SCRATCH PROGRAMMING AND REMIX CULTURE:
GENDER DIFFERENCES IN INTERACTION AND MOTIVATION FOR
PRE-ADOLESCENTS

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SCRATCH PROGRAMMING AND REMIX CULTURE: GENDER DIFFERENCES IN INTERACTION AND MOTIVATION FOR PRE-ADOLESCENTS

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ABSTRACT

Science, Technology, Engineering, and Math (STEM) disciplines have become a ubiquitous curriculum focus for American educators and children’s entertainment producers, but are the ways in which children are introduced STEM truly engaging? This study set out to explore factors that affect a positive learning experience with STEM and the ways in which children are creating interactive content. In this study, girls and boys from 9-12 years of age worked as partners to produce original and remixed digital works of art using Scratch. Each participant in this study had four Scratch lessons. There were six classes of students (two from each grade: fourth, fifth, and sixth) and each class had one Scratch session per week. In total, the experimenter ran 24 instructional sessions for 98 participating students.

What it means to be a digital game designer today is an ever-expanding construct because of the rise of kid-generated content and the popularity of remix. The relationship between gamers and games is no longer one-sided. Building on research on incidental learning through play, this study explores gender differences in motivation and engagement for novice programmers. While existing research concludes that variables such as female mentorship and open-ended platform design are key to motivate girls as programmers, this study builds on that premise and finds that extrinsic factors including
peer approval, teacher and parent feedback, and class achievement highly affected
guidance motivation for girls. Data revealed that girls were more sensitive to extrinsic
motivators than boys. This finding suggests that the gender disparity in computer science
can be remedied through immersive, extrinsically motivating environments. Combined
with external feedback and reward, emergent platforms that give children the autonomy
of open-ended creation have the potential to draw in a more diverse user base.

KEYWORDS

Scratch; STEM gender divide; kid-generated content; computational expression; games
for learning; remix culture; gender interaction; achievement motivation
Thanks to the generosity of key people, I am able to take great pride in this work. Thank you Professor Jeanine Turner for connecting me with the warm staff at St. Mark Catholic School in Vienna Virginia, your optimism is always an inspiration to me. To Mrs. Darcie Girmus, who opened her classroom to me, and whose unwavering enthusiasm about coding motivates her students. Professor Diana Owen, thank you for your critical eye in the review process. Melissa Richards, thank you for being a sounding board throughout this process and giving me valuable feedback. Special thanks to my thoughtful, patient Advisor, Professor Sandra Calvert; your tenacity motivated me to push myself harder. It is very meaningful to know that someone of your accomplishments has put her confidence in my work.

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CHAPTER 1: INTRODUCTION

What elements foster motivational play spaces? How can we use what we know about development and gender differences to inform how young learners are introduced to computer science? While Americans are immersed in a culture of technological growth, our youth are challenged by a lack of computational fluency. As a result, teaching American students Science, Technology, Engineering, and Math (STEM) skills has become a pervasive policy focus that has transformed in-school curriculum and educational programming for children.

A looming challenge in growing young coders is in the nature of traditional instruction, which has contributed to a marginal class of learners. Research reveals that gender biases have become a barrier for computational expression. Traditionally, games have more widely been designed for boys’ interests and not girls (Cassell & Jenkins, 1998; Calvert, 1999; Gürer and Camp, 2001; Kafai, 2008; Denner, 2008). Girls form an interest in computers if they perceive a program to be relevant to their personal interests (Calvert, 1999). Furthermore, it is argued that attitudes towards computers and their uses differ based on the way they are taught to boys versus girls (Gürer and Camp, 2001). Educational ambitions in computation are influenced by gender stereotypes (Goode et al., 2006).

The scarcity of girls represented in STEM fields is staggering, particularly as girls grow older (Gürer and Camp, 2001; Goode et al., 2006). Etzkowitz et al. (1994) terms the pipeline to academic science disciplines, “a leaky vessel” for women. From a young age, children from underrepresented groups are often socialized to believe that they will not excel in STEM disciplines, leading to a wide gap in expertise (Margolis and Fischer,
2001; Maloney et al., 2008). Gürer and Camp (2001) explain the trend of female underrepresentation in the field of computer science as a reflection that girls are discouraged from becoming programmers at a young age (Gürer and Camp, 2001).

In order to prepare youth for postsecondary education programs that lead to careers in the field of computer science, the Obama administration appointed an expert advisor to create the first national policy initiative dealing with the role of digital games in education in 2012. “The National STEM Video Game Challenge” was started to encourage children to learn STEM skills by producing their own digital games. The United States Department of Education also awarded 113 grants totaling more than $30.8 million to Upward Bound students to strengthen their math and science skills in September of 2012 (Dept. of Ed., 2012). These efforts exemplify a commitment to media arts and e-learning solutions to grow computational literacy.

One such investment funded by the National Science Foundation, is Scratch. Scratch is an interactive programming language designed to teach children mathematical and computational ideas through creative thinking. Developed at the Massachusetts Institute of Technology (MIT) Media Lab, Scratch was conceived out of the intent to reverse conventional assumptions about the rigid nature of computation in its interactive, visual design. This tool is intended for school-aged children with the goal of learning mathematical and computational ideas through artistic, open-ended play. In May of 2007, the Scratch website was officially launched. At the time, the Scratch Online Community was made up 20 participants who were involved in a Scratch workshop (Monroy-Hernandez & Resnick, 2008). Dr. Mitchel Resnick, LEGO Papert Professor of Learning Research and head of the Lifelong Kindergarten group at the MIT Media Lab
created *Scratch*. Learning lessons from Seymour Papert’s experiences with *Logo*, Resnick describes *Scratch* as an adaptation to Logo in three dimensions: “making programming more tinkerable, more meaningful, and more social” (Resnick, 2012). Dr. Resnick also stated that one main goal of Scratch was to achieve broader participation across genders (Monroy-Hernandez & Resnick, 2008). *Scratch* provides the ideal space to test whether interaction with a pliable, meaningful, social platform lives up to its potential and resolves a history of gender exclusion in computation.

Scratch does not rely on high-level coding skill or deter users who don’t have a natural affinity for the sciences. The platform itself functions as blank canvas for creation, which is inviting to kids of all ages, genders, self-perceived skill, and natural talents. With Scratch, bringing art to life no longer denotes knowledge of dense programming language, it allows one to explore and operate in the pure art form.

This study is based in the Constructionist approach, which involves the principle that learning happens when people are actively engaged in making a meaningful product. Amidst an emergent culture of kid-generated content and game creation, the ways in which children interact with digital games has entirely shifted. The constructionist approach places considerable importance on the social and cultural context in which learning takes place (Kafai, 2006). Learners build new knowledge when they are engaged in creating things in the world according to educational theorist and founder of the *MIT Media Lab*, Seymour Papert (Papert, 1980). According to this theory, “people don’t get ideas, they make them” (Papert, 1980). The constructionist approach is the foundation for many educational reform initiatives. With Scratch, kids learn fundamental properties of math, physics and problem solving by exploring if/then statements and x/y-axes.
without even knowing they are learning. Because Scratch relies on such visual, artistic faculties, it expands the traditional profile of a digital designer. A platform like Scratch could be a key to lighting the spark in STEM for young girls because its appeal stretches across gender and encourages users to explore computation through unrestricted play.

CHAPTER 2: LITERATURE REVIEW

What factors are behind the problem of disparate gender representation in computer science? How does development play into a child’s affinity towards computer science? What has research found as key factors in effecting motivational and learning outcomes for boys and girls? This research review sheds light on all these questions, providing a foundation to build new ones.

