: Gender and experience differences. *Journal of Educational Computing Research* , 31(1), 1-36.

Barron, B. (2004). Learning Ecologies For Technological Fluency: Gender and Experience Differences. *EDUCATIONAL COMPUTING RESEARCH* .

Basow, S. A. (1992). *Gender: Stereotypes and roles.* Thomson Brooks/Cole Publishing Co.

Benbow, C. P., & Stanley, J. (1980). Sex differences in mathematical ability: fact or artifact? *Science* , 1262-1264.

Benbow, C. P., & Stanley, J. (1983). Sex differences in mathematical reasoning ability: more facts. *Science* .

Berenson, S. B., Slaten, K. M., Williams, L., & Ho, C. W. (2004). Voices of women in a software engineering course: reflections on collaboration. *Journal on Educational Resources in Computing (JERIC)* .

Bers, M. (2008). *Blocks to Robots: Learning with Technology in the Early Childhood Classroom.* New York: Teachers College Press.

Beyer, S., Rynes, K., Perrault, J., Hay, K., & Haller, S. (2003). Gender differences in computer science students. *roceedings of the 34th SIGCSE technical symposium on Computer science education* (pp. 49-53). New York, NY: ACM Press.

Blum, L., & Frieze, C. (2005). As the culture of computing evolves, similarity can be the difference. *Frontiers* .

Blum, L., Frieze, C., Hazzan, O., & Dias, D. (2007). A cultural perspective on gender diversity in computing. In C. J. Burger, E. G. Creamer, & P. S. Meszaros, *Reconfiguring the firewall: recruiting women to information technology across cultures and continents.* Wellesley, MA: A K Peters.

Boyce, A. K., Campbell, A., Pickford, S., Culler, D., & Barnes, T. (2011). Experimental evaluation of BeadLoom game: how adding game elements to an educational tool improves motivation and learning. *Proceedings of the 16th annual joint conference on Innovation and technology in computer science education* (pp. 243-247). New York, NY: ACM Press.

Brickhouse, N., & Potter, J. (2001). Young women's scientific identity formation in an urban context. *Journal of Research in Science Teaching* , 965–980.

Bridgeman, B., & Wendler, C. (1991). Gender differences in predictors of college mathematics performance and in college mathematics course grades. *Journal of Educational Psychology* , 275-284.

Brosnan, M. J. (1998). The impact of psychological gender, gender-related perceptions, significant others, and the introducer of technology upon computer anxiety in students. *Journal of Educational Computing Research* , 63-78.

Bruner, J. S. (1996). *The Culture of Education.* Cambridge, MA: Harvard University Press.

Bruner, J., Jolly, A., & Sylva, K. (1976). *Play: Its role in development and evolution.* New York: Basic Books.

Brunner, C. (2008). Games and Technological Desire: Another Decade. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 33–45). Cambridge, MA: MIT Press.

Brunner, C., Bennett, D., & Honey, M. (1998). Girls games and technological desire. In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games* (pp. 72-79). Cambridge, MA: MIT Press.

Bryson, M., & de Castell, S. (1996). Learning to make a difference: Gender, new technologies, and in/equity. *Mind, Culture and Activity* , 119-135.

Buckley, K., & Anderson, C. (2006). A Theorotical model of Effects and consequences of playing video games. In J. Vorderer, & P. Bryant, *Playing Video games – Motives, Responses and Consequences* (p. Routledge). Mahwah, NJ: Routledge.

Budden, A., Tregenza, T., Aarssen, L., Koricheva, J., Leimu, R., & Lortie, C. (2007). Double-blind review favours increased representation of female authors. *Ecology and Evolution* .

Buechley, L., & Hill, B. M. (2010). LilyPad in the Wild: How Hardware's Long Tail is Supporting New Engineering and Design Communities. *In Proceedings of the 8th ACM Conference on Designing Interactive Systems* (pp. 199-207). ACM Press.

Buechley, L., Eisenberg, M., Catchen, J., & Crockett, A. (2008). The LilyPad Arduino: Using Computational Textiles to Investigate Engagement, Aesthetics, and Diversity in Computer Science Education. *Proceedings of the SIGCHI conference on Human factors in computing systems.* ACM Press.

Burke, P. J. (1989). Gender Identity, Sex, and School Performance. *Social Psychology Quarterly* , 159-169.

Busch, T. (1995). Gender differences in self-efficacy and attitudes toward computers. *Journal of educational computing research* , 147-158.

Butler, D. (2002). Gender, girls, and computer technology: what's the status now? *The Clearing House* , 225-229.

Butler, J. (1990). *Gender trouble: Feminism and the subversion of identity.* London: Routledge.

Caplan, P. J., MacPherson, G. M., & Tobin, P. (1985). Do sex-related differences in spatial abilities exist? A multilevel critique with new data. *American Psychologist* .

Cassell, J. (2002). Genderizing HCI. In J. Jacko, & A. Sears, *The Handbook of Human-Computer Interaction* (pp. 402-411). Mahwah, NJ: Lawrence Erlbaum.

Cassell, J. (1998). Storytelling as a nexus of change in the relationship between gender and technology: A feminist approach to software design. In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games* (pp. 298-327). Cambridge, MA: MIT Press.

Cassell, J., & Jenkins, H. (1998). Chess for girls? Feminism and computer games. In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games* (pp. 2-45). Cambridge, MA: MIT Press.

Charlton, J. P. (1999). Biological sex, sex-role identity, and the spectrum of computing orientations: A reappraisal at the end of the 90s. *Journal of Educational Computing Research* , 393-412.

Charsky, D. (2010). From Edutainment to Serious Games: A Change in the Use of Game Characteristics. *Games and Culture* , 177-198.

Cheryan, S. (2012). Understanding the Paradox in Math-Related Fields: Why Do Some Gender Gaps Remain While Others Do Not? *Sex Roles* .

Cheryan, S., & Plaut, V. C. (2010). Explaining Underrepresentation: A Theory of Precluded Interest. *Sex Roles* .

Cheryan, S., Drury, B. J., & Vichayapai, M. (2013). Enduring Influence of Stereotypical Computer Science Role Models on Women's Academic Aspirations. *Psychology of Women Quarterly* .

Cheryan, S., Master, A., & Meltzoff, A. N. (2015). Cultural Stereotypes as Gatekeepers: Increasing Girls' Interest in Computer Science and Engineering by Diversifying Stereotypes. *Frontiers in Psychology* .

Cheryan, S., Plaut, V., Davies, P., Paul, G., & Steele, C. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and Social Psychology* , 1045-1060.

