

# The Attitudes of African American Middle School Girls Toward Computer Science: Influences of Home, School, and Technology Use

Ashley R. Robinson

Dissertation submitted to the Faculty of the  
Virginia Polytechnic Institute and State University  
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Computer Science and Applications

Manuel Pérez-Quiñones, Co-Chair

Glenda Scales, Co-Chair

Andrea Kavanaugh

Scott McCrickard

Tonya Smith-Jackson

March 27, 2015

Blacksburg, Virginia

Keywords: African Americans, Computational Thinking, Computer Confidence,  
Computer Science, Human-Computer Interaction, Middle School Girls, Self-Efficacy

Copyright 2015, Ashley R. Robinson

# The Attitudes of African American Middle School Girls Toward Computer Science: Influences of Home, School, and Technology Use

Ashley R. Robinson

## ABSTRACT

The number of women in computing is significantly low compared to the number of men in the discipline, with African American women making up an even smaller segment of this population. Related literature accredits this phenomenon to multiple sources, including background, stereotypes, discrimination, self-confidence, and a lack of self-efficacy or belief in one's capabilities. However, a majority of the literature fails to represent African American females in research studies.

This research used a mixed methods approach to understand the attitudes of African American middle school girls toward computer science and investigated the factors that influence these attitudes. Since women who do pursue computing degrees and continue with graduate education often publish in Human-Computer Interaction (HCI) in greater proportions than men, this research used an intervention to introduce African American middle school girls to computational thinking concepts using HCI topics. To expand the scope of the data collected, a separate group of girls were introduced to computational thinking concepts through Algorithms. Data were collected through both quantitative and qualitative sources, and analyzed using inferential statistics and content analysis.

The results show that African American middle school girls generally have negative attitudes toward computer science. However, after participating in a computer science intervention, perceptions toward computer science become more positive. The results also reveal that four factors influence the attitudes of African American middle school girls toward computer science, such as the participation in an intervention, the intervention content domain, the facilitation of performance accomplishments, and participant characteristics like socioeconomic status, mother's education, school grades, and the use of smart phones and video game consoles at home.

# Acknowledgments

I give all honor to my Lord and Savior Jesus Christ, who is the source of my life. I came to Virginia Tech for a Doctoral degree and by the grace of God, I am leaving with so much more. God has placed so many amazing people in my life, who have all inspired me and helped me to develop into the person I am today.

I thank my family for supporting me in their own unique ways. To my parents, Surley and Jacqueline Robinson, thank you for being my biggest supporters throughout the years. I appreciate you both for valuing education and your relationship with God, and for instilling those values in me. Dad, thank you for introducing me to my first computer, which positively influenced my interest in computer science at an early age. Thank you for never putting limits on me and for always being available and willing to teach me anything I wanted to learn. Mom, thank you for always being by my side while on the path toward my degree. You rejoiced when I rejoiced and was always there to help me through the difficult times. Thank you for always reminding me that “I can do all things through Christ which strengtheneth me”, Philippians 4:13. To my brothers,

Antoine and Raynardo Robinson, thank you for your support and for believing in me. Nina Candia Robinson, thank you for supporting me and reviewing my document. To my nieces, Brooklynn and Naeemah Robinson, thank you for brightening up my life with your smiling faces.

Dr. Manuel Pérez-Quiñones and Dr. Glenda Scales, words cannot express how truly blessed I am to have had both of you as my dissertation committee co-chairs. Thank you for going above and beyond to mentor and guide me through the process of obtaining my Doctoral degree. You both always stood by me through the ups and downs, and taught me to believe in myself. Dr. Pérez-Quiñones, you have taught me so much about mentoring through our interactions and in seeing you interact with others as well. Thank you for always being there to offer scholarly advice, while giving me room to grow in my own academic pursuits. I also appreciate you for making sure I always felt like I belonged, and for encouraging me to pursue numerous personal and professional development opportunities. Dr. Scales, thank you for teaching me how to advocate for myself. Those intense office visits really paid off and made me a stronger person. I am so glad I returned to your office after the first visit, even though it took a whole year. I also thank you for having a genuine interest in my future and well-being, and for ensuring that I am prepared for whatever comes my way after my tenure as a graduate student. Dr. Pérez-Quiñones and Dr. Scales, you both brought out the best in me and for that, I am eternally grateful.

To my other dissertation committee members, Dr. Scott McCrickard, Dr. Andrea

Kavanaugh, and Dr. Tonya Smith-Jackson, thank you for providing valuable insight and for strengthening my skills as a researcher. Dr. McCrickard, thank you for recruiting me to attend Virginia Tech, and for allowing me to work with the NSF Research Experiences for Undergraduates program. Dr. Kavanaugh, thank you for your constructive feedback and for providing me with resources to enhance my document. Dr. Smith-Jackson, thank you for your words of encouragement and for guiding me in quasi-experimental design and statistical analysis.

Pastor Ronald A. Watson Sr. and the Radford Church of God in Christ, thank you for being my home away from home. You welcomed me with open arms on the first day we met, and from that day forth, you have been nothing less than family. Thank you for your prayers and for your practical biblical instruction. Worshiping and fellowshiping with you gave me the tools I needed to overcome challenges and accomplish my goals.

Bishop Wilbert L. Daniels Sr. and the St. Paul Church of God in Christ, thank you for your prayers and for all of your support throughout the years. Thank you for giving me the opportunity to get involved, which contributed to my spiritual and professional growth starting at an early age. I also appreciate your words of encouragement and for literally being my cheerleaders on the sidelines during my visits. Even with me living hundreds of miles away, your presence was definitely felt from afar.

To my College of Engineering colleagues, Dr. Catherine Amelink, Lisa Burns, Dr. Julaine Fowlin, Dr. Shreya Kothaneth, Brandon Landreth, Jeff Lewis, Tom Long,

Dr. Vaishali Nandy, David Okoth, Jeff Phillips, Dr. Nicole Sanderlin, Sam Schaller, Ryan Spoon, Beth Tront, and Wesley Tse, thank you for all of your support. I would like to especially thank Dale Pokorski. Dale, thank you for your direct, honest approach to mentoring and for encouraging me to focus on my dissertation at the times I needed it the most.

To the YMCA and Boys and Girls Club organizations in the Southeast Hampton Roads area of Virginia, thank you for welcoming me and allowing your summer camp enrollees to participate in my research study.

I also would like to acknowledge Dr. Tracy Lewis, Dr. Cheryl Seals, Dr. Felicia Doswell, and Dr. Jamika Burge, who paved the way for me as Virginia Tech's first four African American female Computer Science Ph.D. graduates. Thank you all for your words of encouragement throughout the years and for always making time to meet with me whenever we cross paths at various conferences.

So many people have helped me along my journey that I cannot name them all. To everyone, I thank you for your prayers, wisdom, support, and encouraging words.

# Dedication

To my parents, Surley and Jacqueline Robinson, who prayed for me and believed in me  
at times when I struggled to believe in myself.

# Contents

<b>Abstract</b>	<b>ii</b>
<b>Acknowledgments</b>	<b>iii</b>
<b>Dedication</b>	<b>vii</b>
<b>List of Figures</b>	<b>xi</b>
<b>List of Tables</b>	<b>xiii</b>
<b>1 Overview</b>	<b>1</b>
1.1 Introduction	1
1.1.1 Societal Consequences	2
1.1.2 Significance	3
1.2 Problem Statement	4
1.3 Terminology	5
1.4 Intervention Approach	6
1.5 Theoretical Framework	7
1.6 Guiding Principles in Research Question Development	8
1.7 Purpose of Study and Research Questions	11
1.8 Research Design and Methodology	12
1.9 Contributions	13
1.10 Guide To Reading This Document	13
<b>2 Literature Review</b>	<b>15</b>
2.1 Introduction	15
2.2 Computing, Computer Science, and HCI	16
2.3 Influences on Computing Entry and Retention	18
2.4 Recruiting and Retaining Women in Computing	22
2.5 Problem-based Learning	24
2.5.1 Computing	26
2.5.2 Women	27
2.6 Computational Thinking	28
2.6.1 Connecting Computing	30



2.6.2	Developing Computational Artifacts and Abstracting . . . . .	30
2.6.3	Analyzing Problems and Artifacts . . . . .	31
2.7	Self-efficacy . . . . .	32
2.8	Summary . . . . .	37
<b>3</b>	<b>Research Methodology . . . . .</b>	<b>38</b>
3.1	Introduction . . . . .	38
3.2	Research Design . . . . .	39
3.2.1	Quantitative . . . . .	40
3.2.2	Qualitative . . . . .	41
3.3	Participants . . . . .	43
3.4	Instructional Design . . . . .	45
3.4.1	Learning Objectives . . . . .	46
3.4.2	Activities . . . . .	48
3.5	Data Collection . . . . .	62
3.5.1	Participant Background Information . . . . .	62
3.5.2	Computer Confidence Survey . . . . .	63
3.5.3	Computational Thinking Survey . . . . .	65
3.5.4	Focus Group Interviews . . . . .	67
3.5.5	HCI Activities . . . . .	69
3.6	Researcher’s Stance . . . . .	69
3.7	Summary . . . . .	70
<b>4</b>	<b>Results . . . . .</b>	<b>71</b>
4.1	Introduction . . . . .	71
4.2	Participant Background Information . . . . .	72
4.3	Computer Confidence and Computational Thinking . . . . .	72
4.3.1	Handling Missing Data . . . . .	73
4.3.2	Pre- and Post-Workshop Survey Score Comparisons . . . . .	73
4.3.3	Participant Characteristics and Survey Score Predictions . . . . .	75
4.4	Focus Group Interviews . . . . .	80
4.4.1	Creation of the Codebook . . . . .	80
4.4.2	Coding Scheme Validation . . . . .	81
4.4.3	Emerging Themes . . . . .	82
4.5	HCI Activity Findings . . . . .	89
4.5.1	User Interface Evaluation . . . . .	89
4.5.2	User Interface Design . . . . .	91
4.6	Summary . . . . .	96
<b>5</b>	<b>Discussion and Conclusions . . . . .</b>	<b>98</b>
5.1	Introduction . . . . .	98
5.2	Revisiting the Research Questions . . . . .	99
5.2.1	Research Question 1 . . . . .	100