2.1 Gender and Programming Experience

It is widely acknowledged that a child’s initial exposure to programming has great influence on continued engagement (Corston & Coleman, 1996; Gürer and Camp, 2001; Goode et al., 2006; Kafai, 2008; Heeter et al., 2011). First exposure includes the instructor, the lesson structure and contents. Research yields various conclusions explaining the gender disparity in computation, proposing differing solutions as well.

Another facet that determines whether students gravitate towards the sciences is learner autonomy. Development of learner autonomy grows between the ages of 11-13, when students are making choices about what subjects they like and are good at (Fouad and Smith, 1996). These choices influence their future options (Fouad and Smith, 1996).
Coupled with the notion that young girls are told that STEM is not a strong suit for them (Gürer and Camp, 2001; Margolis and Fischer, 2001; Maloney et al., 2008), this maturation has important implication for fostering STEM motivation and learning confidence.

To promote a change in women’s participation in Information Technology and gaming, Denner (2008) emphasized the educator’s approach to teaching computer science. She concludes that a lesson must involve collaboration, design, and production to harness widespread appeal (Denner, 2008). The structure, language, and content of games as they appeal to both genders have been under much evaluation, effectively challenging the design of many computer-programming platforms. Kelleher, Pausch, & Kiesler (2008) found that girls who played with Storytelling Alice, a narrative based programming language, spent an average of forty-two percent more time using it, were three times as likely to use free time to work on their programs, and were more interested in using the program in the future than girls who played with the generic object-oriented version of Alice (Kelleher, Pausch, & Kiesler, 2008).

Corston & Coleman (1996) found that girls with little or no computing experience performed well and reported positive attitudes on a computer assignment when they were in the presence of a female instructor (Corston & Coleman, 1996). Denner, Werner, and Ortiz (2012) support this finding with their work. They found that programming can engage female middle school students in learning computer science concepts, but that mentorship is necessary for the girls to fully develop their potential (Denner, Werner, and Ortiz, 2012).
In their research on performance achievement and serious games, Heeter et al. (2011) found that males tended to seek more difficult challenges in games than females, and this finding is the most distinguished gender difference to consider when designing serious games (Heeter et al., 2011). Figuring out how to play a game required more effort from non-gamers than experienced gamers, making it harder for non-gamers to benefit from serious games (Heeter et al., 2011). Therefore, they concluded that a player must successfully master how to play a game in order to learn intended content (Heeter et al., 2011).

2.2 Pair Engagement and Play Styles

Research has examined pair interaction in the virtual space (Valkenburg et al., 2005; Calvert et al., 2009; Fristoe et al., 2011). To deduce pair interaction, pre-adolescent development must be taken into account. In terms of maturation, from middle childhood until adolescence children are typically involved in gender-segregated play (Ruble et al., 2006). Gender differences in children’s interaction styles also manifest themselves in children’s play with same-sex peers (Else-Quest et al., 2006). For example, Calvert et al. (2009) examined gender interaction in Multi-User Domains (MUDs) to answer developmental questions about gender differences in play styles, social interaction styles (Calvert et al., 2009). Consistent with the literature on development, they found that boy pairs made up more games than girl pairs, and mixed-gender pairs had the most difficulty communicating (Calvert et al., 2009). Calvert et al. (2009) also found that girl pairs “talked more” through texting than boy pairs did in the MUD (Calvert et al., 2009).
Just as Kelleher, Pausch, & Kiesler (2008) found in their study on gender and *Storytelling Alice*, girls are inclined to narrative (Kelleher, Pausch, & Kiesler, 2008). Communication and programming have gone hand in hand as engagement styles of young girls. Using a game creation platform, Fristoe et al. (2011) found that girls generally prefer to make games based on storytelling, social interactions, and dynamic relationships (Fristoe et al., 2011).

2.3 Ideal Conditions For Collaboration

Argon et al. (2009) discuss the key components of a digital community that allow collaboration and creativity to flourish. By analyzing the chat logs in two online communities, they expose the importance of socio-emotional communication in successful creative work (Argon et al., 2009). Among these criteria is a low barrier to entry. Young learners cannot feel excluded or deterred by a social expectation or requirement (Argon et al., 2009). Open sharing and communication is a key element of creative collaboration (Argon et al., 2009). Fostering creative collaboration is an important direction to explore because it predicts the ideal conditions for digital engagement.

Research suggests that the Internet, with its endless nodes of connectivity, is an ideal breeding ground for collaborative learning (Bruckman, 1998). Online communities have the potential to offer a supportive environment for new learning experiences (Bruckman, 1998). Bruckman (1998) highlights that digital tools built with this understanding of online community can support collaboration and facilitating the formation of “communities of practice” (Bruckman, 1998).
2.4 Scratch

To Mitchel Resnick and the team at the Lifelong Kindergarten group, the purpose of Scratch was not to train kids for careers in IT, but instead to present them with a new medium of expression. Scratch is a vital part of fulfilling the dreams of Seymour Papert says Resnick (2012). Scratch aims to engage everyone, of all backgrounds and interests, in creating their own interactive stories, games, animations, and simulations (Resnick, 2012). These foundational goals make Scratch the ideal learning environment for teaching girls about programming.

What is it about Scratch itself that is appealing to girls and other traditionally marginalized programmers? In a 2012 TED talk, Resnick explains that “learning to code is really coding to learn” (Resnick, 2012). By this, he means that applied learning is essential is communicating scientific lessons within a meaningful context.

Scratch facilitates open-ended play and gives kids a chance to explore and learn from their mistakes. The benefits of experiment are ample for young learners. In the process of creating, children try out their ideas and if their designs don’t turn out as they expected, they can revise their ideas and create something new (Resnick, 2006). Combined with external feedback and reward, emergent platforms that give children the autonomy of open-ended creation have the potential to draw in a diverse user base.

In 2008, 70 percent of Scratch users were male (Monroy-Hernandez & Resnick, 2008). In the original sample, no correlation was found between gender and the number of projects, r=.001, p=.923 (Monroy-Hernandez & Resnick, 2008). This finding indicates that even though the majority of users are male, the females who engage with
Scratch are just as engaged in creating projects as the males (Monroy-Hernandez & Resnick, 2008).

In a 2009 study on user roles in Scratch, two categories of participants were created: "project creators" and "social participators". No gender differences were found in participation patterns or in project complexity, suggesting that Scratch provides similar opportunities to both genders in programming, learning, and participation (Zuckerman, Blau, & Monroy-Hernández, 2009).

2.5 The Constructionist Approach

What benefits are derived from playing an educational game verses making an original game that is personally inspired? The Constructionist approach involves the principle that learning happens when people are actively engaged in making a meaningful product. Others term this process experiential learning. This principle is a conceptual underpinning for certain game programming platforms (Denner et al., 2012).

The constructionist approach places considerable importance on the social and cultural context in which learning takes place (Kafai, 2006). Gee (2003) emphasizes the use of games to promote experiential learning. He argues that games are the ideal environment to exercise an active learning approach. Bruckman (1998) found that collaborative learning is positively affected by working on personally meaningful projects (Bruckman, 1998).

Research has found that experiential learning is taking place within innovative “configurable cultures”, such as game alteration (modding) and digital creation. Modding is a popular trend in the gaming community that refers to the modification of a digital
program to perform a function not intended by the original designer. This trend is made possible by networked technologies that create platforms for children to find inspiration in existing creations and feel compelled to remix original works themselves (Sinnreich, Latonero, and Gluck, 2009). The key to making constructionist-learning possible on the web is community support (Bruckman, 1998). If a user has a problem they cannot solve alone, they can crowd-source the answer. Crowd sourcing is a unique aspect of a robust online community that takes place in group forums and public wikis. Scratch understands that an interconnected network of diverse users encourages collaborative learning.