Cheryan, S., Plaut, V., Handron, C., & Hudson, L. (2013). The Stereotypical Computer Scientist: Gendered Media Representations as a Barrier to Inclusion for Women. *Sex Roles* .

Cockburn, C. (1992). The circuit of technology: Gender, identity and power. In R. Silverstone, & E. Hirsch, *Consuming technologies: Media and information in domestic spaces* (pp. 33-42). London: Routledge.

Cohoon, J. M., Nable, M., & Boucher, P. (2011). Conflicted identities and sexism in computing graduate programs. *Frontiers in Education Conference (FIE).* IEEE.

Cohoon, J. M., Nigai, S., & Kaye, J. J. (2011). Gender and Computing Conference Papers. *Communications of the ACM* , 72-80.

Colley, A., & Comber, C. (2003). Age and gender differences in computer use and attitudes among secondary school students: What has changed? *Educational Research* , 155-165.

Corston, R., & Colman, A. M. (1996). Gender and social facilitation effects on computer competence and attitudes toward computers. *Journal of educational computing research* , 171-183.

Crombie, G., & Armstrong, P. I. (1999). Effects of classroom gender composition on adolescents' computer-related attitudes and future intentions. *Journal of Educational Computing Research* , 317-327.

Crombie, G., Abarbanel, T., & Trinneer, A. (2002). All-female classes in high school computer science: Positive effects in three years of data. *Journal of Educational Computing Research* , 385-409.

Dann, W., Cosgrove, D., Slater, D., Culyba, D., & Cooper, S. (2012). Mediated transfer: Alice 3 to Java. *Proceedings of the 43rd ACM technical symposium on Computer Science Education.* New York, NY: ACM Press.

Dasgupta, N., & Asgari, S. (2004). Seeing is believing: exposure to counterstereotypic women leaders and its effect on the malleability of automatic gender stereotyping. *Journal of Experimental Social Psychology* , 642–658.

Davies, P. G., Spencer, S. J., Quinn, D. M., & Gerhardstein, R. (2002). Consuming Images: How Television Commercials that Elicit Stereotype Threat Can Restrain Women Academically and Professionally. *Personality and Social Psychology Bulletin* .

Denny, P., Luxton-Reilly, A., Tempero, E., & Hendrickx, J. (2011). Understanding the syntax barrier for novices. *Proceedings of the 16th Annual Joint Conference on Innovation and Technology in Computer* (pp. 208-212). New York, NY: ACM Press.

Dickey, M. D. (2006). Girl gamers: the controversy of girl games and the relevance of female-oriented game design for instructional design. *British journal of educational technology* , 785-793.

DiSalvo, B. J., & Bruckman, A. (2009). Questioning video games' influence on CS interest. *Proceedings of the 4th International Conference on Foundations of Digital Games.* ACM Press.

DiSalvo, B., & Bruckman, A. (2010). Race and Gender in Play Practices: Young African American Males. *The Foundations of Digital Games Conference.* ACM Press.

DiSalvo, B., Yardi, S., Guzdial, M., McKlin, T., Meadows, C., Perry, K., et al. (2011). African American Males Constructing Computing Identity. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.* ACM Press.

diSessa, A. (2000). *Changing Minds: Computers, Learning, and Literacty.* MIT Press.

Dockterman, E. (2014 йил Nov). *New GoldieBlox Doll Takes Aim at 'Barbie' Beauty Standards*. Retrieved 2015 йил 9-April from time.com: http://time.com/3557696/goldieblox-doll-barbie-beauty-standards/

Doerschuk, P., Liu, J., & Mann, J. (2011). INSPIRED high school computing academies. *ACM Transactions on Computing Education (TOCE)* .

Duplantis, W., MacGregor, E., Klawe, M., & Ng, M. (2002). Virtual Family: an approach to introducing Java programming. *Proceedings of SIGCSE* (pp. 40-43). ACM Press.

Durndell, A., Glissova, P., & Sianna, G. (1995). Gender and computing: persisting differences. *Educational Research* .

Eagly, A. H., & Steven, J. K. (2002). Role congruity theory of prejudice toward female leaders. *Psychological review* .

Eccles, J. S. (1987). Gender roles and women's achievement-related decisions. *Psychology of women Quarterly* , 135-172.

Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender role stereotypes, expectancy effects, and parents' socialization of gender differences. *Journal of Social Issues* , 183-201.

Eglash, R., Gilbert, J. E., & Foster, E. (2013). Broadening Participation: Toward Culturally Responsive Computing Education. *communications of the acm* .

El-sanabary, N. (1994). Female education in Saudi Arabia and the reproduction of gender division . *Gender and Education* , 141-150.

Eliot, L. (2010). *Pink brain, blue brain: how small differences grow into troublesome gaps—and what we can do about it?* New York, NY: Houghton Mifflin Harcourt.

Elkjaer, B. (1992). Girls and information technology in Denmark—an account of a socially constructed problem. *Gender and Education* , 25-40.

Ensmenger, N. (2010). *N. Ensmenger. The computer boys take over: Computers, programmers, and the politics of technical expertise.* Cambridge, MA: MIT Press.

Epstein, C. F. (1988). *Deceptive distinctions: sex, gender and the social order.* New Haven: Yale University Press.

Falk, J. H. (2006). An identity-centered approach to understanding museum learning. *Curator: The museum journal* , 151-166.

Fernaeus, Y., & Jacobsson, M. (2009). Comics, Robots, Fashion and Programming: outlining the concept of actDresses. *Proceedings of the Third International Conference on Tangible and Embedded Interaction.* Cambridge, UK: ACM Press.

Fine, E., Wendt, A., & Carnes, M. (2014). Gendered expectations: are we unintentionally undermining our efforts to diversify STEM fields? *XRDS: Crossroads, The ACM Magazine for Students* .

Flanagan, M. (2005). Troubling'games for girls': notes from the edge of game design. *Unpublished proceedings of Digital Games Research Association.*

Flanagan, M., Howe, D., & Nissenbaum, H. (2005). Values at play: design tradeoffs in socially-oriented game design. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 751-760). ACM Press.

Frieze, C., & Quesenberry, J. L. (2013). From Difference to Diversity: Including Women in The Changing Face of Computing. *SIGCSE Technical Symposium on Computer Science Education.* ACM Press.

Frieze, C., Quesenberry, J. L., Kemp, E., & Velazquez, A. (2011). Diversity or Difference? New Research Supports the Case for a Cultural Perspective on Women in Computing. *Journal of Science Education and Technology* , 423-439.

Furger, R. (1998). *Does Jane Compute?: Preserving Our Daughter's Place in the Cyber Revolution.* New York, NY: Warner Books, Inc.