5.2.2	Research Question 2	100
5.2.3	Research Question 3	104
5.2.4	Research Question 4	108
5.3	Interesting Research Directions	117
5.4	Conclusions	118
5.5	Recommendations	122
<b>Bibliography</b>		<b>124</b>
<b>Appendix A Institutional Review Board Package</b>		<b>152</b>
<b>Appendix B Instrumentation</b>		<b>172</b>
<b>Appendix C Qualitative Coding</b>		<b>181</b>
<b>Appendix D Results</b>		<b>192</b>

# List of Figures

- 3.1 Participants paper prototyping (a) and iPhone 5 template [1] (b) . . . . . 53
- 3.2 POP app screenshots [2] . . . . . 55
- 3.3 A participant using the POP app (a) and a participant presenting their user interface created in POP (b). . . . . 56
- 3.4 An algorithm created by a participant (a), the resulting picture that another participant produced (b), the intended outcome of the algorithm (c). . . . . 59
- 3.5 Screenshots of the Cargo-Bot iPad app [3]. . . . . 60
  
- 4.1 Low (a), medium (b), and high (c) levels of abstraction when representing the iPhone keyboard . . . . . 93
- 4.2 Low (a), medium (b), and high (c) levels of abstraction when representing text . . . . . 93
- 4.3 Low (a), medium (b), and high (c) levels of abstraction when representing people . . . . . 94
  
- C.1 Coding sample . . . . . 191

D.1	Normal Q-Q plots of all pre- (left) and post-workshop (right) computer confidence survey scores . . . . .	199
D.2	Normal Q-Q plots of all pre- (left) and post-workshop (right) computational thinking survey scores . . . . .	199
D.3	Normal Q-Q plots of the HCI group's pre- (left) and post-workshop (right) computer confidence survey scores . . . . .	200
D.4	Normal Q-Q plots of the HCI group's pre- (left) and post-workshop (right) computational thinking survey scores . . . . .	200
D.5	Normal Q-Q plots of the Algorithms group's pre- (left) and post-workshop (right) computer confidence survey scores . . . . .	201
D.6	Normal Q-Q plots of the Algorithms group's pre- (left) and post-workshop (right) computational thinking survey scores . . . . .	201

# List of Tables

- 2.1 Computer self-efficacy instruments . . . . . 35
  
- 3.1 Summary of research questions, data sources, and analysis methods . . . . . 39
- 3.2 Computer science workshop activities with associated learning objectives . 50
  
- 4.1 Test of normality of pre- and post-workshop survey scores . . . . . 74
- 4.2 Paired samples t-test of pre- and post-workshop survey scores . . . . . 75
- 4.3 Stepwise multiple regression analysis variables . . . . . 76
- 4.4 Stepwise multiple regression analysis coefficients (Case 1) . . . . . 77
- 4.5 Stepwise multiple regression analysis coefficients (Case 2) . . . . . 78
- 4.6 Stepwise multiple regression analysis coefficients (Case 4) . . . . . 79
- 4.7 HCI activity social networking app names divided by category . . . . . 92
  
- B.1 Computational thinking survey items with associated computational think-  
ing practices . . . . . 180
  
- C.1 Codebook . . . . . 190
  
- D.1 Participant characteristics . . . . . 194

D.2	Computer confidence survey descriptive statistics . . . . .	195
D.3	Computational thinking survey descriptive statistics . . . . .	198
D.4	Independent samples t-test of pre-workshop survey scores . . . . .	202

# Chapter 1

## Overview

### 1.1 Introduction

There is a lot of interest to increase the number of women in computer science. According to the National Science Foundation [4], in 2012, there were 47,960 computer science Bachelor's degree recipients. However, women only accounted for 18.2% (8,730) of students who earned computer science Bachelor's degrees. Of those women, 16.7% (1,460) were Black or African American. This indicates that Black or African American women only made up 3% of the computer science Bachelor's degree recipients in 2012. The gender and ethnic gap found in undergraduate education is also apparent in the workforce, where females only accounted for 24% (575,000) of the total number (2,387,000) of workers in computer and information science occupations in 2013 [4]. Of those females, 10.6%

(61,000) were black or African American, making up only 2.5% of the entire computer and information science workforce. This indicates that African American women can benefit from research that focuses on increasing their interest in computer science.

### **1.1.1 Societal Consequences**

The lack of diversity in computer science negatively impacts the workforce. Innovation, productivity, and competitiveness are at risk when teams are not diverse [5]. Research conducted by the National Center for Women & Information Technology indicates that patents invented by gender diverse teams are cited more often than female-only or male-only teams. It is speculated that these diverse teams are capable of creating more complex inventions [6]. The Lehman Brothers Centre for Women in Business [7], in a study of more than 100 teams at 21 companies, found that the teams with equal proportions of men and women were more innovative and productive than teams of uneven proportions.

The lack of women in computer science also suggest that the inventors of some technology do not reflect the diversity of the consumers. Women were responsible for 45% of and influenced up to 61% of all consumer electronics purchases in 2007, according to the Consumer Electronics Association's 10th Annual Household CE Ownership and Market Potential Study [8, 5]. More recently, the Consumer Electronics Association reported in their 13th Annual Study that women spent on average of \$520 on consumer electronics while men spent \$793 in 2011 [9]. Although a comparison of consumer elec-



tronic purchases by African American women are unknown, Blacks spent 10% more time on consumer electronics sites than the total market consumers, according to the 2013 African American Consumer Report [10]. The same report indicates that 71% of African Americans own smart phones compared to 62% of the total population [10]. Also, African Americans spend more of their discretionary income on computers, cell phones, and other electronics than any other racial group [11]. Although women and African Americans are strong consumers of technology, they often do not have a voice in the design of these devices, putting these groups at a disadvantage in society [12].

### 1.1.2 Significance

The significance of this research is in relation to increasing the number of African American women in computer science. Increasing female interest and retention in computer science is a topic well studied [13, 14, 15, 16, 17, 18, 19, 20]. However, research on increasing the number of African American females in computer science is a topic that is understudied. Additionally, minorities from low-economic backgrounds often lack computer training and the knowledge necessary to select a computing major [21]. Being exposed to computer science in middle school will give students an opportunity to take relevant high school courses in order to ensure that they will have a leveled playing field when pursuing their career interests [22]. Knowledge of the computer science discipline is important because it has the capability of helping students from low-income backgrounds cross economic boundaries by earning a computer science degree. When underrepre-

sented populations do not choose to pursue careers with high income potential, such as computer science, they are at a financial disadvantage. Even if students do not choose to pursue a computer science career, utilizing the skills they learn from taking computer science courses can become a foundation for generating income. This research will serve a great role in gaining insight into the attitudes of African American middle school girls toward computer science, and provide recommendations for developing formal and informal learning opportunities, and instructional strategies, with the goal of increasing the interest of African American middle school girls in computer science.

## **1.2 Problem Statement**

While there is a lack of women in computer science, African American women pursue computer science careers at even smaller rates. The literature dedicated to attracting and retaining women in computer science tends to focus on White women [23], leaving the voices of African American women in computer science unheard. It is important that multiple ethnicities are represented in this literature since there are known cultural differences between ethnicities [24] that may influence their views of computer science. One approach to consider for increasing the number of African American women in computer science is to begin by introducing computer science concepts to African American middle school girls. This research uses a mixed methods approach to understanding the attitudes of African American middle school girls toward computer science.

## 1.3 Terminology

It is important that key terms are defined within the context of this research.

- Computational Thinking [25]: “Computational thinking is taking an approach to solving problems, designing systems and understanding human behaviour that draws on concepts fundamental to computing.”
- Computer Science (CS) [26, 27]: “...the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application.”
- Computing [28]: “... any goal-oriented activity requiring, benefiting from, or creating computers.”
- Human-Computer Interaction (HCI) [29]: “...a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.”
- Problem-based Learning [30]: An approach to learning where students work collaboratively to solve a real-world, cross-disciplinary problem, with the non-expert tutor acting as a guide that provides students with the appropriate resources.
- Self-Efficacy [31]: “...the belief in one’s capabilities to organize and execute the courses of action required to manage prospective situations.”

## 1.4 Intervention Approach

When Cohoon et al. [32] surveyed female authorship in ACM-affiliated conferences, results showed that women had a greater proportion of authorship than men in human factors, a subarea of Human-Computer Interaction (HCI). Between 1998 and 2008, the average share of women authors were 28% at CHI, the premiere ACM conference in Human Factors, which contains researchers from computer science among other disciplines. This number is high considering that women made up 27.8% of people who earned computer science Master's degrees and 21.4% of people who earned computer science PhDs in 2012, according to the National Science Foundation [4]. Therefore, this data is one type of indicator that women not only are interested in HCI, but they are very active in the field. This type of indicator aligns with the notion that women tend to navigate towards the social sciences and people-oriented disciplines [33]. HCI is also interdisciplinary in nature, which relates to the broad set of interest that women in computing tend to have.

HCI is a sub-area of computer science [27, 34] that is dedicated to designing, implementing, and evaluating computer systems for human use [29]. HCI is an appropriate gateway to computer science because it tends to focus on application development and user centered design. Women are often motivated to pursue computer science because of the perception that computer science provides them with opportunities to be creative, communicate [35], and address societal concerns [36, 35]. The ability to design facilitates creativity while the application and user focus of HCI enables women to communicate

and help people, which was found to be important to women when choosing a career [37, 38]. On the other hand, traditional computer science areas, such as computer programming, tends to focus on the inner workings of computer systems rather than the people who use them. Since HCI does not require high levels of prior knowledge about the workings of computers, it has been taught to middle and high school students to increase their interest in computing [39]. It also has been incorporated into undergraduate computing programs in an effort to retain women in computer science [19].

In this research, an instructional intervention, consisting of two types of workshops, was designed and implemented to introduce computer science to primarily African American middle school girls. Building upon existing literature [39, 19], a HCI user interface design and evaluation workshop was implemented. A second type of workshop, Algorithms, was also implemented to represent the traditional approach to computer science and expand what we learned from the intervention. Both the HCI and Algorithms workshops incorporated computational thinking and problem-based learning into the instructional design.