In a series of studies using Scratch, 10-year-old students met every day to design their own games to teach fractions to a group of younger students in their school over a period of 6 months (Kafai, 2006). Kafai (2006) found significant gender differences in game design and content. However, there were no significant gender differences in game making proficiency. Kafai (2006) outlines the differences between the instructionist and constructionist modes of thought on games for learning. Instructionists are accustomed to making education materials that teach embedded curriculum while constructionists provide greater opportunity for children to navigate their own way through academic benchmarks by constructing their own games (Kafai, 2006).

2.6 Intrinsic Motivation

Intrinsic motivation is rooted in self-determination theory (Deci and Ryan, 1985; Ryan and Deci, 2000). This theory states that humans have a psychological need for autonomy, competence, and relatedness and designing relevant instruction that enables learner autonomy and competence is inherently motivating. Because this theory is not
predisposed by gender, it is a solid framework to explore gender differences in gaming motivation.

Recent studies confirm that game-oriented programming can motivate young learners (Basawapatna, Koh, & Repenning, 2010; Robertson & Howells, 2008; Seif El-Nasr, Yucel, Zupko, Tapia, & Smith, 2006). While education researchers are divided between instructivist and constructionist gaming approaches (Kafai, 2006), sustained engagement with educational media of any nature involves both intrinsic and extrinsic motivation (Malone, 1981; Kafai, 2006). Satisfaction can result from extrinsic or intrinsic factors (Cameron & Dwyer, 2005). However, this assertion is based on the finding that instructional games are attractive to learners because they provide the potential for high-level motivation, clear and consistent goals, and continual interactivity (Cameron & Dwyer, 2005). Interactive learning is grounded in the theoretical assumption that learners build understandings by interacting with information, tools, and materials as well as by collaborating with other learners (Dickey, 2007). What factors of the game play and game creation environments foster innate motivation and personal goal construction?

Malone (1981) developed a theory of intrinsically motivating instruction, in which instructional game features were examined as a way to engage learners as well as educate them. In his theory, Malone describes Challenge as a facet of motivation. Challenge is the process of exploration, embarking upon and striving toward new skills. Ultimately learners find pleasure in practice because they are applying recently acquired skills (Malone, 1981). Curiosity is also a facet of motivation, quantified by the degree to which an activity can continue to arouse and then satisfy our interest by being novel,
complex, surprising, and incongruous (Malone, 1981). Fantasy, another tenant of Malone’s motivation theory, explains that children invent imaginary worlds to project unconscious desires. When children play pretend or create something out of sheer ingenuity they are working within the construct of their external reality (Malone, 1981). Malone and Lepper (1987) expand this research and argue that control and cooperation are also key characteristics that foster intrinsic motivation.

Dickey (2007) examined how the structure in MMORPGs might inform the design of interactive learning and game-based learning environments by looking at the elements that support intrinsic motivation. When there is no uniform end of a game to which players strive to achieve, there is no one way to the play the game (Dickey, 2007). The design of an open-ended MMORPG allows players choice, collaboration, challenge, and achievement (Dickey, 2007).

In the context of MMORPGs, Bartle (1996) designed a test to classify gamers into character personalities. These categories reflect intrinsic motivation in game play and can be applied to not only game play, but also game creation. What motivates a child to participate in digital community? How does an individual’s innate nature inform his/ her play style? Bartle’s taxonomy is based off player interaction within MUDs and MMOPRGs. The explorer and socializer classifications are pervasive in game creation settings. In Scratch, the free-play platform construction encourages exploration while the online community facilitates socializing as means of learning. Understanding how children play and manipulate instructionist environments is important in how research can interpret play with constructionist platforms.
Malone’s theory of challenge as motivation is the underpinning of how a discouraged learner can rebound from failure.

In order to measure motivational effects on non-computer science students, McGill (2009) introduced special robots designed by Institute for Personal Robots in Education (IPRE) to novice programmers. McGill found that high-school female participants were initially overwhelmed by the robot assignment, but were able to overcome their intimidation and felt accomplishment in completing the assignment (McGill, 2012). This newfound sense of accomplishment was motivating to the novice girl programmers. Studies examining gender and motivation must take the effects of personal accomplishment into consideration. The perception of a social and task environment are essential, says Ryan and Deci (2000). A sense of connection, control and self-perceived competence predicts intrinsic motivation (Ryan and Deci, 2000).

In a 2009 study, Papastergiou tested a computer science curriculum on 88 high-school aged students. She split her sample and conducted the lesson through both a gaming and non-gaming approach. Data analyses revealed that the gaming approach was both more effective in promoting students’ knowledge of computer memory concepts and more motivational than the non-gaming approach (Papastergiou, 2009). She also found that although boys exhibited greater initial memory in computer knowledge on average, motivational and learning outcomes for boys and girls did not significantly differ (Papastergiou, 2009). This study supports Malone’s (1981) theory of intrinsic motivation because self-reported motivational outcomes were not adversely affected by lack of experience.
2.7 Extrinsic Motivation

In contrast to the factors that foster internal motivation, external elements like feedback, reward, and adulation can also play a significant role in motivating engagement. Ryan and Deci (2000) distinguish extrinsic motivation as the performance of an activity in order to attain a separate outcome, like a reward or praise.

Role models can be a key source of motivation for learning (Bruckman, 1997). Bruckman (1997) devised a qualitative study of two pre-adolescents’ interactions in *MOOSE Crossing*, an online text-based virtual world. Bruckman's ethnography provides insight into how character development and role-playing within an open-ended learning environment can be motivating when coupled with the support and encouragement from a mentor and online community (Bruckman, 1997).

Cameron & Dwyer (2005) assert that gaming provides a “rehearsal dimension” that constantly sustains motivation through feedback (Cameron & Dwyer, 2005). It is feedback, they believe, that guides the learning process and provides students with satisfaction and accomplishment (Cameron & Dwyer, 2005). Achievement reward and instructional objectives are highly extrinsic factors. Pittman et al. (1982) found that by varying the difficulty of an activity and presenting a tangible reward predicted changes in what second graders chose for their free-choice activities (Pittman et al., 1982).

Based on the literature on achievement motivation (Kelleher et al. 2008; Heeter et al., 2011; McGill, 2012), females tend to be highly motivated by reward and academic achievement. In a 1978 study, fifth and sixth grade children attempted to solve a series of difficult problems; when faced with failure, some children persevered and even improved
thereafter, while others showed a decline in achievement or gave up (Diener & Dweck, 1978). Girls are particularly prone to learned helplessness in academic settings because they feel that circumstance of their understanding is out of their control (Dweck, 1999). Public perceptions and whether a personal failure is commonly known inform learner motivation as well as confidence. In a follow-up study, Elliot & Dweck (1988) found that when the value of a performance goal was highlighted and children believed their current skills were high, they responded in a mastery-oriented manner in the face of obstacles (Elliot & Dweck, 1988). Based on this model, sensitivity to feedback was affected by the nature of exposure and self-perception. Because girls are less inclined to have computation experience, educators need to pay attention to the way they involve girls in STEM learning.

Students’ motivation to achieve in school may be entirely different than a recreational setting. Based on the knowledge that achievement motivation in school depends on students’ expectancies for success and the value they attach to success, Berndt and Miller (1990) asked 153 seventh graders to complete multiple measures of academic expectancies and values. They found that boys and girls had similar expectations, but boys appeared to value academic success less than did girls (Berndt & Miller, 1990). This finding indicates that girls are more motivated by extrinsic factors than boys who place lessen value on success in a public forum like the classroom.
CHAPTER 3: SUMMARY

In summary, the literature on girls and programming suggests that lack of instructional support, the absence of positive reinforcement, and gender biased game content negatively affect girls, barring the development of an interest in coding. In terms of instruction, the medium and nature in which information is delivered to a child is important in building personal meaning. Individual relevance and mentorship have been found to nurture an interest in computers and positively effect self-perceived competency.