Gee, J. P. (2001). Learning in semiotic domains: A social and situated account. *Unpublished paper presented at International Literacy Conference.* Cape town, South Africa.

Gee, J. P. (2007). *What Video Games Have to Teach Us About Learning and Literacy.* Palgrave Macmillan.

Gee, J. P., & Hayes, E. (2010). *Women and Gaming: The Sims and 21st Century Learning.* Palgrave Macmillan.

Goffman, E. (1959). *The Presentation of Self in Everyday Life.* New York: Doubleday.

Good, J. A., Woodzicka, A., & Wingfield, L. C. (2010). The Effects of Gender Stereotypic and Counter-Stereotypic Textbook Images on Science Performance. *The Journal of Social Psychology* .

Gurer, D. (2002). Pioneering women in computer science. *SIGCSE Bulletin* (pp. 175-180). ACM Press.

Gurer, D., & Camp, T. (2002). An ACM-W literature review on women in computing. *ACM SIGCSE Bulletin - Women and Computing.* New York, NY: ACM Press.

Gurer, D., & Camp, T. (2001). *Investigating the incredible shrinking pipeline for women in computer science.* Final Report–NSF Project.

Guzdial, M. (2014). *Can female LEGO figures attract more girls to science? Sometimes not always?* Retrieved 2015 йил 9-April from Computing Education Blog: https://computinged.wordpress.com/2014/10/06/can-female-lego-figures-attract-more-girls-to-science-sometimes-not-always/

Hartmann, T., & Klimmt, C. (2006). Gender and computer games: Exploring females' dislikes. *Journal of Computer-Mediated Communication* , 910-931.

Hayes, E. (2011). Gender and Gaming. In S. Tobias, & J. D. Fletcher, *Computer Games and Instruction.* Information Age Publishing.

Hayes, E. (2008). Girls, Gaming, and Trajectories of IT Expertise. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 217–229). Cambridge, MA: MIT Press.

Hayes, E. (2005). Women, video gaming, & learning: Beyond stereotypes. *TechTrends* , 23-28.

Heeter, C., & Brian, W. (2008). Gender Identity, Play Style, and the Design of Games for Classroom Learning. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 281–296). Cambridge, MA: MIT Press.

Heeter, C., Egidio, R., Mishra, P., & Wolf, L. (2005). Do girls prefer games designed by girls. *Proceedings of DIGRA.* Vancouver.

Heeter, C., Egidio, R., Mishra, P., Winn, B., & Winn, J. (2008). Alien games: Do girls prefer games designed by girls? *Games and Culture* .

Homer, B. D., Hayward, E. O., Frye, J., & Plass, J. (2012). Gender and player characteristics in video game play of preadolescents. *Computers in Human Behavior* , 1782-1789.

Horn, M. S. (2013). The role of cultural forms in tangible interaction design. *Proceedings of Tangible, Embedded and Embodied Interaction.* ACM Press.

Horn, M. S., & Jacob, R. J. (2007). Designing tangible programming languages for classroom use. *Proceedings of the 1st international conference on Tangible and embedded interaction* (pp. 159-162). ACM Press.

Horn, M. S., Alsulaiman, S., & Koh, J. (2013). Translating Roberto to Omar: Computational literacy, stickerbooks, and cultural forms. *Proceedings of the 12th International Conference on Interaction Design and Children* (pp. 120-127). ACM Press.

Horn, M. S., Crouser, R. J., & Bers, M. U. (2012). Tangible interaction and learning: the case for a hybrid approach. *Personal and Ubiquitous Computing* , 379-389.

Horn, M. S., Solovey, E. T., Crouser, R. J., & Jacob, R. J. (2009). Comparing the use of tangible and graphical programming languages for informal science education. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 975-984). ACM.

Huff, C. (2002). Gender, software design, and occupational equity. *SIGCSE Bulletin* (pp. 112-115). New York, NY: ACM Press.

Huff, C., & Cooper, J. (1987). Sex Bias in Educational Software: The Effect of Designers' Stereotypes on the Software They Design. *Journal of Applied Social Psychology* , 519-532.

Huffman, A. H., Whetten, J., & Huffman, W. H. (2013). Using technology in higher education: The influenceof gender roles on technology self-efficacy. *Computers in Human Behavior* .

Hundhausen, C. D., Farley, S. F., & Brown, J. L. (2009). Can direct manipulation lower the barriers to computer programming and promote transfer of training?: An experimental study. *ACM Transactions on Computer-Human Interaction* .

Hyde, J. S., Fennema, E., & Lamon, S. J. (1990). Gender differences in mathematics performance: A meta-analysis. *Psychological Bulletin* , 139-155.

Hyde, J. S., Lindberg, S. M., Linn, M. C., Ellis, A. B., & Williams, C. C. (2008). DIVERSITY: Gender similarities characterize math performance. *Science* , 494-495.

Inzlicht, M., & Ben-Zeev, T. (2000). A threatening intellectual environment: Why females are susceptible to experiencing problem-solving deficits in the presence of males. *Psychological Science* , 365-371.

Ito, M. (2008). Gender Dynamics of the Japanese Media Mix. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 97-109). Cambridge, MA: MIT Press.

Jenkins, H. (1998). Complete freedom of movement: Videogames as gendered play spaces. In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games* (pp. 262-297). Cambridge, MA: MIT Press.

Jenkins, H., & Justine, C. (2008). From Quake Grrls to Desperate Housewives: A Decade of Gender and ComputernGames. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 5-20). Cambridge, MA: MIT Press.

Jenson, J., & De Castell, S. (2010). Gender, Simulation, and Gaming: Research Review and Redirections. *Simulation Gaming* .

Joiner, R., Iacovides, J., Owen, M., Gavin, C., Clibbery, S., Darling, J., et al. (2011). Digital Games, Gender and Learning in Engineering: Do Females Benefit as Much as Males? *Journal of Science Education and Technology* .

Kafai, Y. B., Fields, D., & Giang, M. T. (2009). Transgressive gender play: Profiles and portraits of girl players in a tween virtual world. *Fourth International Conference of the Digital Games Research Associationof DiGRA.* London, UK: DiGRA.

Kafai, Y. B., Peppler, K. A., Burke, Q., Moore, M., & Glosson, D. (2010). Fröbel's forgotten gift: textile construction kits as pathways into play, design and computation. *In Proceedings of the 9th International Conference on Interaction Design and Children* (pp. 214-217). New York, NY: ACM Press.

Kafai, Y. (2008). Considering gender in digital games: implications for serious game designs in the learning sciences. *Proceedings of the 8th international conference on International conference for the learning sciences* (pp. 422-429). International Society of the Learning Sciences.