## 1.5 Theoretical Framework

Banduras Social Cognitive Theory [40] is the overarching theoretical framework used in this study. The theoretical component of self-efficacy was used as a lens in which to design the intervention, conduct the workshop, and interpret the results of the study.

Self-efficacy, the belief in one's capabilities, influences persistence as well as other psychological processes [41]. Self-efficacy is similar to confidence in that they both refer to the belief in one's capabilities; however, self-efficacy is the belief in one's capabilities to achieve desired outcomes [42]. Interest, confidence, and self-efficacy are closely related. A loss of confidence and self-efficacy often leads to a loss of interest [20, 43]. Self-efficacy has an even deeper influence, often affecting performance [44, 45, 46, 40], personal goals [41], expended effort [41, 47, 48, 46, 40], perseverance [41, 47, 46, 40], resilience to failures [41], and career and choice of other situations [48, 40, 46, 47, 41].

## 1.6 Guiding Principles in Research Question Development

Among the numerous strategies that researchers [13, 19, 16, 49, 50, 15] used to increase the number of women in computer science, the implementation of HCI concepts in courses emerged as a solution that is likely to produce good outcomes. A study conducted at Carnegie Mellon University [20] used several strategies to increase female interest and retention in computer science (e.g. multiple points of entry to CS, interdisciplinary courses, admission policy revisions, high school outreach, etc.), which included incorporating HCI into the curriculum. Yardi et al. [39] evaluated the impact that HCI has on middle school students' interest and perception of computing. While other research studies [20, 39] included the use of HCI in computer science instruction to increase interest in computer science, the lack of interaction of gender and ethnicity provides an opportunity for fur-

ther research. Therefore, this research investigates the understudied African American female population's attitudes toward computer science along with the exploration of topics in HCI as a gateway to the computer science field. Algorithms were also explored as a gateway to the computer science field, in an effort to include the more traditional approach of teaching the workings of the technology and to expand the breath of data collected from the participants. Researchers found that participating in a learning experience, such as taking a computer course, can have a positive influence on one's attitude toward computers [51] and career self-efficacy [38].

Computational Thinking is an approach to problem-solving and is considered to be an educational foundation of computer science [52, 53, 25]. It includes a range of mental tools that reflect the breadth of the field of computer science [53] and must be understood by students in a way that makes sense to them before they can begin computer programming [54]. In recent years, there has been a push to expand computational thinking instruction in K-12 [55, 56, 57], with some researchers placing an emphasis on middle school students [58, 59]. Therefore, both the HCI and Algorithms workshops were based on six computational thinking principles identified by the College Board [60]. These computational thinking principles include connecting computing, developing computational artifacts, abstracting, analyzing problems and artifacts, communicating, and working effectively in teams. Research indicated that women were reluctant to pursue computer science careers, in part, due to seeing little connection between computer work and real-world problems [61]. They typically view the computer as recreational rather than view-

ing computers as a tool to promote human interaction, which is appealing to women [61]. Therefore, problem-based learning instructional strategy characteristics were also integrated into the workshops. Problem-based learning is a pedagogical approach that uses collaborative, real-world problem-solving to motivate students in the classroom [30].

Prior research indicates how one's characteristics and background can play a role in their attitudes toward computers and career choice. Research shows that computer home use has a positive effect on student's attitudes toward computers [62], subsequent computer use [62], self-efficacy [62], academic performance [63], and computer confidence [51]. Parents also influence the attitudes and career choices of students based on various factors, such as parental beliefs [51], support [51, 64, 65], and education-level [66, 67, 68, 69]. Although a majority of the research in recent decades have focused on the mother's education influencing the career choices of women [66, 67, 68, 69], father's education in earlier research was found to also influence career choice in women [70, 71]. Other research reveals the significance of the mother-daughter relationship in the career decisions [72, 73, 68] and career self-efficacy [74] of women. The daughter's attachment to their father, post adolescence, also influenced career self-efficacy [74]. School grades were found to influence persistence [75, 76] and career choice [77]. Students view grades as a key level of achievement [75], which is a source of self-efficacy [41]. Socioeconomic status was also found to influence career choice and career self-efficacy [78]. Most of the research found used a majority White sample, with two studies specifically stating that their sample only consisted of high school and undergraduate White students, [73, 66]



and two studies focusing on high school and undergraduate African American students [69, 67].

Prior literature suggest that middle school is an appropriate age group to participate in a career-related intervention. It was found that self-efficacy regarding career interests are continuously revised and are most fluid up until late adolescence or early adulthood, where those interests tend to stabilize [43, 79]. Once stabilized, new experiences will do very little to change a person's interests [43, 79]. According to Legum and Hoare [22], career interventions are most effective in elementary or middle school, especially for at-risk youth. This increases their chance of establishing an appropriate plan of study in high school to prepare them for their future career selections [22]. Therefore, middle school was the target age group for this research study.

## 1.7 Purpose of Study and Research Questions

The purpose of this research is to understand the attitudes of African American middle school females toward computer science and identify the factors that influence these attitudes. Attitude, in this study, is a broad concept that encompasses self-reported computational thinking beliefs (based on a self-efficacy framework), computer confidence, and general perceptions. This research answers the following research questions:

1. To what extent does the computer science intervention influence the computer con-

- confidence and computational thinking scores of African American middle school females?
2. To what extent do participant characteristics predict the computer confidence and computational thinking scores of African American middle school females?
  3. How does a computer science intervention influence the attitudes of African American middle school females toward computer science?
  4. What are the factors that influence the attitudes of African American middle school females toward computer science?

## 1.8 Research Design and Methodology

This research used an embedded mixed methods approach to understand the attitudes of African American middle school females toward computer science, and identify the factors that influence these attitudes. Two computational thinking workshops, with problem-based learning instructional strategies, were created and implemented with a HCI and an Algorithms focus. Each workshop lasted five days for approximately one hour per day. The participants were primarily African American middle school girls who participated in non computer-based summer day camps provided by two community outreach organizations, the Boys and Girls Club and YMCA. Data were collected through a background questionnaire, a pre- and post-workshop Computer Confidence Survey, a pre-

and post-workshop Computational Thinking Survey, focus group interviews, and written responses and physical artifacts derived from two HCI workshop activities. Data were analyzed using inferential statistics and content analysis.

## **1.9 Contributions**

This research contributes to the body of literature by studying primarily African American middle school girls. It uses an intervention approach with two different themes, HCI and Algorithms, to introduce primarily African American middle school females to computer science. The data gathered from the workshop participants provided insight into the attitudes of these middle school girls toward computer science, and how an intervention and other factors can influence their attitudes. This research also capitalizes on the principles of computational thinking and the integration of problem-based learning to create an intervention for these primarily African American middle school girls. Further, it highlights topics in HCI as a gateway to computer science and provides a breakdown of the characteristics of the workshop that played a role its success.

## **1.10 Guide To Reading This Document**

Chapter 1 presented an introduction to the current research, which included the significance, problem statement, description of the intervention, theoretical framework, pur-

pose of the study, research questions, summary of the research design and methodology, and the contributions to the literature. Chapter 2 presents the literature review, which discusses previous research in relevant topics such as the computing discipline, women in computing, problem-based learning, computational thinking, and self-efficacy. Chapter 3 presents the research questions, design, participants, instructional design, instrumentation, and researcher's stance. Chapter 4 presents the results of the study. Chapter 5 presents the discussion of the findings and conclusions drawn from the research.

# Chapter 2

## Literature Review

### 2.1 Introduction

This chapter discusses previous research as it relates to the Computing discipline, Women in Computing, Problem-based Learning, Computational Thinking, and Self-efficacy. It begins with an introduction to computing and computer science, with a presentation of the characteristics of Human-Computer Interaction (HCI) and its current state in the undergraduate computing curricula. Furthermore, the factors that influence the number of women in computing are discussed. The next section discusses what others have done to increase the number of women in computing. Then, a discussion of problem-based learning is presented, specifying its characteristics and relationship to computing and HCI. This leads to a discussion of computational thinking and the ways in which HCI

facilitates it. The following section discusses previous research on self-efficacy, its' role in society, as well as ways to assess it within the context of computing. This chapter concludes with a summary of prior work.

## 2.2 Computing, Computer Science, and HCI

In the 2005 Joint Task Force for Computing Curricula, Shackelford et al. [28] defines computing as "... any goal-oriented activity requiring, benefiting from, or creating computers." Computing is essentially the integration of the central processes of applied mathematics (theory), science (abstraction or modeling), and engineering (design) [27]. Within the area of computing, five prominent disciplines emerge: information systems, information technology, computer engineering, software engineering, and computer science [28]. For the purposes of this research, computer science will be used, as it is a component of computing [26, 27]. The term "computing" has often been used in the literature to include computer science.

Computer science is defined as "the systematic study of algorithmic processes that describe and transform information: their theory, analysis, design, efficiency, implementation, and application" [26, 27, 29]. As with other disciplines, the foundational freshman level courses provide most computer science majors with their first experience of the discipline. However, conventional computer science courses often do not provide the opportunity for students to experience the full range of diverse areas within computer

science because of the technical emphasis of the courses [80]. Negative experiences may affect retention rates [81], which become a very serious problem if those experiences are not a representation of the computer science discipline as a whole [80]. Programming as a first course for novices has been associated with high dropout rates (35 to 50 percent) along with cheating and plagiarism on assignments [82]. This is an unfortunate misrepresentation of the field because computer science encompasses far more than programming and often uses programming languages as vehicles for gaining access to the rest of the field. As a result, access to the full breath of the discipline can become limited [26, 27]. While a course may emphasize only individual technically focused work, the workforce demands cooperative work groups with a broad problem solving demand, which may have a greater appeal to a diverse range of students. Thus, this is another example of misrepresentation of the discipline [80].