Open-ended play, a foundational underpinning of Scratch, is reflective of the constructionist approach to learning. Research finds that this approach allows beginners to learn at their own pace, around their own interests, personalizing the experience.

The divide between skilled coders and students who carry the sense that STEM is not an inherent skillset they possess can be more deliberatively understood by evaluating all aspects in which learners are initially introduced to coding. Girls learn helplessness in the classroom because they are highly sensitive to extrinsic feedback.

CHAPTER 4: HYPOTHESES

A wide body of literature exists that investigates remedies to gender exclusion in STEM disciplines. Ample studies have also been conducted on achievement motivation, as well as varying applications of the constructionist approach. Building on these findings, the purpose of this study is to examine gender motivation and pair engagement in the context of open-ended play with Scratch.
The following hypotheses provide evidence for the relationship between gender and programming engagement.

H\textsubscript{1}: Based on the literature (Corston & Coleman, 1996; Gürer and Camp, 2001; Goode et al., 2006; Kafai, 2008; Heeter et al., 2011) boys will have more prior experience with programming than will girls.

H\textsubscript{2}: Based on the literature on gender interaction and play styles (Valkenburg et al., 2005; Kelleher, Pausch, & Kiesler, 2008; Calvert et al., 2009; Fristoe et al., 2011), girl pairs will be more likely than boy pairs to talk about their projects, and both will be more likely than mixed gender pairs to interact.

H\textsubscript{3}: Based on the literature (Else-Quest et al., 2006; Ruble et al., 2006; Calvert et al., 2009), children in same-gender pairs will be more likely to interact than children in mixed-gender pairs if one partner has outside scratch experience.

H\textsubscript{4}: Based on the literature (Dickey, 2007; Papastergiou, 2009), boy pairs will be more intrinsically interested than girl or mixed-gender pairs.

H\textsubscript{5}: Based on the literature (Diener & Dweck, 1978; Elliot& Dweck, 1988; Kelleher et al. 2008; Heeter et al., 2011; McGill, 2012), girl pairs will be more extrinsically interested than boy or mixed-gender pairs.
CHAPTER 5: METHOD

5.1 Participants

Participants were fourth, fifth, and sixth grade children (54 boys; 58 girls) from The St. Mark Catholic School in Vienna, Virginia. Originally, 112 students were enrolled as participants in the Scratch workshop. Participant attrition occurred for 14 students due to absenteeism or missing one or more of the four Scratch lessons. Seven girls and 7 boys made up 14 participants who were dropped from the study. Mean age was 11 years, 1 month (range 9 years, 3 months to 12 years, 10 months).

Participants were grouped by sex, then randomly selected from a class roster and paired with another student of the same-sex or opposite-sex. Five girl pairs, 5 boy pairs, and 4 mixed-gender pairs were disrupted by absenteeism. Students in disrupted pairs were not included in the final sample of 98. The partnerships were closely distributed between girl pairs, boy pairs, and mixed-gender pairs. There were 18 girl pairs, 17 boy pairs, and 14 mixed-gender pairs who participated in four, 45-minute sessions, yielding 24 total sessions.

5.2 Scratch

Scratch is a unique game-programming platform that provides a dynamic canvas for production. Its visual, building block design presents an alternative to the rigid syntax of conventional programming language. The Scratch platform has two components: a downloadable offline project space and an online community comprised of growing galleries of user generated content. Scratch is offered in 15 languages. It provides
interactive forums for educators as well as dynamic comment hubs for game creators.

The Scratch platform designers at the Lifelong Kindergarten Project, at the MIT Media Lab, put a high priority on personalization. In practice, it easy for people to distinguish their Scratch projects by importing photos and music clips, recording voices, and creating graphics that are personally meaningful (Resnick, 2012).

5.2.1 The Offline Project Creator

*Scratch* runs on Windows 2000 or later, Mac OS X 10.4 or later, and Ubuntu Linux 9.04 or later. Computers need 120 megabytes of free space to install *Scratch* (Scratch.mit.edu). The offline project creator is a four-section workspace (see figure 1). The left section is a command gallery of “scripts” that control the movement and appearance of your animated character (pictured far right). Scripts assign action to your character or “Sprite”.

*Figure 1. Scratch Blank Canvas*
There are eight categories of commands: **Motion, Looks, Sound, Pen, Control, Sensing, Operators, and Variables**. The motion scripts rely on a fundamental understanding of x and y-axes. One example of a motion script is “glide _ seconds to x: _ and y: _”. The looks scripts control the color, size, and general appearance of your avatar. For example, if you want to add a word or thought bubble, you find these commands under the “looks” scripts. To edit scripts, you drag the chosen command block to the middle section of the canvas and stack them together like Legos (see figure 2).

*Figure 2: Moving Scripts in Scratch*
A Sprite can be chosen from the Scratch galleries of images and cartoons, drawn or uploaded by the user. The bottom right corner is where the user collects and controls sprites. When a sprite is added, it then populates the top right “view finder” (see figure 3).

Figure 3: Choosing a Sprite

Only when a sprite is outlined in blue can a user add scripts (control codes) to it. The user can also import sounds, backgrounds “Stages”, and costumes. A stage is the background and you can program it to be as interactive as the character itself. The same scripts that control the sprite can be used to modify the stage. Changing your sprite’s costume by adding timing commands gives the appearance of live animation (see figure 4).
If you want a dancer to change positions, you add costumes to that sprite and apply “change costume” scripts as well as timing cues to simulate movement.

Changing sound is also very simple in Scratch. You import and apply sounds the same way you change costume (see figure 5).
5.2.2 Scratch Online Community

In May of 2007, the Scratch website was officially launched. At the time, the Scratch Online Community was made up 20 participants who were involved in a Scratch workshop (Monroy-Hernandez & Resnick, 2008). Today, the Scratch online community is an ever-burgeoning network. Each day, Scratchers from around the world upload more than 1,500 new projects to the site, with source code freely available for sharing and remixing (Resnick et al., 2009). As of April 2013, the Scratch community had 1,506,007 registered members, 450,276 project creators, and 3,257,574 published projects (retrieved 16, April 2013, scratch.mit.edu).
The homepage features most recent projects uploaded, new Scratch features, user trends and project examples from the Scratch design studios. When you click on a user’s project you can access their profile page complete with every project they have published to date. The project galleries (see figure 7) feature links to explore a wealth of work including “your friends’ latest projects”.

Figure 6: Scratch Online Homepage
The online forums provided on the Scratch website offer learning objectives for educators that outline a framework for learning code through designing. ScratchEd is a forum for educators and parents to crowd-source instruction techniques.
This page of resources for educators connects teachers who want to engage in a learning community surrounding the implementation of this tool in their classrooms. It also has outlines of Scratch lesson plans available. A “Getting Started with Scratch” guide is available under the “Support” tab and provides a visual walk through of the program of the installation and creation process. Video tutorials are also available through the support page to introduce learners to the functionality of Scratch (see Figure 9).
The video tool is helpful for educator and novice Scratchers alike. Produced by kids themselves, these videos instill a true sense a learning community.