Kafai, Y. (2008). Gender Play in a Tween Gaming Club. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 111-123). Cambridge, MA: MIT Press.

Kafai, Y. (1994). *Minds in Play: Computer Game Design as a Context for Children’s Learning.* Routledge.

Kafai, Y. (2006). Playing and making games for learning. *Games and Culture* , 36-40.

Kafai, Y. (1998). Video Game Designs by Girls and Boys: Variability and Consistency of Gender Differences. In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games* (pp. 90-114). Cambridge, MA: MIT Press.

Kafai, Y. (2010). World of Whyville: An Introduction to Tween Virtual Life. *Games and Culture* , 3-22.

Kafai, Y., & Burke, Q. (2014). Beyond Game Design for Broadening Participation: Building New Clubhouses of Computing for Girls. *Proceedings of Gender and IT Appropriation.* European Society for Socially Embedded Technologies.

Kafai, Y., & Burke, Q. (2014). *Connected Code: Why Children Need to Learn Programming.* MIT Press.

Kafai, Y., Searle, K., Martinez, C., & Braybo, B. (2014). Ethnocomputing with electronic textiles: culturally responsive open design to broaden participation in computing in American indian youth and communities. *Proceedings of the 45th ACM technical symposium on Computer science education.* ACM Press.

Kelleher, C., Pausch, R., & Kiesler, S. (2007). Storytelling Alice motivates middle school girls to learn computer programming. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.* ACM Press.

Kersteen, Z., Linn, M., Clancy, M., & Hard, C. (1988). Previous experience and the learning of computer programming: The computer helps those who help themselves. *Journal of Educational Computing Research* .

Kiesler, S., Sproull, L., & Eccles, J. S. (1985). Pool halls, chips, and war games: Women in the culture of computing. *Psychology of Women Quarterly* , 451-462.

Kinder, M. (1998). An interview with Marsha Kinder. In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games* (pp. 214-230). Cambridge, MA: MIT Press.

Klawe, M., Inkpen, K., Phillips, E., Upitis, R., & Rubin, A. (2002). E-Gems: A Project on Computer Games, Mathematics and Gender. In N. Yelland, & A. Rubin, *Ghosts in the Machine: Women's Voices in Research with Technology.* New York: Peter Lang.

Klopfer, E., Osterweil, S., & Salen, K. (2009). *Moving learning games forward: Obstacles, Opportunities and Openness.* The Education Arcade, MIT.

Koch, S. C. (2008). Women and computers. Effects of stereotype threat on attribution of failure. *Computers & Education* .

Lamberty, K. K., & Kolodner, J. L. (2004). Towards a new kind of computational manipulative: children learning math and designing quilts with manipulatives that afford both. *In Proceedings of the conference on Interaction design and children: building a community* (pp. 143-144). ACM.

Laurel, B. (1998). An interview with Brenda Laurel. In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games.* Cambridge, MA: MIT Press.

Lazzaro, N. (2008). Are Boys Games Even Necessary? In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 199-215). Cambridge, MA: MIT Press.

Leslie, S. J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science* , 262-265.

Lin, H. (2008). Body, Space and Gendered Gaming Experiences: A Cultural Geography of Homes, Cybercafes, and Dormitories. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 67-80). Cambridge, MA: MIT Press.

Little, J. C. (1999). The Role Of Women In The History Of Computing. *Technology and Society* (pp. 202-205). IEEE.

Littleton, K., & Hoyles, C. (2002). The gendering of information technology. In N. Yelland, & A. Rubin, *Ghosts in the machine: Women's voices in research with technology.* New York: Peter Lang.

Loius, F., Silverman, B., Kazakoff, E., Bers, M., Bonta, P., & Resnick, M. (2013). Designing ScratchJr: Support for Early Childhood Learning Through Computer Programming. *Proceedings of the International Conference on Interaction Design & Children.* ACM Press.

Lucas, K., & Sherry, J. L. (2004). Sex differences in video game play: A communication-based explanation. *Communication Research* .

Luker, K. (2008). *Salsa dancing into the social sciences: Research in an age of info-glut.* Harvard University Press.

Margolis, J., & Fisher, A. (2002). *Unlocking the Computer Clubhouse: Women in Computing.* Cambridge, MA: MIT Press.

Markus, A. (2012). Are heavy users of computer games and social media more computer literate? *Computers & Education* .

McNerney, T. (2004). From turtles to tangible programming bricks: explorations in physical language design. *Personal and Ubiquitous Computing* , 326-337.

Mead, M., & Metraux, R. (1957). Image of the scientist among high-school students. *Science* , 384–390.

Mercier, E. M., Barron, B., & O'Connor, K. M. (2006). Images of self and others as computer users: the role of gender and experience. *Journal of Computer Assisted Learning* , 335-348.

Miller, D. I., & Halpern, D. F. (2014). The new science of cognitive sex differences. *Trends in cognitive sciences* , 37-45.

Misa, T. J. (2011). *Gender codes: Why women are leaving computing.* John Wiley & Sons.

Moss-Racusin, C. A., Dovidio, J. F., Brescoll, V. L., Graham, M. J., & Handelsman, J. (2012). Science faculty's subtle gender biases favor male students. *Proceedings of the National Academy of Sciences*, (pp. 16474-16479).

Murphy, C., Powell, R., Parton, K., & Cannon, A. (2011). Lessons learned from a PLTL-CS program. *Proceedings of the 42nd ACM technical symposium on Computer science education* (pp. 207-212). New York, NY: ACM Press.

Murphy, L., Richards, B., McCauley, R., Morrison, B., Westbrook, S., & Fossum, T. (2006). Women catch up: gender differences in learning programming concepts. *In ACM SIGCSE Bulletin* (pp. 17-21). New York, NY: ACM Press.

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling Threat: How Situational Cues Affect Women in Math, Science, and Engineering settings. *Psychological Science* , 879-885.

National Institute of Mental Health. (2009). Retrieved 2014 йил 6 from Behavioral training improves connectivity and function in the brain: http://www.nimh.nih.gov/science-news/2009/behavioral-trainingimproves-connectivity-and-function-in-the-brain.shtml

Pane, J. F., Myers, B. A., & Miller, L. B. (2002). Using HCI techniques to design a more usable programming system. *In Human Centric Computing Languages and Environments,.* IEEE.

Papert, S. (1998). Does easy do it? Children, Games, and Learning. *Game Developer* .

Papert, S. (1980). *Mindstorms: Children, Computers, and Powerful Ideas.* New York, NY: Basic Books.

Papert, S. (1993). *The children's machine.* New York, NY: Basic Books.