Human-Computer Interaction (HCI) is a sub-area of computer science [27, 34]. According to ACM SIGCHI [29], “Human-computer interaction is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them.” From a computing perspective, HCI focuses on the interaction between humans and computational machines. However, HCI is interdisciplinary in itself, transcending across several disciplines with their own agendas. These disciplines include computer science (application design and engineering of human interfaces), psychology (the application of theories of cognitive processes and the empirical analysis of user behavior), sociology and anthro-

pology (interactions between technology, work, and organization), and industrial design (interactive products) [29]. Since the field of computing is not only driven by scientific questions and technological innovation, but also by societal demands, HCI bridges the gap between science, technology, and society [25].

For every school that integrates HCI into their computing curriculum at the undergraduate level, there are those who do not. Among the schools that do offer HCI courses, students usually are not exposed to them until senior year [29]. In some cases, students are not aware of the field of HCI or the related field of Human-Centered Computing (HCC) until right before applying to a graduate school program [83]. This is a disservice to students because they usually are only exposed to HCI at the surface level, without the option to probe deeper with other HCI courses that may be offered in complementary disciplines. In addition, without freshmen level HCI courses, the core values of computing that are closely related to HCI [84] may be suppressed by the challenging technical aspects of computing typically taught in programming courses.

## **2.3 Influences on Computing Entry and Retention**

There are various factors that influence the number of females in computing. Cohoon [49, 50] divides these factors into five categories: gender composition, support, faculty characteristics and behaviors, institutional, and community. Computing tends to be largely dominated by males [85] which can make females uncomfortable. This unequal gender



composition often limits the number of same-gender role models that females have [86]. Support for pursuing a computing discipline can come from family and peers [87, 88], who have more of a positive impact if they are the same gender [49, 50] and/or are socially similar [89]. In addition, faculty can provide support through encouragement to persist [50], supportive interactions [90, 91, 92], mentoring [50, 93] (e.g. encouraging diversity [50] and developing talents [87]), and concern that the department has sufficient faculty [50]. Seymour and Hewitt [91] found that faculty can also impact the retention of females in computing through their academic expectations of their students and teaching. However, Cohoon [50] did not come to the same conclusion and believes that faculty expectations do not impact the retention of females in computing programs. Darlington [88] defines the institutional factors that influence the number of women in computing degree programs as the climate, program support, and perception of the field. The media plays a role in influencing the perception of the field, often portraying people associated with technology as boys and men [86, 20]. Institutional factors also include program ties to the job market [50], access to computers [94], and active recruitment of students [87]. However, Cohoon [49] found that student quality is an institutional factor that does not impact females in computing.

Bunderson and Christensen [86] list five additional factors that impact the number of females in computing such as student background, culture, gender discrimination, perception of computing, and satisfaction with the degree program. A student's background, as it relates to computing, can range anywhere from their pre-college experiences

with computers [85, 86, 19] to their mathematical background [94], since mathematics is often associated with computer science. However, several researchers disagree with background influencing female retention [95, 96], since females are capable of doing the work [97, 95, 98] and there is no difference in women's programming knowledge or course grades after completing the early courses [98, 97]. According to Scragg and Smith [85], math anxiety also does not have an effect.

The gender divide in computing may not be an issue of gender at all but of culture differences [19], which includes religious views [86], according to Blum et al. [99]. Culture also includes the culture of the department, which may be perceived as majority male students who are obsessed with computers and view females as incapable [20]. The absence of the gender divide in countries like India reinforces the notion that the ways in which society views computing can impact the number of women in computing [100]. However, the views of some cultures toward computing can lead to discrimination against females because of their gender. This can make females believe that they are not smart enough to be in computing programs, and that their gender was the primary reason why they were selected for the program [20].

A female's perception of computing is often influenced by various stereotypes. These stereotypes tend to portray computing to be a male dominated field [83], with people who are nerdy, and obsessed with computers and programming [94, 19, 101]. They also tend to portray computing to be boring and not social enough [102, 103]. When Yardi and Bruckman [83] interviewed thirteen male and female students, ages 11-20, a majority

of them lacked interest in computing-related careers and presumed the field to be boring, difficult, tedious, and having little practical meaning or relevance to the real world. However, twenty-two graduate students in the Human-Computer Interaction (HCI) M.S. program and the Human-Centred Computing (HCC) Ph.D. program at Georgia Tech were also interviewed and perceived computing to be relevant to the real world, interdisciplinary, and fun [83]. This shows clear disconnection between perceptions of computing and reality.

The external factors that influence retention of women in computing, in turn, influences the internal factors such as satisfaction [86] and self-confidence [85, 19, 104, 105]. According to Fisher and Margolis [19], a person's initial motivation for choosing computing (e.g. entering computing because they enjoy programming, the job opportunity, etc.) also affects whether or not they stay in computing. Women are motivated to enter computing for various reasons such as the perception that computing is a form of communication, and provides the opportunity to creatively apply computing to societal concerns [36, 35] or other areas of interest [106, 19] (e.g. education, art, music, medicine, space exploration, etc.). It essentially depends on whether or not the computing program meets the student's expectations. Internal factors are the focus of this research since women tend to leave computing because of these factors (e.g. dissatisfaction with the major), while men tend to leave because of external factors (e.g. a greater interest in another discipline) [86].

## 2.4 Recruiting and Retaining Women in Computing

Researchers have tried various methods to recruit and retain women in computing. These methods have been recommended and/or implemented to address the factors that affect the number of women in computing, such as background, perception of computing, culture, and gender discrimination [86]. Offering multiple points of entry into a computer science program, where students can participate in tutorial and bridge programs that build upon their existing skill set [13], standardizes student backgrounds in the more advance courses [19, 16]. Diversity considerations were included in the discussions of curriculum and programming among faculty in order to create a more inclusive culture. Students were also informed of how their computing background is not critical to their success and how computer science is a diverse discipline, inhabited by more than the typical “boy hacker icon” [19]. To change the perception of computer science, it has been recommended that departments actively counter negative stereotypes by reviewing the images and text in publications to ensure that inclusive images are being portrayed to female students [16]. Perception and culture tend to go hand in hand with perception influencing culture. Gender discrimination has been addressed through raising awareness of the lack of women in computing to faculty as well as students, so that they can intentionally create a more inclusive environment for women [19].

Gender composition, faculty characteristics and behaviors, and community and institutional factors have also been addressed by researchers [49, 50]. In order to make the

gender composition less apparent, where women are the minority, researchers have established networks among women through electronic mailing lists [15] and residence hall clusters [13], encouraging learning communities [16] and peer mentoring [13, 16]. By conducting staff development activities [14] and encouraging mentoring relationships with students [19], researchers work to ensure that faculty have a positive impact on female student retention. Cohoon [16] agreed with this approach and recommended mentoring undergraduates, with the addition of maintaining a stable faculty, employing faculty who enjoy teaching undergraduates, increasing the number of female faculty role models, and communicating positive opinions of female students' strengths. Outreach programs, which worked with high school Advanced Placement teachers, were established at Carnegie Mellon University [20] in order to increase the interest of the community in computing. Cohoon [16] recommended that outreach be extended by using role models to recruit high school students, attract first and second year students from within the institution, and form partnerships with high school teachers, high school guidance counselors, community colleges, and the local community. Institutional factors were addressed in admissions and in the curriculum at Carnegie Mellon University [20]. Since computing background is not necessarily a prerequisite for success in computing, admissions adjusted their criteria by considering other factors such as diverse interests and high achievement in related subjects (e.g. math and science), with less emphasis on programming experience when admitting students [20]. Carnegie Mellon University [20] modified their computer science curriculum by incorporating interdisciplinary courses that enable

students from diverse backgrounds to collaborate and work on complex problems. A social aspect to computer science was added by providing a course that enables students to apply their skills to community issues [20].

This social approach is an aspect of problem-based learning. Problem-based learning aims to connect course content to real-world applications [107]. The real-world application of computer technology to end-users, as facilitated by the area of HCI, is where women thrive [108]. In spite of the curricula changes at Carnegie Mellon University yielding an undergraduate concentration in HCI [19], the combination of the institutional, cultural, and curricular changes do not reveal the impact of HCI on computer science female student retention. When Yardi et al. [39] taught HCI to middle and high school students, they found that practicing HCI increased their interest and improved their perception of computing. Even though they did not control for gender, this shows that HCI has some promise in increasing female interest in computing.

## 2.5 Problem-based Learning

Conventional computer science courses tend to be lecture-based, which often fails to benefit the diverse group of students enrolled in those courses. Students enter the computer science discipline with a variety of interests, backgrounds, and abilities. Varying abilities can range from programming at a very young age to absolutely no experience. First year conventional courses tend to be based on individual work, with a narrow technical focus

that tends to reach the small percentage of “average” students. Students can also find course material irrelevant to their needs and interests [81]. This results in an inadequate portrayal of the discipline. More realistically, computer scientists usually work in teams to solve broad problems in the workforce [80].

An alternative to conventional lecture-based courses is problem-based learning. Problem-based learning is an approach to learning where students work collaboratively to solve real-world, cross-disciplinary problems, with the non-expert tutor acting as a guide who provides students with the appropriate resources [30]. There are five characteristics of problem-based learning. First, the learning experience must be based on a real-world problem, which contextualizes the attributes of the discipline. Second, problem-based learning emphasizes the utilization of critical thinking for problem solving, which is one of the many soft skills that the workforce values. Since steps to solving the problem are not provided, a problem-based approach emphasizes self-directed learning. In order to solve the problem, students have to teach themselves how to utilize the available resources, which facilitates self-directed learning. The fourth characteristic of problem-based learning is cooperative learning, or working in groups, which is common in the workforce. Finally, the problem must be interdisciplinary in nature, where an abundance of skills (e.g. technical, communication, analytical, planning, interpersonal, teamwork, etc.) are required to solve the problem. Interdisciplinary problems typically require a diverse group of people to solve them, enabling those who may not necessarily have strong technical strengths to still be a valuable part of the team [109]. Problem-based learning

addresses the criticisms of lecture-based approaches by contextualizing the course material with a real-world problem [30]. Therefore, students are able to see the relevance of the course material to professional practice. Problem-based learning has generally been known to motivate students more than conventional pedagogical approaches [110].