5.3 Procedure

Each participant in this study had four Scratch lessons. There were six classes of students (two from each grade: fourth, fifth, and sixth) and each class had one Scratch session per week. In total, the experimenter ran 24 instructional sessions for 98 participating students. Each participant had one week’s time between sessions. Before the workshop began, all participants took a 4-question pre-test to assess prior
programming experience. After the workshop was complete, each participant completed a 16-question Likert scale post-test survey. The post-test survey adapted the structure of the Harter (1980, 1981) scale that assesses intrinsic motivation versus extrinsic motivation for each item. In Harter’s scale, children were asked to value intrinsic factors against extrinsic factors. The adaptation for this study instead provides extrinsic and intrinsic based questions, all asked in the format of a uniform 4-answer scale.

Figure 10: The Scratch Workshop Classroom

5.3.1 Session One

The first lesson was an introduction to Scratch. The session started with a four-question pre-test and an experimenter lead discussion. The students were asked about
general knowledge of programming software (pre-test included in study addendum). The
function and origin of Scratch was presented via this Scratch Ed. Introduction video:
http://vimeo.com/29457909 on the classroom projector. The experimenter led the class in
a group project, collected input and modeled different functions through a projected
screen view of the master computer. Scratch language such as “sprite”, “script”,
“costume”, and “stage” were defined for the students. Questions were taken before
everyone’s individual computers were activated. Everyone opened the Scratch platform
at his/her individual station from the desktop icon. Students were given twenty minutes
for free-play while the experimenter and computer teacher walked around the room
answering questions as they arose. Common questions asked during this session were:
“How do I make my sprite jump?” “How do I change the background?” and “How do I
record my own voice?”

5.3.2 Session Two

Session two started with a one-question survey asking students whether they had
any extracurricular exposure to Scratch since the first session. The experimenter informed
the students that the day’s lesson would be dedicated to creating original Scratch works.
The students learned, for the first time, that everyone would be given a partner that was
assigned randomly. After the pairs were announced, the students settled in their new
computer stations next to their partners. It was once again reiterated that every person
was to create his/ her own project but that your partner was there to consult and
collaborate with if inclined. Lastly, the classes were all informed that there would be a
prize given to the best original Scratch work in each class, as determined anonymously
by a group of peer judges.
The remaining 35 minutes of session two were dedicated to project creation. On 10-minute intervals, two experimenters walked around the room together to observe pair interaction. If the pair was talking at the minute the experimenters walked behind them, they received a “Yes” for observed interaction. A “No” was recorded if the pair was not talking, and notes were taken on other observed interaction such as talking to another student and whether a student had vacated his/her seat. The session ended with explicit instructions to save all projects.

5.3.3 Session Three

In session three, the students sat by assigned pairs. Again, everyone answered a one-question survey measuring extracurricular Scratch use. Before the students were given the day’s assignment, the experimenter explained the context of the larger Scratch online community and led a discussion about the culture of “remix”. Remixing was defined as taking something in one form and making it new and different. The experimenter explained that the Scratch community encourages remixing the work of others for the purposes of learning.

The students were then told to pull up the original project they had completed on their computers, take a step back and switch seats with their partners. The assignment was to remix their partner’s original creation. All remixes were saved under a new file name so that everyone was assured that their projects would still exist elsewhere in their original forms. On 10-minute intervals, once again the two experimenters walked around the room together to observe pair interaction. If the pair was talking at the minute the experimenters walked behind them, they received a “Yes” for observed interaction. A
“No” was recorded if the pair was not talking, and notes were taken on other observed interaction such as talking to another student and whether a student had vacated his/her seat. The session ended with explicit instructions to save all projects.

5.3.4 Session Four

The fourth and final session was the only session that the students did not interact with the offline platform. All the participants filled out a 19 question post-test survey, evaluating their degree of engagement with Scratch (see Appendix A). Sixteen questions were written on a Likert scale of 4 possible answers and there were 3 open-ended questions for qualitative responses.

The experimenter then introduced the class to the online community at scratch.mit.edu and each participant registered for a user ID. The students were told that they could now make and publish Scratch creations from home. In the week after the ID was created, projects were uploaded and the experimenter tracked post-session engagement. The class then watched a presentation of another class’ de-identified projects. They voted for the project they thought was best by closed ballot and then received certificates of achievement for “participation and mastery” in the Scratch workshop.

5.4 Dependent Measures

Gender and pair assignment (boy pairs, girl pairs, mixed-gender pairs) were independent variables. The dependent variables were prior programming scores, extracurricular engagement scores, intrinsic motivation scores, and extrinsic motivation scores. The dependent measures are explained in detail below.
5.4.1 Prior Programming Experience

A pre-test exposure score was calculated for all workshop participants. This score ranged from 0-3. Before interacting with the Scratch platform in session one, the students filled out a Programming Experience survey (see Appendix B). Each question was coded with variables, a “0” representing no, and “1” representing yes. The prior programming score is the sum of 3 questions: “Have you ever made your own computer program?”, “Have you ever made a program with Scratch?”, and “Are you in your school’s robotics club?”

5.4.2 Pair Interaction

Six pair interaction observations took place during Session Two during the individual, original project assignment and during Session Three, during the partner remix-assignment. These observations were noted once every 10 minutes, amounting to 3 observations per/pair per/class. The scores were transformed into variables, “0” representing if the pair received a “No” for an observed interaction and “1” if the pair received a “Yes” for an observed interaction. A Pair interaction score ranges from 0-3 for each class session. Each pair received two interaction scores.

5.4.3 Extracurricular Play

The variable of extracurricular play was determined by a one question at the beginning of Session Two and Session Three: “Did you play with Scratch on your own since the last class workshop?” After being introduced to the Scratch platform in Session One, if a student self-reported that he/she played with Scratch at home on their own time he/she received a score of “1” for “yes” or “0” for “no”. Every student received two extracurricular scores, each ranging from 0-1.
5.4.4 Intrinsic Motivation

The experimenter coded intrinsic scores for each participant based on their individual post-test survey answers. Six questions in the survey were deemed to expose intrinsic motivation. Each question was written on a Likert scale of 4 possible answers. The individual intrinsic score had a range of 0-24. The sum of the following questions determined an individual’s intrinsic score. Once these scores were calculated, the intrinsic pair score, equal to the average of partners’ post-test score for intrinsic motivation, was computed resulting in a new score for the pair. The pair score also had a range of 0-24.

5.4.5 Extrinsic Motivation

Just like the intrinsic score, the experimenter coded extrinsic scores for each participant based on their individual post-test survey answers. Six questions in the survey measured extrinsic motivation. Each question was written on a Likert scale of 4 possible answers. The individual extrinsic score had a range of 0-24. The sum of the questions determined an individual’s extrinsic score. Once these scores were calculated, the extrinsic pair score, equal to the average of partners’ post-test score for extrinsic motivation, was computed resulting in a new score for the pair. The pair score also had a range of 0-24.

5.5 Inter-coder Reliability for Pair Interaction

On 10-minute intervals, the two experimenters walked around the room together to observe pair interaction. If the pair was talking at the minute the experimenters walked behind them, they received a “Yes” for observed interaction. A “No” was recorded if the
pair was not talking, and notes were taken on other observed interaction such as talking to another student and whether students had vacated their seats. Inter-coder reliability was calculated by an equation of 2 times the number of agreements divided by the total number of scores for Observer A and Observer B, which yielded 99% agreement.

CHAPTER 6: RESULTS

6.1 Prior Programming Experience

Based on the literature (Corston & Coleman, 1996; Gürer & Camp, 2001; Goode et al., 2006; Kafai, 2008; Heeter et al., 2011). My first hypothesis predicted that boys would have more prior experience with programming than will girls. A 2 (gender) one-way ANOVA was conducted on individual programming scores for the prior experience in computation. As predicted, boys reported significantly more prior programming experience than mixed pairs or girl pairs, \( F(1, 96) = 7.953, p = .006 \). The mean values for boys = .31 and girls = .02.