Papert, S., & Resnick, M. (1995). *Technological Fluency and the Representation of Knowledge, Proposal to the National Science Foundation.* Cambridge, MA: MIT Media Lab.

Patitsas, E., Craig, M., & Easte, S. (2014). A Historical Examination of the Social Factors Affecting Female Participation in Computing. *Proceedings of the 2014 conference on Innovation & technology in computer science education.* ACM Press.

Peckham, J., Stephenson, P. D., Harlow, L. L., Stuart, D. A., Silver, B., & Mederer, H. (2007). Broadening Participation in Computing: Issues and Challenges. *Proceedings of the 12th annual SIGCSE conference on Innovation and technology in computer science education.* ACM Press.

Pelletier, C. (2008). Gaming in Context: How Young People Construct Their Gendered Identity in Playing and Making Games. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 145-159). Cambridge, MA: MIT Press.

Phillips, S. P., & Austin, E. B. (2009). The feminization of medicine and population health. *JAMA: The Journal of the American Medical Association* .

Piaget, J. (1937). The Construction of Reality in the Child. In H. Gruber, & J. Voneche, *The Essential Piaget.* New York, NY: Basic Books.

Pittman, L., & Richmond, A. (2007). University belonging, friendship quality, and psychological adjustment during the transition to college. *The Journal of Experimental Education* , 270-290.

Powell, R. M. (2008). Improving the persistence of first-year undergraduate women in computer science. *SIGCSE Bulletin* (pp. 518-522). New York, NY: ACM Press.

Purdie-Vaughns, V., Steele, C. M., Davies, P. G., & Ditlmann, R. (2008). Social Identity Contingencies: How Diversity Cues Signal Threat or Safety for African Americans in Mainstream Institutions. *Journal of Personality and Social Psychology* , 615-630.

Purdie-Vaughns, V., Steele, C., Davies, P., Ditlmann, R., & Crosby, J. R. (2008). Social identity contingencies: how diversity cues signal threat or safety for African-Americans in mainstream institutions. *Journal of Personality and Social Psychology* , 615-630.

Raffini, J. (1993). *Winners without losers: Structures and strategies for increasing student motivation.* Needham Heights, MA: Allyn and Bacon.

Rankin, Y., Gooch, A., & Gooch, B. (2008). The Impact of Game Design on Students' Interest in CS. *Proceedings of the 3rd international conference on Game development in computer science education.* ACM Press.

Ray, S. G. (2004). *Gender inclusive game design: Expanding the market.* Hingham, MA: Charles River Media.

Resnick, M. (2008). Sowing the seeds for a more creative society. *Learning & Leading with Technology* .

Resnick, M. (1997). *Turtles, Termites, and Traffic Jams: Explorations in Massively Parallel Microworlds.* MIT Press.

Resnick, M., Maloney, J., Monroy-Hernández, A., Rusk, N., Eastmond, E., Brennan, K., et al. (2009). Scratch: programming for all. *Communications of the ACM* .

Ridgeway, C. L. (2011). *Framed by gender: How gender inequality persists in the modern world.* New York, NY: Oxford University Press.

Roberts, D. F., Foehr, U. G., & Rideout, V. (2005). *Generation M: Media in the Lives of 8- to 18-Year-Olds.* Menlo Park, California: Kaiser Family Foundation Study.

Rounds, J. (2006). Doing identity work in museums. *Curator: The Museum Journal* , 49(2), 133-150.

Schofield, J. W. (1995). *Computers and Classroom Culture.* New York, NY: Cambridge University Press.

Sekaquaptewa, D., & Thompson, M. (2003). Solo status, stereotype threat, and performance expectancies: Their effects on women's performance. *Journal of Experimental Social Psychology* , 68-74.

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

Shaffer, D., Squire, K., Halverson, R., & Gee, J. P. (2005). Video games and future of learning. *Phi Delta Kappan* , pp. 104-111.

Shapiro, J. R., & Williams, A. M. (2012). The Role of Stereotype Threats in Undermining Girls' and Women's Performance and Interest in STEM Fields. *Sex Roles* .

Shashaani, L. (n.d.). Gender Differences in Computer Attitudes and Use Among College Students. *Journal of Educational Computing Research* , 1997.

Sheldon, J. P. (2004). Gender stereotypes in educational software for young children. *Sex Roles* , 433-444.

Sherry, T., & Papert, S. (1990). Epistemological Pluralism: Styles and Voices within the Computer Culture. *Journal of Women in Culture and Society* , 128-157.

Shuler, C. (2012). *What in the World Happened to Carmen Sandiego?* Retrieved 2015 йил April from The Joan Ganz Cooney Center at sesame Workshop: http://www.joanganzcooneycenter.org/wp-content/uploads/2012/11/jgcc_edutainment.pdf

Squire, K. (2006). From content to context: Video games as designed experiences. *Educational Researcher* .

Squire, K. (2007). Games, learning and society: Building a field. *Educational Technology* .

Squire, K. (2008). Video game-based learning: An emerging paradigm for instruction. *Performance Improvement Quarterly* , pp. 7-36.

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

Squire, K., & Jenkins, H. (2004). Harnessing the power of games in education. *Insight* .

Squire, K., & Steinkuehler, C. (2005). Meet the gamers. *Library Journal* .

Squire, K., Barnett, M., Grant, J. M., & Higginbotham, T. (2004). Electromagnetism supercharged!: Learning physics with digital simulation games. *International Conference on Learning Sciences.* Santa Monica, CA.

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American psychologist* .

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of personality and social psychology* , 797.

Stefik, A., & Siebert, S. (2013). An Empirical Investigation into Programming Language Syntax. *ACM Transactions on Computing Education (TOCE)* .

Steinpreis, R. E., Anders, K. A., & Ritzke, D. (1999). The impact of gender on the review of the curricula vitae of job applicants and tenure candidates: A national empirical study. *Sex Roles* , 509-528.

Stepulevage, L. (2001). Gender/Technology Relations: Complicating the gender binary. *Gender and Education* , 325-338.

Stevens, R., Satwicz, T., & McCarthy, L. (2008). In-game, in-room, in-world: Reconnecting video. In K. Salen, *The ecology of games: Connecting youth, games and learning* (pp. 41–66). Cambridge, MA: MIT Press.

Stoilescu, D. (2010). Gender differences in the use of computers, programming, and peer interactions in computer science classrooms. *Computer Science Education* .

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of personality and social psychology* .

Stout, J., & Camp, T. (2014). Now what?: action items from social science research to bridge the gender gap in computing research. *ACM SIGCAS Computers and Society - Special Issue on Women in Computing* , pp. 5-8.