### 2.5.1 Computing

Problem-based learning can be very useful in the computing field. Computing tends to be problem driven in itself, where computation is often used to solve both scientific and social problems. The diverse problems that computer scientists solve often requires the computing field to become interdisciplinary, stretching beyond the boundaries of the field into other areas. When exploring other areas that may at times be unfamiliar, or even exploring areas within the discipline, critical thinking skills are necessary in order to utilize the available resources for problem-solving. With the development of new technologies, the computing discipline is rapidly and continuously changing. As a result, self-directed, independent learning is valuable since computer scientists have to keep their skills updated in order to keep up with the demands of the discipline [111]. Cooperative learning in the classroom, where communication skills are developed, also transfers to the computing industry since project groups are the predominate mode of operation in the workforce, especially in software engineering [111, 112].

HCI lends itself to problem-based learning through design. According to Schultz



and Christensen [113], designing through HCI share many of the same characteristics as problem-based learning. These characteristics include analyzing the problem domain, gathering requirements, defining team roles, brainstorming creative ideas and solutions, and process iteration until a solution is found [113]. Due to the very nature of HCI, which is designing computer systems for human use, it is natural to begin with a real-world problem. The interdisciplinary problem that characterizes problem-based learning can be fully supported by HCI, due to its multidisciplinary nature of using concepts from various disciplines to understand and improve the interactions between humans and computers [114]. HCI teams enable problems to be approached from multiple perspectives. Diversity on a team brings a variety of knowledge sources and expands the possibilities of creative solutions. Problems posed in HCI are often unique; therefore, self-directed learning can naturally take place in order to find solutions to the problems. The instructor can provide resources but there will not necessarily be a right or wrong answer, where only the instructor (or a textbook) holds the key to the solution.

### **2.5.2 Women**

Women tend to benefit most from the problem-based learning approach, especially the social aspects (e.g. group-work, support and collaboration [115]) [116, 117, 118, 119]. In a study conducted by Reynolds [115], women favored the responsibility of self-directed learning as well as the collaborative nature of problem-based learning slightly more than men. They were twice as likely than men to refer to working with others, peer support,

friendship, and collaboration as the highlights of their problem-based learning experience [115]. In addition to being enjoyable, collaborative work, according to Lundeberg and Moch [120], has also been known to advance the intellectual skills among female science students. Women also have more trust than men in the information provided by other students [115], which could be a result of the value that women tend to place on connected learning [121, 122, 123]. Connected learning is where emphasis is placed on listening to understand the viewpoints of others rather than criticizing them [123]. Since women have been known to value life outside of the classroom (e.g. personal relationships), they are more likely than men to appreciate the connections made between personal experiences and abstract knowledge that are facilitated through the practical problems that problem-based learning yields [116]. According to Colwill and Vinnicombe [124], women enjoy encountering ambiguous problems and searching for creative solutions in the workforce, which are attributes of problem-based learning. Therefore, it is believed that women would benefit most from computing courses when the characteristics of problem-based learning, such as working with real-world problems collaboratively with peers, are utilized within a HCI framework.

## 2.6 Computational Thinking

According to Guzdial [54], students must understand computing in a way that makes sense to them before they can begin programming. Computing (e.g. computer science,

computer engineering, communications, information science and information technology [25]) is built upon the concepts of computational thinking, with programming being only a small component. According to Wing [53]:

Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science. Computational thinking includes a range of mental tools that reflect the breadth of the field of computer science [53].

In a later publication, Wing [25] extends her definition of computational thinking to draw on concepts fundamental to the field of computing as a whole. Computational thinking encompasses mathematical, engineering, as well as scientific thinking. The foundations of computing rests on mathematical thinking as a general approach to problem solving. Engineering thinking builds upon mathematical thinking in the approach to designing and evaluating interactive systems that operate within the constraints of the real world. Building upon engineering thinking, scientific thinking is the general approach to understanding computability, intelligence, the mind, and human behavior [53, 25]. As an approach to problem-solving, computational thinking trains one to take a series of steps in order to solve a problem, and generalize it to transfer to a wide variety of other problems that can be found in non-computing related disciplines [52, 53, 25]. This approach, in turn, requires one to have confidence, persistence, tolerance for ambiguity, the ability to deal with open-ended problems, and communication skills [52].

The College Board [60] operationalized computational thinking by identifying six computational thinking practices: connecting computing, developing computational artifacts, abstracting, analyzing problems and artifacts, communicating, and working effectively in teams.

### **2.6.1 Connecting Computing**

Connecting computing refers how computing relates to and impacts the real world [60]. Today, computing is so integrated into our daily lives that it can often become seamless or unnoticeable. However, when actions performed using computers do not yield the intended results, computers can become a burden to human users. In an attempt to prevent inconveniencing users, HCI is concerned with designing computer systems for humans who inhabit the real world [29]; therefore, impacting all aspects of the world in which we live.

### **2.6.2 Developing Computational Artifacts and Abstracting**

The design and interpretation of artifacts are central to the discipline of HCI [125]. A largely recognized key concept of HCI is usability [126]. Usability refers to the quality of the system with respect to functionality, learnability, ease of use, and user satisfaction [127, 128, 129]. Usability engineering is a sub-area of HCI that refers to “concepts and techniques for planning, achieving, and verifying objectives for system usability” [129].

Artifacts are produced during the prototyping phase of usability engineering. A prototype is a realistic representation of the system design. The purpose of the prototyping phase is to refine the usability requirements by sharing design ideas with potential users. Prototypes can range from low-fidelity (rough sketches of the system design) to high-fidelity (executable version of the system). The various levels of prototyping are typically associated with various levels of abstraction, with low-fidelity prototypes utilizing more abstraction. Abstraction removes details from the prototype, reducing the system to representations that are easily configurable. The choice of a prototyping approach depends on available resources, the audience, as well as the goals of the prototype [129]. Naturally, a high-fidelity prototype would require more resources, be more appealing to an advanced audience, and provide a more realistic view of the system than a low-fidelity prototype. However, a low-fidelity prototype will require less resources and will be less costly in terms of time to implement. Even though low-fidelity prototyping may be less aesthetically appealing, it will be easier to modify the system design based on user feedback due to the low cost. Therefore, usability engineers tend to use low-fidelity prototyping in the early stages of the design process, where the usability requirements are not as clearly defined and potential users are least likely to commit the design ideas.

### **2.6.3 Analyzing Problems and Artifacts**

Problems and artifacts are analyzed during the usability evaluation phase of usability engineering. Usability evaluation analyzes the usability of the system prototype to detect

problems, reveal the source of the problems, plan solutions to the problems, and justify the appropriateness and correctness of the solutions [60], to ensure that system design meets the needs of the potential users. Two main types of usability evaluation methods are analytic evaluation and empirical evaluation. Analytic evaluation analyzes the system features while empirical evaluation conducts analysis based on the user's interactions with the system [130, 129]. Due to the nature of analytic evaluation, it is recommended that this type of evaluation is used early and throughout the usability engineering process in order to refine the system design. The results of the analytic evaluation can then be used to plan empirical evaluation tests to determine how well the system meets usability needs (known as mediated evaluation [130]).

## 2.7 Self-efficacy

Self-efficacy, a theoretical component of Bandura's Social Cognitive Theory, is "people's judgments of their capability to organize and execute courses of action required to attain designated types of performance" [40]. Self-efficacy is similar to confidence in that they both refer to the belief in one's capabilities, but self-efficacy is the belief in one's capabilities to achieve desired outcomes [42]. According to Bandura [41], there are four sources of self-efficacy. These four sources include performance accomplishments, vicarious learning, verbal persuasion, and psychological responses. Successful performances, learning by observing others, positive messages conveyed by others, and a lack of anx-

xiety or stress all have a positive effect on self-efficacy. Since HCI does not require high levels of prior knowledge about the workings of computers, students are more likely to successfully complete their assignments. The integration of problem-based learning and collaboration in HCI enables students to work closely together and as a result, learn from one another. By working with others in a collaborative rather than competitive environment, students are more likely to receive encouragement from their peers. Students may also receive positive feedback from the users of the system that they are designing. The first three sources of self-efficacy, performance accomplishments, vicarious learning, verbal persuasion, work together to determine how one interprets and copes with stress and anxiety.

Self-efficacy beliefs are known to affect several psychological processes. These include performance [44, 45, 46, 40], the goals people set for themselves [41], how much effort they expend [41, 47, 48, 46, 40], how long they persevere in the face of difficulties [41, 47, 46, 40], their resilience to failures [41], and their choice of situations (activities and environments) [48, 40, 46, 47]. People tend to select situations in which they believe they are capable of handling [131]. For example, people who have greater self-efficacy consider a wider range of career options and have a greater interest in them. People with greater self-efficacy also prepare themselves better educationally for their desired career path and are more successful in their academic pursuit [41].

Career choice, such as a person's decision to pursue a computing discipline, is affected by self-efficacy. Self-efficacy, for women, is typically greater when women are

performing stereotypically feminine tasks, in spite of capability [131]. Computers are typically perceived to be masculine by society and as a result, women are not encouraged as much as men to pursue computing careers [131]. Women often seek careers that are perceived to be more feminine such as education and the social sciences, which are people-oriented disciplines [33]. Perhaps if women are able to relate computing to their interest, computers can be perceived to be more feminine and women may be more attracted to the computing field.

Computer self-efficacy, which refers to one's judgment of their capability to perform a computing task successfully [132], can range from basic computer literacy (e.g. using computer software applications) to building computer applications (e.g. computer programming) [133]. As a result, computer self-efficacy instruments usually focus on these skills [134]. Computer self-efficacy instruments also assess courses that teach various computer skills [135]. Bandura's [40, 47] self-efficacy model is commonly used to create self-efficacy scales. However, most existing computer self-efficacy instruments (shown in Table 2.1) are narrowly focused and insufficient, because computing is more than knowing basic computer skills and advance computer programming skills often associated with the computer science discipline [136]. A self-efficacy instrument must be tailored to the specific situation since self-efficacy consists of individualized self-percepts that can vary across activities and situational circumstances [40].