6.2 Engagement and Gender Interaction

Based on the literature on gender interaction and play styles (Valkenburg et al., 2005; Kelleher, Pausch, & Kiesler, 2008; Calvert et al., 2009; Fristoe et al., 2011), the second hypothesis predicted that girl pairs would be more likely than boy pairs to interact while working on their projects, and both boy and girl pairs would be more likely to interact than mixed-gender pairs. A 3 (gender pair) ANOVA was conducted on interaction scores during the construction of the original individual programs (session 2) and the remix programs (session 3). The analysis for the week 2 individual programs was
not significant. By contrast, the analysis for pair type was significant for the remix programs in week 3, F (2, 92) = 4.762, p = .011. Contrary to prediction, LSD follow-up post-hoc comparisons revealed that boy pairs interacted significantly more than mixed-gender pairs (p = .03) and girl pairs (.052). The means for girl pairs did not significantly differ in interaction scores. The mean values for interaction scores were as follows: boy pairs=1.44, girl pairs= 0.80, and mixed gender pairs= 0.48.

6.3 Extracurricular Play

My third hypothesis predicted that children in same-gender pairs would be more likely to interact than children in mixed-gender pairs if one partner had outside Scratch experience. A 2 (outside play) x 3 (gender pair) ANOVA was conducted on interaction scores for the remixing assignment condition. Contrary to assumption, the predicted interaction was not significant between the three gender pairs, perhaps because so few participants had outside Scratch experience. Of the 98 study participants, only 32 were involved in extracurricular play. These students were closely distributed by gender, with 18 boys and 14 girls (See table 1).

6.4 Intrinsic Motivation

My fourth hypothesis predicted that boy pairs would be more intrinsically interested than girl or mixed-gender pairs. Contrary to prediction, a 3 (gender pair) ANOVA conducted on intrinsic pair scores revealed that there were no significant differences between pair type and intrinsic motivation. The potential range was 0-24 (See table 1).
6.5 Extrinsic Motivation

Based on the literature on achievement motivation (Kelleher et al. 2008; Papastergiou, 2009; McGill, 2012), the fifth hypothesis was that girl pairs would be more extrinsically interested than boy or mixed-gender pairs. A 3 (gender pair) ANOVA was conducted on extrinsic pair motivation scores (the average of partners’ post-test score for extrinsic motivation). The analysis for pair type was significant at F (2,95)= 3.33, p= .04. As predicted, LSD follow-up post-hoc comparisons revealed that girl pairs were more extrinsically motivated than boy pairs (p= .017). LSD post-hoc comparisons also revealed a trend for girl pairs to demonstrate more extrinsic motivation than mixed gender pairs (p= .063). There was no difference between mixed-gender and boy pairs in extrinsic motivation scores. The mean values on extrinsic motivation scores were as follows: girl pairs= 16.778, mixed gender pairs= 15.214, and boy pairs= 14.853. The potential range was 0-24 (See table 1).

Table 1: Mean Scores

<table>
<thead>
<tr>
<th></th>
<th>Girl Pairs</th>
<th>Boy Pairs</th>
<th>Mixed-gender Pairs</th>
<th>Significance</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extracurricular Play</td>
<td>0.888</td>
<td>1.000</td>
<td>0.714</td>
<td>0.310</td>
<td>0-1</td>
</tr>
<tr>
<td>Intrinsic Motivation</td>
<td>19.166</td>
<td>17.941</td>
<td>18.000</td>
<td>0.195</td>
<td>0-24</td>
</tr>
<tr>
<td>Extrinsic Motivation</td>
<td>16.778</td>
<td>14.853</td>
<td>15.214</td>
<td>0.040</td>
<td>0-24</td>
</tr>
</tbody>
</table>
6.6 Award

After all the classes reviewed their peers’ original Scratch projects created in Session Two, winners were chosen from each class. To protect student privacy and avoid popularity bias, the student projects were unidentifiable during the presentations, so class 4A did not know they were voting for the best of class 4B’s projects and vice versa. There were 2 female project winners and 4 male project winners. One female project winner came from a fourth grade class and the other from a fifth grade class.

CHAPTER 7: DISCUSSION, LIMITATIONS & IMPLICATIONS

Considering the effects of disparate gender engagement in STEM, this study set out to determine whether Scratch provides a play space that motivates STEM engagement and collaboration. Existing research has suggests that learned helplessness can be combatted through positive reinforcement and the role of female mentorship (Corston & Coleman, 1996; Denner, Werner, and Ortiz, 2012). These solutions are key in fostering a foundational interest in computation in young girls. In the present study, two adult females were involved with programming experiences, the computer teacher and the researcher who introduced Scratch to the class. These females could have served as role models for the girls in the classes, though it is notable that the female teacher’s robotics club was entirely populated by boys.

Open-ended platforms that provide a canvas for kid-altered content (modding and remixing) and original kid-generated content have also changed the relationship between gamers and digital programming. However, this study is novel because it answers the
ever-elusive question: What is the ideal combination of factors to provide novice coders with the motivation to be life-long coders and how do these factors differ by gender?

7.1 Key Findings

This study looked at the role of prior programming experience and found that the amount of prior programming experience a student had before the Scratch workshop was not a predictor for increased extracurricular engagement in Scratch. The study also evaluated what a partner dynamic adds to the experience of learning with Scratch. Most meaningful, was student’s self-reported motivation, both intrinsic and extrinsic because this data revealed that while there is no gender difference in engagement outside the classroom, girls were more extrinsically motivated in a class workshop setting. According to the findings, Scratch did what it was built to do: create a gender, class, and skill neutral space for open-ended exploration.

7.2 The Meaning of No Gender Difference

Research suggests that a learner’s first experience with programming has a great influence on subsequent engagement (Corston & Coleman, 1996; Gürer and Camp, 2001; Goode et al., 2006; Kafai, 2008; Heeter et al., 2011). Consequently, girls with little or no computing experience report positive attitudes towards computer work when they were in the presence of a female instructor (Corston & Coleman, 1996). These findings, coupled with the conclusion that no gender differences were found in participation patterns for new Scratch users (Zuckerman, Blau, & Monroy-Hernández, 2009), implies that there was a strong likelihood that this study would expose equal engagement despite experience.
7.2.1 Experience

Based on the literature (Etzkowitz et al., 1994; Calvert, 1999; Gürer and Camp, 2001; Goode et al., 2006), the first hypothesis predicted that boys would have more prior experience with programming than girls. As predicted, the findings were consistent with the literature. Boys reported significantly more prior programming experience than girls in the sample. However, boys and girls were equally likely to be exposed to Scratch. These findings set the stage to examine the effects of prior programming exposure on engagement in the class sessions.

7.2.2 Outside Play

In order to evaluate the effects of outside experience on interaction, the third hypothesis predicted that children in same-gender pairs would be more likely to interact than children in mixed-gender pairs if one partner had outside Scratch experience. Contrary to assumption, the predicted interaction was not significant between the three types of gender pairs, perhaps because too few participants reported outside Scratch experience. Of the 98 study participants, 32 were involved in extracurricular Scratch play. These students were closely distributed by gender, with 18 boys and 14 girls. Even though the number of children in the sample involved in extracurricular play was low in frequency, girls and boys were found equally likely to participate outside the school setting. This is a promising finding for engaging girls in programming.

Data were collected in four consecutive weeks in the classroom setting. Each participant experienced 4 Scratch lessons, which included ample free play with the offline platform. It was not until the end of the fourth session that the students explored
the online Scratch community and each participant registered for a login. Perhaps if they
did not have in-school access or an earlier knowledge of the robust function of the
community, there may be higher reports of outside engagement.