Subrahmanyam, K., & Greenfield, P. M. (1998). Computer games for girls: What makes them play? In J. Cassell, & H. Jenkins, *From Barbie to Mortal Kombat: Gender and Computer Games* (pp. 46-71). Cambridge, MA: MIT Press.

Svarovsky, S., & Shaffer, D. (2006). Engineering girls gone wild: developing an engineering identity in digital zoo. *Proceedings of the 7th international conference on Learning sciences*, (pp. 996-997).

Taylor, H. G., & Mounfield, L. C. (1994). exploration of the relationship between prior computing experience and gender on success in college computer science. *Educational Computing Research* , 291-306.

Taylor, T. (2008). Becoming a Player: Networks, Structure and Imagined Futures. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 51-65). Cambridge, MA: MIT Press.

Technology, N. C. (2012). *Women and information technology: By the numbers.* Washington, DC: National Center for Women and Information Technology.

Tillberg, H. K., & Cohoon, J. M. (2005). Attracting women to the CS major. *Forntiers: A Journal of Women Studies* , 126-140.

Todd, K., Mardis, L., & Wyatt, P. J. (2005). We've come a long way, baby!: but where women and technology are concerned, have we really? *Proceedings of the 33rd annual ACM SIGUCCS conference on User services* (pp. 380-387). New York, NY: ACM Press.

Townsend, G. C., Menzel, S., & Siek, K. A. (2007). Leveling the CS1 playing field. *In ACM SIGCSE Bulletin.* New York, NY: ACM Press.

Turkle, S. (1988). Computational reticence: Why women fear the intimate machine. In C. Kramarae, *Technology and women's voices: Keeping in touch* (pp. 41-61). London: Routledge.

Turkle, S., & Papert, S. (1990). Epistemological pluralism and the reevaluation of the concrete. *SIGNS: Journal of Women in Culture and Society* , 128-157.

Van Reijmersdal, E. A., Jansz, J., Peters, O., & Van Noort, G. (2013). Why girls go pink: Game character identification and game-players' motivations. *Computers in Human Behavior* .

Vorderer, P., & Bryant, J. (2012). *Playing video games: Motives, responses, and consequences.* Routledge.

Vygotsky, L. S. (1976). Play and its role in the mental development of the child. *Journal of Russian and East European Psychology* , 6-18.

Wajcman, J. (1991). *Feminism confronts technology.* University Park: Pennsylvania State University Press.

Wajcman, J. (2004). *TechnoFeminism.* Cambridge, UK: Polity Press.

Walkerdine, V. (2006). Playing the game: Young girls performing feminity in videogame play. *Feminist Media Studies* .

Weibe, E., Williams, L. A., Yang, K., & Miller, C. (2003). *Computer Science Attitude Survey.* Raleigh, NC: North Carolina State University.

Weibert, A., Marshall, A., Aal, K., Schubert, K., & Rode, J. A. (2014). Sewing Interest in E-Textiles: Analyzing Making from a Gendered Perspective. *Proceedings of the ACM conference on Designing Interactive Systems.* ACM Press.

Weintrop, D., & Wilensky, U. (2013). RoboBuilder: A Computational Thinking Game. *Proceedings of the 44th ACM technical symposium on Computer science education* (pp. 736–736). Denver, CO: ACM Press.

West, C., & Zimmerman, D. H. (1987). Doing gender. *Gender and Society* , 125-151.

Whitley Jr, B. E. (1997). Gender differences in computer-related attitudes and behavior: A meta-analysis. *Computers in Human Behavior* , 1-22.

Wideman, H. H., Owston, R. D., Brown, C., Kushniruk, F. H., & Pitts, K. C. (2007). Unpacking the potential of educational gaming: A new tool for gaming research. *Simulation and Gaming* , 10-30.

Wing, J. M. (2008). Computational Thinking and Thinking About Computing. *Philosophical Transactions of the Royal Society* , 3717-3725.

Wu, Z., Cohoon, J. M., & Neesen, K. (2006). Action and Intention: Considering the Relationship between Educational Software and Gendered Career Interests. *In 36th Annual Conference of Frontiers in Education.* IEEE.

Wyeth, P. (2008). How young children learn to program with sensor, action, and logic blocks. *Journal of the Learning Sciences* , 517-550.

Yates, S., & Littleton, K. (2001). Understanding computer game cultures: A situated approach. In E. Green, & A. Adam, *Virtual gender: Technology, consumption and identity* (pp. 103-123). London: Routledge.

Yee, N. (2008). Maps of Digital Desires: Exploring the Topography of Gender and Play in Online Games. In Y. Kafai, & C. Heeter, *Beyond Barbie and Moral Kombat: New Perspectives on Gender and Gaming* (pp. 83–95). Cambridge, MA: MIT Press.

Yelland, N., & Rubin, A. (2002). *Ghosts in the Machine: Women's Voices in Research with Technology.* New York: Peter Lang.

Appendices

[1] pre-survey

#	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I am interested in learning more about programming					
2	Programming can be fun					
3	I'm not the type to do well in computer programming					
4	Programming is of no relevance to my life					
5	Programming is boring					
6	I would love it if the school offers a programming class					
7	I could get good grades in a programming class					
8	I can't think of any way that I will use programming in the future					

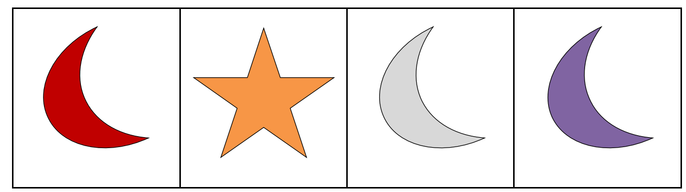
[2] post survey

#	Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I am interested in learning more about programming					
2	Programming can be fun					
3	I'm not the type to do well in computer programming					
4	Programming is of no relevance to my life					
5	Programming is boring					
6	I would love it if the school offers a programming class					
7	I could get good grades in a programming class					
8	I can't think of any way that I will use programming in the future					
9	I had fun while playing this game					
10	I think this game is designed for girls					
11	I think girls will enjoy this game more than boys					
12	I would love to play this game again in my free time					
1	Games designed for boys are my favorite					

3						
14	Games designed for girls are my favorite					
15	I think girls and boys like different kinds of games					

[3] Assessment

<table>
<tr><th colspan="2">EXAMPLE</th></tr>
<tr><td>The following program draws the output shown on the right:

</td><td></td></tr>
</table>

SECTION1: CODE GENERATION QUESTIONS

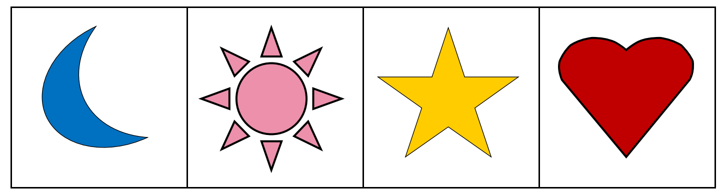
- Read the questions below and choose the correct answer (there could be more than one correct answer!)