Although a majority of existing computer self-efficacy instruments are either too basic (computer literacy) or technical (computer programming), there are instruments



Instrument	Population	Focus
Computer Science Self-efficacy Scale [135]	Undergraduate students	Self-efficacy in a CS0 (introductory computer science) course: problem solving confidence, computer troubleshooting confidence, career encouragement, satisfaction with college major, career exploration, and course anxiety
Computer Self-efficacy Scale [134]	Graduate students, adult vocational students, and professionals (nurses)	Perceptions of capability regarding specific computer-related knowledge and skills: beginning computer skills, mainframe computer skills, and advanced-level computer skills
Computer Self-efficacy Scale [137] (based on [134])	Undergraduate students	Examine the influence of computer training (introductory computer course) on computer self-efficacy: beginning computer skills, mainframe computer skills, advanced-level computer skills, and computer file and software management
Computer Programming Self-efficacy Scale [138]	Undergraduate students	Computer programming self-efficacy for the C++ language: meaningful programming tasks such as designing, writing, comprehending, modifying, and reusing programs
Computer Self-efficacy Scale [139]	Undergraduate students	Overall computer literacy self-efficacy: computer programming, computer coursework, and personal uses of the computer

Table 2.1: Computer self-efficacy instruments

that evaluate the general aspects of computer self-efficacy as it relates to the overall computing discipline. The Longitudinal Assessment of Engineering Self-Efficacy (LAESE) Survey [140, 141] was developed for undergraduate students by the Assessing Women and Men in Engineering (AWME) Project. The LEASE Survey contains thirty-one items that are divided into six measures or subscales: Engineering Career Success Expectations, Engineering Self-efficacy I, Engineering Self-efficacy II, Feeling of Inclusion, Coping Self-efficacy, and Math Outcome Expectations. Based on the LEASE instrument, the Pre-College Annual Self-Efficacy Survey was created for high school females by the Female Recruits Explore Engineering (FREE) Project [140]. Although LEASE is an engineering self-efficacy scale, it has been used to evaluate computer self-efficacy by replacing the

word “engineering” with “computing” [142]. However, the content and structure of the LEASE survey items seemed a bit mature for middle school students.

The Computer Attitude Scale, developed by Loyd et. al. [143, 144, 145] has also been used to measure computer self-efficacy. It has been administered to participants in 5th grade, 7th-12th grade, and adults [143, 144, 145, 146]. The Computer Attitude Scale consist of forty items that are divided into four subscales: Computer Anxiety, Computer Confidence, Computer Liking, and Computer Usefulness. The items in each subscale include both positively and negatively worded items that are distributed throughout the instrument [144]. According to Wu [146], the computer confidence subscale can be considered to be a computer self-efficacy component when changing the two items worded “would do” to “could do.” However, Wu’s modifications do not change the wording of every question to coincide with the way Bandura [147] says they should be worded to evaluated self-efficacy.

Due to the lack of appropriate computer self-efficacy instruments available, a Computational Thinking Survey was created based on Bandura’s framework [147]. The use of the computational thinking domain operationalized the definition of computer science, making the survey content appropriate for middle school children. Since confidence is related to self-efficacy, Loyd and Gressard’s [143] Computer Confidence Subscale was used to evaluate confidence and validate the Computational Thinking Survey.

## **2.8 Summary**

The literature reveals that an HCI approach to computer science is understudied but relevant [39, 19]. Previous research captures the factors that influence the number of women in computing, which are broad in spectrum. Researchers have used various methods (e.g. peer mentoring, community outreach, etc.) [13, 16] to increase the number of women in computing. While HCI instructional interventions showed promise in previous literature [39, 19], the studies did not fully capture its' effectiveness regarding African American female students. The use of HCI topics in computer science courses is relevant in that it lends itself to existing instructional design approaches, like problem-based learning, which is known to appeal to women [115]. HCI topics also support the integration of computational thinking concepts as a foundation to computer science. In addition, this research looks at Bandura's Social Cognitive Theory of Self-efficacy [41] and how HCI-related activities can facilitate self-efficacy through performance accomplishments, vicarious learning, verbal persuasion, and psychological responses.

# Chapter 3

## Research Methodology

### 3.1 Introduction

This chapter discusses the research methodology used to explore the attitudes of African American middle school females toward computer science, and identify factors that influence these attitudes. A summary of research questions introduced in the previous chapter, data sources, and analysis methods can be found in Table 3.1. RQ4 is an overarching question designed to merge the quantitative and qualitative results. This chapter describes the research design, participants, instructional design, data collection, and researcher's stance.

Research Questions	Data Sources	Analysis Methods
<b>RQ1:</b> To what extent does the computer science intervention influence the computer confidence and computational thinking scores of African American middle school females?	Pre- and post-workshop computer confidence and computational thinking survey scores	Paired samples t-test
<b>RQ2:</b> To what extent do participant characteristics predict the computer confidence and computational thinking scores of African American middle school females?	Pre-workshop and gain computer confidence and computational thinking survey scores, background questionnaire	Stepwise multiple regression
<b>RQ3:</b> How does a computer science intervention influence the attitudes of African American middle school females toward computer science?	Focus group interviews	Content analysis
<b>RQ4:</b> What are the factors that influence the attitudes of African American middle school females toward computer science?	All + HCI activity data	All

Table 3.1: Summary of research questions, data sources, and analysis methods

## 3.2 Research Design

A mixed methods approach was used to explore the attitudes of African American middle school females toward computer science, and identify the factors that influence these attitudes. Mixed methods was selected because it uses both quantitative and qualitative data collection, enabling the strengths of one method to offset the limitations of the other to create a holistic picture. The quantitative component reduces bias interpretations by the researcher, while the qualitative component provides a better understanding of the context by allowing the voices of the participants to be heard [148].

This research uses an embedded mixed methods design, which embeds quantitative or qualitative data collection and analysis within a traditional quantitative or qualitative research design. In this case, the qualitative data is embedded within a quasi-experimental design to enhance the understanding of the attitudes of African American middle school females toward computer science. This type of embedded design, qualitative data embedded within an experimental design, is the most common type found in the literature [148]. This variant of the embedded mixed methods design is referred to as the embedded-experiment variant by Creswell and Clark [148]. In an embedded-experiment design, the qualitative strand can be implemented before, during, and/or after the intervention in an experiment [148]. This research implements the qualitative strand during the experiment to describe the participants' experiences with the intervention and attitudes towards computer science. This essentially makes the qualitative stream both independent and interrelated to the quantitative stream of research. In order to minimize bias with concurrently embedding qualitative data into the intervention, qualitative data were collected through the written responses and physical artifacts produced during the HCI workshop, and through focus group interviews conducted after the participants completed the post-workshop surveys.

### **3.2.1 Quantitative**

Quantitative research is an objective approach that investigates phenomena through statistical techniques. This research used a quasi-experimental pretest-posttest nonequiva-

lent control group design [149]. A quasi-experimental rather than a true experimental design was selected due to an inability to randomly assign individual participants to a group. A between groups design was used, where there were two separate groups. The groups remained intact but were randomly assigned to one of two conditions. According to Gliner and Morgan [150], this research is considered to be a strong quasi-experimental design because of the ability to control for the independent variable by the random assignment of the groups, making it similar to a random experimental design.

This research used workshops to expose primarily African American middle school females to computational thinking practices through two different content domains. One group learned about HCI, while the other group learned about Algorithms. The lack of randomization of the individual subjects in this design did present a threat to internal validity through the possibility of selection bias. Since both groups were administered pre- and post-workshop surveys, an independent samples t-test was used to determine that there was no significant difference between the pre-workshop scores for the HCI and Algorithms groups (See Table D.4 in Appendix D). This removed the selection bias internal validity threat.

### **3.2.2 Qualitative**

Qualitative research is a subjective approach that investigates phenomena through the classification of themes and patterns. The researcher made firsthand observations, and

engaged in activities and interactions as a participant observer. As a participant observer, the researcher was able to experience the phenomenon firsthand, where personal knowledge, impressions, and feelings became a part of the data, and played an intricate role in how the data were interpreted. This firsthand account provides the advantages of a close relationship with participants and deeper contextual insight, where the researcher can learn things that participants are either unaware of or unwilling to report in an interview. However, it does pose the risk of selective perception [151].

In the instance of this research, the observer was immersed as the workshop instructor, developing the perspective of an insider in an adult role. All of the participants were aware that the workshop instructor was a Ph.D. student conducting dissertation research. Although they were aware that they would be learning about computer science, they were not informed of the particular research questions that this research sought to answer. With the exception of the pre- and post-workshop surveys and focus group interviews, the observer tried to minimize overt signs of data collection so that participants felt that the intervention was a typical instructional workshop. During the instructional components of the workshop, data collection was limited to dictated field notes, and the collection of written responses and physical artifacts resulting from workshop activities. The dictated field notes described the participants and the context in which they interacted. The written responses and physical artifacts captured the degree to which the participants were engaged in the activities and assessed their ability to understand concepts presented in the workshop.



Audio recorded focus group interviews were conducted on the last day of the workshops to describe the participants' experiences with the intervention and attitudes toward computer science. Focus groups are open-ended interviews given to a small group that target focused topics [151]. A standardized open-ended interview approach was used to conduct the interviews, where the exact wording and sequence of the questions were determined in advance. This approach ensured that the data were complete from each group, and facilitated the organization and the analysis of the data. Since the standardized open-ended interview approach limits the flexibility and contextual relevance of the interview questions, the informal conversational interview approach was also incorporated as follow-up questions. In an informal conversational interview approach, questions emerge from the immediate context rather than being pre-determined. This provided the ability to capture relevant circumstances. A weakness of the informal conversational interview approach is that it is more likely to be less systematic and comprehensive if specific questions do not naturally arise, and data organization can be difficult. These weaknesses are counterbalanced in the strengths of the standardized open-ended interview approach [151].

### **3.3 Participants**

The population for this research consisted of female middle school students. Crombie and Armstrong [152] found that 11th grade females from an all-female computer science

course report similar levels of computer confidence, intrinsic motivation, and future academic intentions when compared to their male counterparts. However, females in the mixed gender class reported lower computer confidence, intrinsic motivation, and future academic intentions than both males and females from the all-female course. Females from the all-female computer science course also reported significantly less stereotypes regarding computer science being a male discipline [152]. Therefore, an all-female workshop was used to enhance the computer science learning environment and help to reduce any confounding factors affecting perception of females toward computer science.