In the process of creating, children try out their ideas and if their designs don’t
turn out as they anticipated, they are able to reshape their ideas and create something
effectively new (Resnick, 2006). Observations echoed this sentiment revealing that the
students wanted to learn from their mistakes and the more they explored, the more they
wanted to change their works to reflect their newfound knowledge. After the original
work assignment in Session Two, students protested for more time to work on their
projects. In response to this complaint, the regular computer science teacher, extended the
Scratch lesson after the four-session data collection was complete. Students’ user IDs
were tracked one week after the fourth lesson, but the number of users that published
their works was not significant. It seemed that due to in-school immersion, there was less
of an impetus to play at home during free time.

Most importantly, despite the low frequency, there was no gender difference in
extracurricular play. This finding builds on the premise that the medium of instruction,
whether it is self-guided or mentored, effects engagement more than prior experience.

7.3 Program Mediated Collaboration

Based on the literature on children’s social interaction and play in the digital
space (Valkenburg et al., 2005, Calvert et al. 2009, Fristoe et al., 2011), the second
hypothesis predicted that girl pairs would be more likely than boy pairs to interact while
working on their projects, and both boy and girl pairs would be more likely to interact
than mixed-gender pairs. Contrary to prediction and the literature on girl interaction, boy pairs interacted significantly more than mixed pairs.

7.3.1 Talking and Narrative Play

Previous studies on pair interaction in MUDs found that girl pairs talked more than boy pairs did (Calvert et al., 2009), but boy pairs in the current study talked more than girl pairs did. Considering the narrative nature of female play, this finding was not expected. Using a game creation platform, girls are generally inclined to narrative (Kelleher, Pausch, & Kiesler, 2008) and prefer to make games based on storytelling, social interactions, and dynamic relationships (Fristoe et al., 2011). However, perhaps because the “pair interaction” measure did not evaluate the contents of the projects or individual play preferences, it cannot be concluded whether the girl participants did in fact use the platform to create more narrative based projects than boys. The question at hand is whether they are social while creating with Scratch.

This finding could be due to the task at hand. Boys in this sample were found to have more prior programming expertise. While novice learners spend more time exploring a platform and acclimating to an environment (Heeter et al., 2011), seasoned programmers would not experience that learning curve. Heeter et al. (2011) asserts a player must learn how to play a game in order to learn intended content (Heeter et al., 2011). Perhaps this familiarity with coding had an effect on pair collaboration. The isolated concentration witnessed in this study could reflect the initial process a player experiences before he/she will talk freely. McGill (2012) also found that high-school female participants were initially overwhelmed by a computation assignment with robots.
and the results may further reflect the process in which beginners acclimate to an environment and gain confidence.

7.3.2 Qualitative Observations

Open sharing and communication are key elements of creative collaboration (Argon et al., 2009). Qualitative observations revealed that girls attempted to build together when interacting and boy pairs were trying to undercut and one-up one another. For example, four sixth-grade boys collected behind one student’s computer to test his project. The creator exclaimed, “Watch how fast this guy can go!” This prompted one of the four boys to run back to his seat and shout back, “I bet I can get mine to turn faster!” Another 6th grade boy in a boy pair said to his partner, “I can’t believe I’m helping you destroy my work!” during the remix assignment. Two 5th grade girls decided that they would help one another through the Scratch learning process. When given the task to create two individual projects, they collaborated and chose many of the same elements such as background, sprites, and music. These observations reveal that the expertise, comfort, as well as competition contribute to pair interaction, and they may by gender.

As predicted, mixed-gender pairs did interact the least. In terms of maturation, from middle childhood until adolescence, children are involved in increased levels of gender-segregated play (Ruble et al., 2006). Further, gender differences in children’s interaction styles manifest themselves in children’s play with same-sex peers (Else-Quest et al., 2006). Qualitative observation yielded similar findings. Most mixed-gender pairs kept to themselves. However, two observations of mixed-gender pair interaction are worth noting. Contrary to the norm, one pair of mixed-gender 5th grade students decided
to connect their projects as a Part 1 and Part 2 of one narrative. The girl created a space
ship and the boy created a racetrack in space for the ship. Another mixed-gender pair did
not connect nearly as harmoniously; during the remix assignment, the boy in the pair
decided to delete all of the sprites in the girl’s original work. She then retaliated by
changing the background of his work to a pink candy land and featuring young pop-star
Taylor Swift dancing in the foreground. Because of the randomized pair assignments, we
did not control whether good friends with outside friendships or children who did not get
along were partners.

7.4 Intrinsic Motivation

Based on the literature on motivation and gaming (Malone, 1981; Kafai, 2006;
Seif El-Nasr, Yucel, Zupko, Tapia, & Smith, 2007; Robertson & Howells, 2008;
Basawapatna, Koh, & Repenning, 2010) the fourth hypothesis predicted that boy pairs
would be more intrinsically interested than girl or mixed-gender pairs. Contrary to
prediction, there were no significant differences between pair type and intrinsic
motivation.

This outcome is supported by research that revealed that although boys had
greater initial computer memory knowledge on average, boys and girls both found the
game motivational and the learning outcomes for boys and girls did not significantly
differ (Papastergiou, 2009). This study supports Malone’s (1981) theory of intrinsic
motivation because self-reported motivational outcomes were not adversely affected by
lack of experience. In his theory, Malone describes Challenge as a facet of motivation.
Challenge is the process of exploration, embarking upon and striving toward new skills.
Ultimately learners find pleasure in practice because they are applying recently acquired skills (Malone, 1981).

7.4.1 The Success of Scratch

Motivation is an important indicator for appeal. Dr. Resnick, creator of Scratch, stated that one main goal of Scratch was to achieve broader participation across gender (Monroy-Hernandez & Resnick, 2008). In 2008, 70 percent of Scratch users were male (Monroy-Hernandez & Resnick, 2008). In the original sample, no correlation was found between gender and the number of projects, r=.001, p=.923 (Monroy-Hernandez & Resnick, 2008). In a 2009 study classifying Scratch users as “social” versus “creative”, no gender differences were found in participation patterns or in project complexity, suggesting that Scratch provides similar opportunities to both genders in programming, learning, and participation (Zuckerman, Blau, & Monroy-Hernández, 2009). In a free-play setting, Kafai (2006) also found that there were no significant gender differences in game making proficiency (Kafai, 2006).

Research suggests that open-ended platforms like Scratch are intrinsically motivating my nature. The design of an open-ended game allows players choice in how to play (Dickey, 2007). A sense of connection, control and self-perceived competence predicts intrinsic motivation (Ryan and Deci, 2000). The finding that there is no gender difference in intrinsic motivation implies that Scratch is doing what it set out to because it incorporates the interests of all users by allowing total learner autonomy.
7.5 Extrinsic Motivation

Based on the literature on achievement motivation (Kelleher et al. 2008; Heeter et al., 2011; McGill, 2012), the fifth hypothesis stated that girl pairs would be more extrinsically interested than boy or mixed-gender pairs. As predicted, girl pairs were more extrinsically motivated than boy pairs and there was a trend for girl pairs to demonstrate more extrinsic motivation than mixed-gender pairs.

Females tend to be highly effected by reward and feedback, placing high importance on academic achievement and public perception (Dweck, 1999; Kelleher et al. 2008; Heeter et al., 2011; McGill, 2012). In the face of obstacles, girls tend to focus on success in order to display competence and gain teacher’s favor (Elliot & Dweck, 1988). Based on the knowledge that achievement motivation in school depends on the value students attach to success, Berndt and Miller (1990) found boys appeared to value academic success less than did girls (Berndt & Miller, 1990). As revealed by the current study, girls are more motivated by extrinsic factors than boys who place less value on public achievement in the classroom and the favor of a teacher. Girls were more sensitive to extrinsic motivators than boys and therefore designing a stimulating environment for STEM learning should consider that difference.