1.1 Which of the following programs draws the output shown on the right?

A

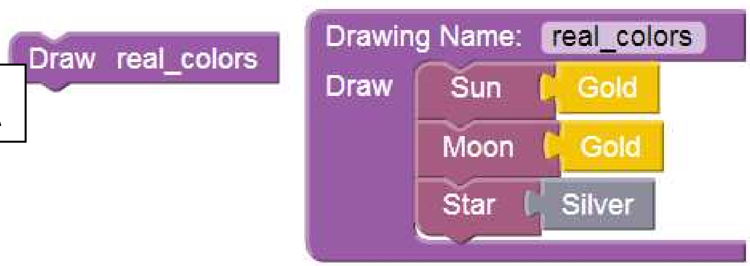
B

C



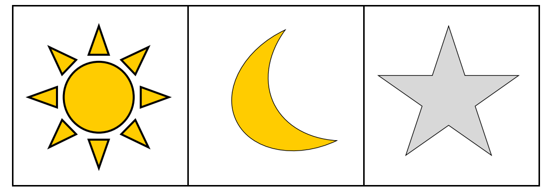
1.2 Which of the following programs would you choose if the teacher wants you to create a program that draws a moon, sun and a star with only realistic colors?

A



B

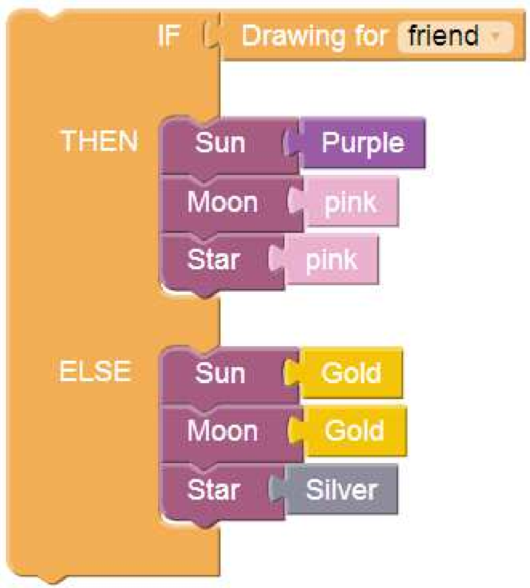
C



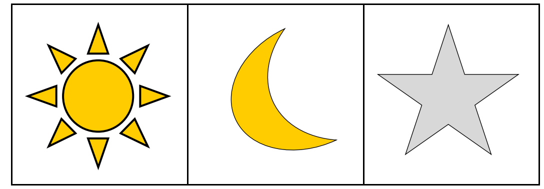
1.3 Which of the following programs draws a sun, moon then star so that when teacher asks to draw, it will put the real colors; otherwise, it will draw the second line?

A

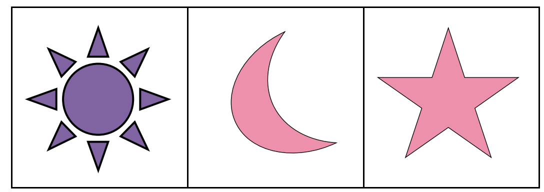
B



When drawing for teacher:

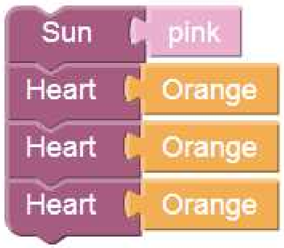


When drawing a friend:



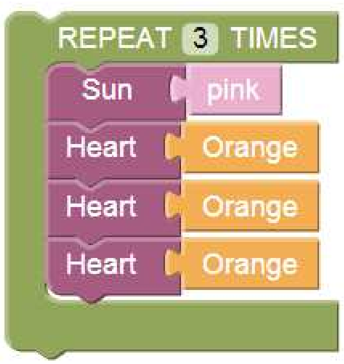
1.4 Which of the following programs draws the output on the right?

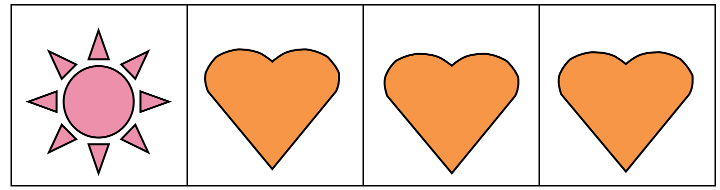
A



B

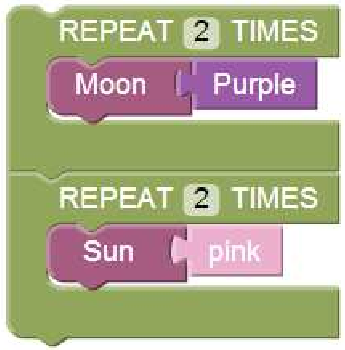
C



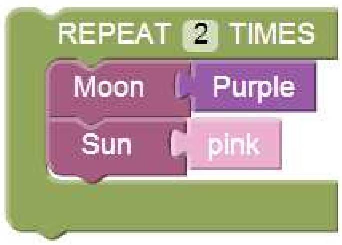


1.5 Which of the following programs draw the output shown on the right?

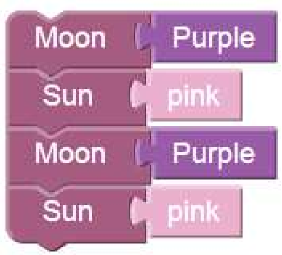
A

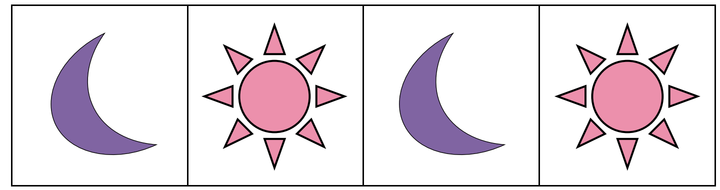


B



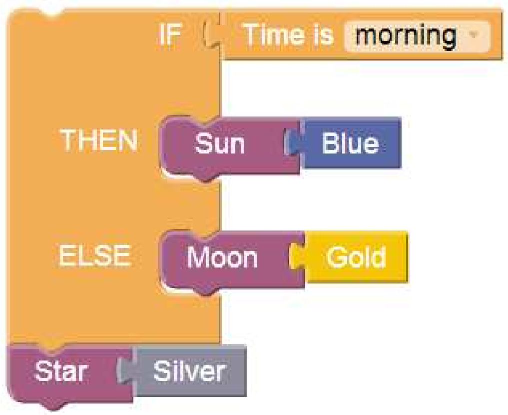
C





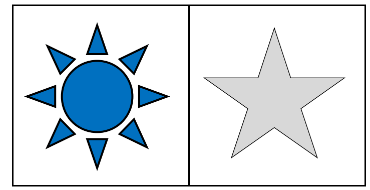
1.6 Which of the following programs draws the output on the right?