Participants were selected from two national outreach organizations in the Southeast Hampton Roads area of Virginia using purposive sampling. The specific type of purposive sampling used was criterion sampling, which involves selecting cases that meet some pre-determined criterion of importance [151]. The criterion for sample selection was geographical location, gender, grade level, and ethnicity. These Hampton Roads organizations were selected because they represent a diverse population and already contained summer day programs for the target age group with a non computing-based focus. This provided the unique opportunity to gain access to females who may not be initially interested in computer science, rather than females who would voluntarily sign up for computing-based activities. Five sites from organization A and two sites from organization B participated in the study.

### 3.4 Instructional Design

Surveys distributed by the National Science Foundation indicate a lack of women in computer science [4]. The number of women in computer science are often influenced by their perception of computing, satisfaction with computing [86], and self-confidence [85, 19, 104, 105]. Instructional types of interventions have been used in previous research to address these issues [19, 39]. This research used an instruction-based intervention to gain insight into the attitudes of African American middle school females toward computer science. The purpose of the workshop was to generate an awareness of computational thinking practices through HCI and algorithm instruction.

The ADDIE (Analyze, Design, Develop, Implement, and Evaluate) instructional design model [153] was used to develop the workshop content. In the analysis phase, the problem is defined and specific learning needs are identified. The design phase specifies how learning will occur, and verifies the desired performances and appropriate testing methods. The development phase is the process of producing the course content. The implementation phase is deploying the final course to the target audience. The evaluation phase determines how effective the course was in achieving the identified learning objectives. The ADDIE instructional design model [153] is more of a generic framework that serves as a way to organize common procedures associated with instructional design.

The workshop participants were rising 6th-8th grade primarily African American females, ages 11-13, from diverse socioeconomic backgrounds. The workshop was

designed to accommodate both students with a novice and advanced knowledge of computers. Not all participants were expected to be initially excited about computer science and voluntarily participate, so the workshop was designed to be engaging, realistic, and informative.

The activities came from various websites [154, 155] and were re-purposed to suit the needs of the workshop. The workshops took place at several pre-existing summer camp locations. Since all site locations did not have Internet access, the activities selected did not require Internet access to function. The content was delivered in person, by one instructor, through a variety of mediums such as video, PowerPoint, mobile device, and hands-on activities.

### **3.4.1 Learning Objectives**

The purpose of the workshop was to generate an awareness of computational thinking practices through HCI and algorithm instruction. Therefore, in order to operationalize “awareness,” Bloom’s taxonomy [156, 157] was used to develop behavioral learning objectives. Awareness is the first level of Bloom’s affective domain and is also considered to be the lowest form of knowledge, which is the first level of Bloom’s cognitive domain. This is consistent with Krathwohl’s [157] indication of levels in the the affective domain corresponding with levels in the cognitive domain. The difference between awareness and knowledge is that awareness is merely passively attending to a phenomenon where

knowledge is active recall. Since it is difficult to verbalize awareness behavioral objectives and awareness is a prerequisite for knowledge [157], this workshop utilizes behavioral objectives in the knowledge level of the cognitive domain rather than the awareness level of the affective domain.

The learning objectives were derived from the six computational thinking practices developed by The College Board [60, 158]: connecting computing, developing computational artifacts, abstracting, analyzing problems and artifacts, communicating, and working effectively in teams. These computational thinking practices were used to develop learning objectives for the HCI and algorithm workshops. The learning objectives (LO) are listed below.

1. Connecting Computing

- (a) To identify the impact of computing
- (b) To describe the connections between people and computing

2. Developing Computational Artifacts

- (a) To reproduce an artifact with practical, personal, or societal intent
- (b) To select appropriate techniques to develop a computational artifact
- (c) To use appropriate algorithmic and information-management principles

3. Abstracting

- (a) To state how data, information, or knowledge are represented for computational use
- (b) To identify abstractions

4. Analyzing Problems and Artifacts

- (a) To identify a proposed solution to a problem
- (b) To locate and correct errors

- (c) To describe how an artifact functions
  - (d) To recognize the appropriateness and correctness of an artifact
5. Communicating
    - (a) To describe using accurate and precise language, notation, or visualizations
  6. Working Effectively in Teams
    - (a) To collaborate with other participants

### 3.4.2 Activities

The researcher conducted seven five-day workshops, lasting one hour per day, in order to introduce computer science concepts to middle school females. The overall goal of each workshop was to expose primarily African American middle school females to computational thinking practices through HCI topics or algorithms. One group learned about HCI through user interface design and evaluation, while the other group learned about algorithms. According to Cohoon et al. [32], algorithms are negatively associated with women's share of authorship, with men being much more likely than women to publish in this area. This was contrary to the area of HCI, where women had a greater proportion of authorship than men in the subarea of human factors.

The algorithms workshop was similar to the HCI workshop in that they both were designed for middle school girls as an introduction to computational thinking. They differed in the content being introduced to participants, where the algorithms workshop had a system focus while the HCI workshop had a user focus. Designing both workshops

using the same framework controlled for the “fun factor” of the computer science-based workshops and placed the focus on the significance of the workshop content.

Table 3.2 shows the daily activities of the workshops and the associated learning objectives. Gagné’s Nine Events of Instruction [159] were used as a guide to structure the daily activities of the workshop. These events include gaining attention, informing learner of lesson objectives, stimulating recall of prior learning, presenting stimulus with distinctive features, guided learning, eliciting performance, providing informative feedback, assessing performance, and enhancing retention and learning transfer. However, this research adopted the simplified terminology used by Branch [153]: gain attention, objective, prerequisites, present the content, guided practice, independent practice, feedback, assessment, and closure. Due to the nature of the workshops, all events do not occur everyday nor in the same order that Gagné [159] and Branch [153] present them. The events will be referenced in parentheses as the daily activities are discussed in detail below.

### **Day 1**

The purpose of day 1 was to introduce an overview of computer science to the workshop participants. This first day had the same activities for both the HCI and Algorithms groups. Day 1 was the first time that the researcher/workshop instructor met the participants. The participants were told that the instructor was a computer science Ph.D. student from the Hampton Roads area of Virginia. The workshop instructor was able to

build some initial rapport with the girls, being an African American female who grew up in the same location as the workshop participants.

Day	HCI	Algorithms
1	Introduction Pre-workshop surveys Background discussion Code.org video Discussion about computer science careers (1a, 1b) Assessment questions (1a, 1b)	
2	Day 1 review Introduction to HCI user interface design Group user interface evaluation on iPad (4d) User interface guideline discussion (2b, 4d) Assessment questions (2b, 4d)	Day 1 review Introduction to algorithms First look at algorithm design Peer algorithm evaluation (2b, 4d) Assessment questions (4a, 4b)
3	Day 2 review Abstraction introduction (3a) iPhone social networking user interface prototyping (2a, 6a) Assessment questions (3a)	Day 2 review Deeper look into algorithm design (3a) Introduction to Cargo-Bot app (2c, 6a) Assessment questions (3b)
4	Day 3 review Introduction to POP (Prototyping On Paper) app Group prototyping and iPad integration (2a, 6a, 4d) Prototype presentations (4c, 5a)	Day 3 review Group Algorithm development in Cargo-Bot (6a) Cargo-Bot presentations (4c, 5a)
5	Day 4 review Finish prototype presentations	Day 4 review More practice with Cargo-Bot and presentations
	Post-workshop surveys Focus group interviews	

Table 3.2: Computer science workshop activities with associated learning objectives

The workshop participants then read a description of the research study and verbally assented to participating. The assent script along with the entire Institutional Review Board Package can be found in Appendix A. Next, there was an icebreaker where the participants introduced themselves and answered four questions (gain attention):



- What type of career do you want when you graduate? Why?
- How do you usually use a computer?
- What do you like the most about computers?
- What do you like the least about computers?

The participants were then instructed to complete the pre-workshop surveys found in Appendix B. They were told to be honest and to read each survey item carefully. The instructional aspect of the workshop officially began with an introduction of the learning objectives (objective). All of the discussion topics throughout day 1 of the workshop, unless otherwise stated, came from dotdiva.org [154]. To begin the discussion, participants were asked to provide their own definition of computer science (prerequisites). The instructor then provided a definition of computer science and discussed the differences between computer science and the use of computer applications (feedback). Next, the instructor showed the participants a video produced by code.org [160] (content). The code.org video featured a diverse group of people, of various ethnicities and genders, who spoke about the importance of learning to code. These people included a hip hop/pop band member, a basketball player, and founders and CEOs of popular technology companies such as Facebook and Twitter. Following the video, the instructor had a discussion with the girls about how computer science is more than just programming/coding, how it is a broad field, and how it can be integrated with a lot of other disciplines to be creative and change how people live (content). The instructor also em-

phasized that computer science is open to anyone and that it does not take a specific type of person to pursue a computer science career (content). Next, the instructor discussed the computer science work of several women, of various ethnicities, who were featured on dotdiva.org [154] (content). These women integrated computer science with public safety, robotics and artificial intelligence, science, social networking, and sports. Day 1 concluded with a discussion about the benefits of having a computer science career. Participants also answered the following assessment questions (assessment):

- What are two types of jobs or careers that people in computer science can have? (LO:1a)
- What impact do these jobs or careers have on the world? (LO:1b)

## Day 2-HCI

The purpose of day 2 was to make participants aware of the nature of user interface design. Day 2 began with a review of Day 1 and with participants sharing their responses to the assessment questions asked on day 1 (prerequisite, feedback). Next, the instructor informed the participants of the day 2 learning objectives (objective). The instructional component of day 2 began with an introduction to user interface design and the importance of a good user interface design (content). Then, the participants worked in groups of two or three to evaluate two user interfaces on the iPad (guided practice) (LO:6a). The two user interfaces belonged to apps that were designed to enable students to record