7.5.1 The Role of Award

As explain in the Method, at the beginning of workshop Session Two, the students were told that there would be an award given to the individual whose Scratch project was deemed “best” by the vote of an anonymous group of peers. Aside from the admiration
from their classmates and the title of “class winner”, a prize from the class goodie chest was included in the award.

7.6 Limitations & Future Directions

Analysis of this study was constricted by time. The data collected far surpassed what time allowed for evaluation. However, excess data will be used in future directions for this study. This study was conducted at a private Catholic school in a high-income county in Northern Virginia and therefore the data is limited by a widely homogeneous sample. Running the same tests on motivation with a more representative sample would expand this work. It would also be useful to have stronger consistency between the pre-test and post-test surveys.

Initially, this study was set up to evaluate how students involved in a formal Scratch workshop engaged with the platform outside the formal setting. Original data collection was conducted in four consecutive weeks in a classroom setting. Each participant experienced 4 Scratch sessions, including plentiful free play with the offline platform. As described in the discussion, extracurricular engagement with Scratch was sparsely reported. This finding reveals that students were not interacting online while the still immersed in school. Also, 3 full classes were dedicated to the offline platform and students were only shallowly introduced to the online community. To address the in-class play confound, following up on the participants by tracking their Scratch accounts over the summer when they will not have in school access would be very valuable.

In the post-test survey of 16 Likert scale questions, four questions reported the difficulty of the workshop as well as how the student perceived his/her own learning and
their experience working in pairs. Each student was given a difficulty score, ranging from 0-4 and a learning score ranging from 0-4. Each student also received a partner experience score ranging from 0-8 because there were two questions in the survey that reported pair experience. This data could be used in future studies to test if there is a correlation between self-perceived difficulty and extrinsic motivation in girls.

Finally, the content of these projects is of great value and time did not allow them to be incorporated into this current study. However, there is potential for a future study to do a content analysis on the 196 projects created (2 per participant in the study) and evaluate creativity as it relates to Scratch.

CHAPTER 8: CONCLUSION

In this study, despite the fact that boys had more prior programming experience than girls, this proclivity had no effect on outside the classroom engagement, which was evenly distributed between genders. There were no gender differences in intrinsic motivation, however the gender differences in extrinsic motivation were highly significant. Scratch effectively engages learners across gender, leading to the discovery that disparate STEM motivation disappears when girls interact with Scratch.

These findings have major policy and curriculum implications. Engaging learners early on with Scratch will lessen the STEM divide because children will incidentally learn science concepts through working in the digital arts. This practice can help turn all Americans from digital consumers into digital producers with a burgeoning skill set that will change the technological landscape in America. Policy needs to take into account that pre-adolescent girls self-report high feedback and rewards based motivation in the
classroom setting. Therefore, interacting with an open-ended platform like Scratch should be recommended as curriculum in elementary school classrooms, just as it is being adopted in middle and high schools. This practice can effectively build confidence in young girls at a young age, thus remedying the misconception that they cannot succeed in the sciences.

Not only do these findings present solutions to bridging the STEM divide, but also can offer insight into gender interaction in elementary school settings. Combined with external feedback and reward, emergent platforms that give children the autonomy of open-ended creation have the potential to draw in a diverse user base are changing the landscape of Computer Science as we know it.
APPENDIXES

Appendix A: Post-test

Post-Project Scratch Survey

Directions: The following questions will ask you about your experience with Scratch. Please check the box above the statement you feel is true. The last three questions do not have boxes. Please answer those in your own words.

1. How much did you like making a Scratch program?

[ ] I didn’t really like it  [ ] It was ok  [ ] A lot  [ ] A whole lot

2. How hard was it to make your Scratch project?

[ ] It was really easy  [ ] It was kind of easy  [ ] It was kind of hard  [ ] It was really hard

3. How much fun did you have making your Scratch program?

[ ] It was really boring  [ ] It was kind of boring  [ ] It was kind of fun  [ ] It was a whole lot of fun
4. How much fun did you have remixing your partner’s Scratch program?

- [ ] It was really boring
- [ ] It was kind of boring
- [ ] It was kind of fun
- [ ] It was a whole lot of fun

5. How much fun was it to have your partner remix your Scratch program?

- [ ] I disliked it a lot
- [ ] I didn’t really like it
- [ ] It was kind of fun
- [ ] It was a whole lot of fun

6. Would you like to make more Scratch programs in the future?

- [ ] I wouldn’t do it again
- [ ] I probably wouldn’t do it again
- [ ] I might do it again
- [ ] I definitely would do it again

7. How important were the comments your teacher gave you about your Scratch project?

- [ ] Not important at all
- [ ] Not very important
- [ ] Important
- [ ] Really, really important

8. How important were other kids’ comments about your project?
9. How curious are you about learning to make more programs?

Not curious at all  Not very curious  Curious  Very curious

10. How much did you learn about computer programming by using Scratch?

I didn’t learn anything  I didn’t learn much at all  I learned a fair amount  I learned a whole lot

11. How important is your grade for the Scratch program?

Not important at all  Not very important  Important  Really, really important

12. How important was it for you to make a program that your peers liked?

Not important at all  Not very important  Important  Really, really important
13. How important was it for you to win the prize of "Most Creative" Scratch project?

Not important at all  Not very important  Important  Really, really important

14. How important is it to you to share your project with your parent?

Not important at all  Not very important  Important  Really, really important

15. How helpful was your partner when you were working on Scratch?

Not helpful at all  Somewhat helpful  Very helpful  Extremely helpful

16. How much did you talk with your partner about Scratch?

Not at all  A little bit  A lot  A whole lot
17. What did you like most about making a Scratch program?

18. What did you dislike the most when you made a Scratch program?

19. What did you talk to your partner about?
Appendix B: Pret-test Programming Survey

Programming Survey

Directions: The following questions will ask you about your past experience with computer programs. Please write your name, grade, and age below and circle “Yes” or “No” to answer the questions.

Name: ____________________________________________________________
Grade: ____________________________________________________________
Age: _____________________________________________________________

1. Have you ever made your own computer program?

   Yes                   No

2. Do you have a computer in your home?

   Yes                   No

3. Have you ever made a program with Scratch?

   Yes                   No

4. Are you in Mrs. Girmus’ robotics club?

   Yes                   No
Appendix C: Intrinsic questions

(Numbers correspond to survey, Appendix A):

1. How much did you like making a Scratch program?
3. How much fun did you have making your Scratch program?
4. How much fun did you have remixing your partner’s Scratch program?
5. How much fun was it to have your partner remix your Scratch program?
6. Would you like to make more Scratch programs in the future?
9. How curious are you about learning to make more programs?

Appendix D: Extrinsic questions

(Numbers correspond to survey, Appendix A):

7. How important were the comments your teacher gave you about your Scratch project?
8. How important were other kids’ comments about your project?
11. How important is your grade for the Scratch program?
12. How important was it for you to make a program that your peers liked?
13. How important was it for you to win the prize of "Most Creative" Scratch project?
14. How important is it to you to share your project with your parent?
Appendix E: Certificate of Achievement

Certificate of Achievement

The Children’s Digital Media Center is proud to present:

This award for participation and mastery in the St. Mark 2013 Scratch Workshop.

Ms. Adieberg  Mrs. Girmus  Dr. Calvert
REFERENCES