A

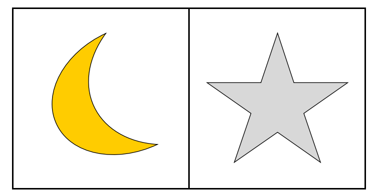


B

When in the morning:

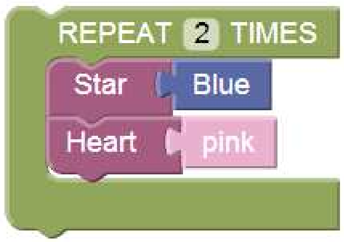


When in the evening:

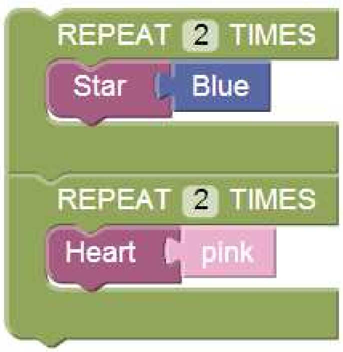


1.7 Which of the following programs draws the output on the right?

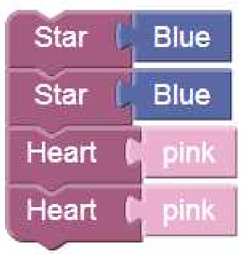
A

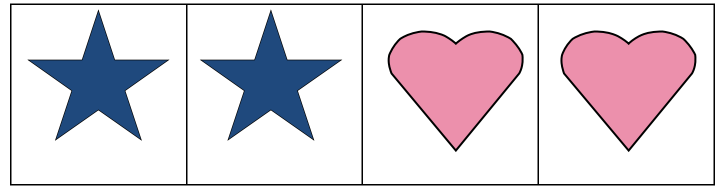


B



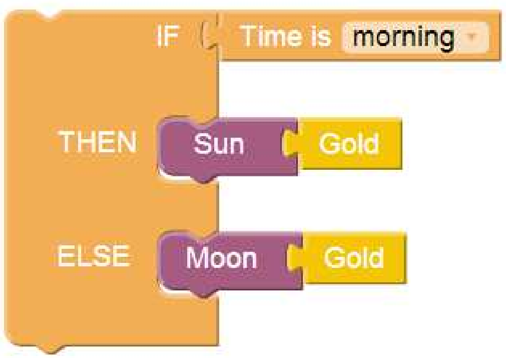
C



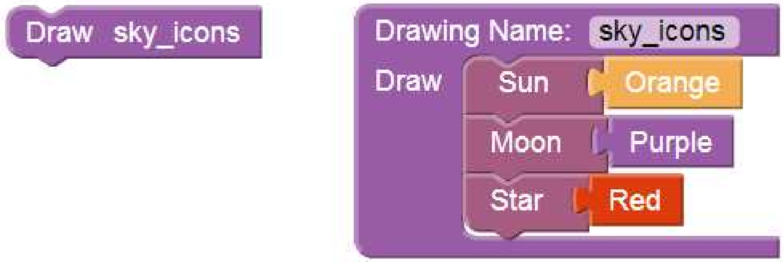


SECTION2: CODE PREDICTION QUESTIONS

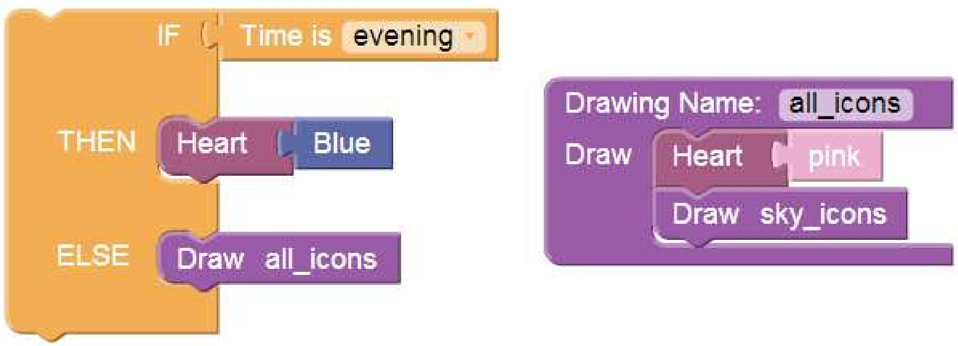
- Each of the following programs draws a different and interesting combination of shapes and colors. Can you guess what each program would draw?

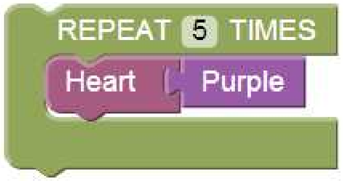
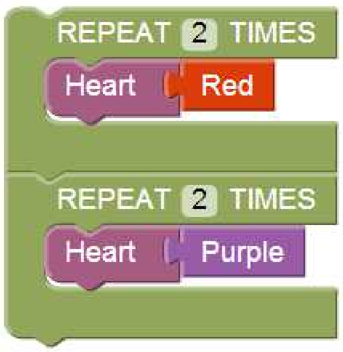
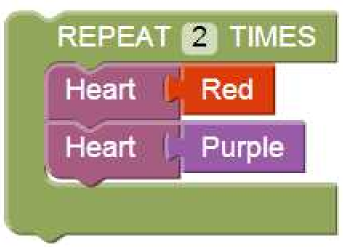
2.1. 	
2.2 	

2.3


Draw sky_icons
Drawing Name: sky_icons
Draw
Sun
Orange
Moon
Purple
Star
Red

2.4


IF
Time is evening
THEN
Heart
Blue
ELSE
Draw all_icons
Drawing Name: all_icons
Draw
Heart
pink
Draw sky_icons

<table>
<tr><td>2.5

</td><td></td></tr>
<tr><td>2.6

</td><td></td></tr>
<tr><td>2.7

</td><td></td></tr>
</table>