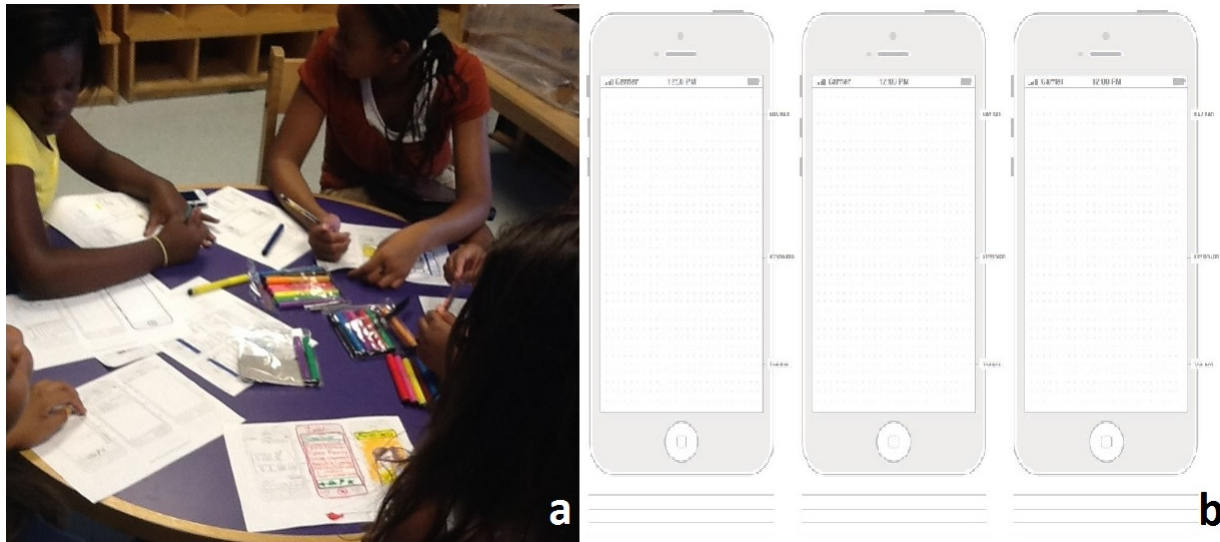


Figure 3.1: Participants paper prototyping (a) and iPhone 5 template [1] (b)

homework assignments [161, 162]. The participants were instructed to use both apps by creating a homework assignment, editing it, and marking it as complete. The groups then shared their likes and dislikes about each user interface and why (LO:4d). Following the evaluation, participants were introduced to the usability principles proposed by Nielsen [163], which included learnability, efficiency, memorability, errors, and satisfaction (content). Based on Nielsen's usability principles, participants suggested changes that could be made to their least favorite user interface to make it better (guided practice) (LO:2b). Day 2 concluded with participants answering the following assessment question (assessment): What are two goals you can have when designing user interfaces? (LO: 2b)

**Day 3-HCI**

The purpose of day 3 was to enable participants to gain experience designing a user interface. Day 3 began with a review of day 2 and with participants sharing their responses to the assessment question asked on day 2 (prerequisite, feedback). Next, the instructor informed the participants of the day 3 learning objectives (objective). The instructional component of day 3 began with a discussion about abstraction in user interface design and prototyping (content) (LO:3a). The lesson put an emphasis on paper prototyping. Paper prototyping has been advocated as a valid HCI design technique for at least 20 years [164]. Still today, even with the advances in prototyping tools, it is considered an effective prototyping mechanism [165]. Participants worked in groups of two or three to create a low-fidelity prototype of an iPhone that included text chat, video chat, and/or audio chat features (independent practice) (LO:2a, 6a). They were reminded to utilize the usability principles that they learned about on the previous day. Participants used paper, pencil, and markers to create a low-fidelity paper prototype of an iPhone app (displayed in Figure 3.1a). The paper contained images of multiple iPhones with blank screens that participants used to design their user interfaces, as shown in Figure 3.1b. Day 3 concluded with the following assessment question (assessment): What is one way that you used or can use abstraction to represented something in your user interface? (LO:3a)



Figure 3.2: POP app screenshots [2]

#### Day 4 and Day 5 Part 1-HCI

The purpose of day 4 was to enable participants to see a realistic portrayal of their user interface designs. Day 4 began with a review of day 3 and with participants sharing their responses to the assessment question asked on day 3 (prerequisite, feedback). Next, the instructor informed the participants of the day 4 learning objectives (objective). For day 4, the instructor showed participants how to use an application available for iOS and Android devices, that brings paper prototypes to life (content).

This application, named POP (Prototyping on Paper) [2], takes advantage of basic, but efficient, tools often used for prototyping, such as pencil and paper. However, pen and paper have interaction distribution limitations associated with the lack of digitalization, with the simulation not occurring on an actual device. POP reduces these limitations

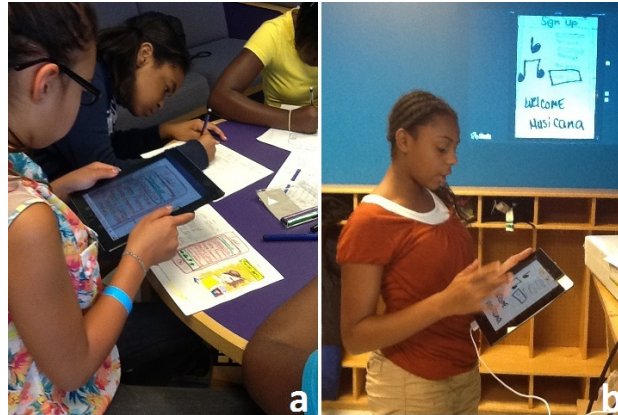


Figure 3.3: A participant using the POP app (a) and a participant presenting their user interface created in POP (b).

by enabling the user to transform their paper designs into digital interactive prototypes. POP has a three step work-flow where the user would design their user interface on paper, take pictures of each user interface screen, and finally, link the pictures together and allow the user to “play” the interface. Figure 3.2 shows several screenshots of the POP app. The front-most screenshot (bottom left) shows several pictures of paper prototypes. The top-right picture shows a picture with “active regions” highlighted in green. These areas are linked by the user to other pictures. When the prototype is “run,” POP then makes the transitions. This gives an illusion of a working app.

Participants spent the remainder of day 4 of the workshop working in their groups to make their paper prototypes interactive, using the POP app on an iPad (independent practice) (LO:2a, 6a). Figure 3.3a shows one of the participants using the POP app. Groups that finished with their interactive prototypes early demonstrated their prototypes for the class (LO:5a), as pictured in Figure 3.3b. Day 4 concluded with participants

answering the following assessment questions (assessment):

- How does your user interface work? (LO:4c)
- What makes it a good user interface (think about the rules: learnability, efficiency, memorability, errors, satisfaction)? (LO: 4d)

The purpose of day 5 was to wrap-up the workshop session. Day 5 began with a review of day 4 and with participants sharing their responses to the assessment questions asked on day 4 (prerequisite, feedback). The groups that did not finish their interactive prototypes spent a few minutes at the beginning of day 5 completing their work (independent practice). Then, the remaining groups who did not present on day 4 presented their interactive prototypes to the other workshop participants (LO:5a).

## **Day 2-Algorithms**

The purpose of day 2 was to make participants aware of the nature of algorithm design. Day 2 began with a review of Day 1 and with participants sharing their responses to the assessment questions asked on day 1 (prerequisite, feedback). Next, the instructor informed the participants of the day 2 learning objectives (objective). The instructional component of day 2 began with an introduction to algorithms (content). Participants were given two different algorithms on how to make a peanut butter and jelly sandwich, and participants discussed which algorithm was better and why (guided practice) (LO:2b). Next, the participants did an activity, based on the CS Unplugged Marching

Orders-Programming Languages activity [155], where they were given an algorithm and asked to use it to draw a picture. After viewing the intended picture resulting from the algorithm, participants discussed how the algorithm could be improved (guided practice, feedback) (LO:4d). Next, participants were asked to select one of two pictures provided on an index card, and create an algorithm telling someone else how to draw that shape without using a picture of the shape as a reference. Then participants exchanged algorithms with another participant who selected a different picture, so that each participant had two algorithms created by two different people. Based on the given algorithm, participants tried to reproduce the picture as shown in Figure 3.4 (independent practice). This activity was also based on the CS Unplugged Marching Orders-Programming Languages activity [155]. After the instructor showed everyone pictures of the correct shapes, participants answered the following assessment questions (assessment):

- Which algorithm do you think is the best one for drawing the picture (write the person's ID number who wrote it)? (LO:4a)
- How would you improve the algorithm you thought was not correct? (LO:4b)

### **Day 3-Algorithms**

The purpose of day 3 was to introduce participants to designing efficient algorithms to accomplish a goal. Day 3 began with a review of day 2 and with participants sharing their responses to the assessment questions asked on day 2 (prerequisite, feedback). Next,



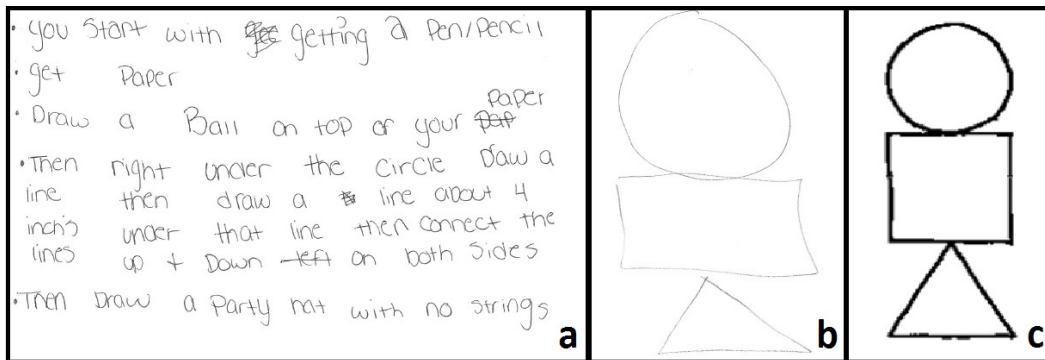


Figure 3.4: An algorithm created by a participant (a), the resulting picture that another participant produced (b), the intended outcome of the algorithm (c).

the instructor informed the participants of the day 3 learning objectives (objective). The instructional component of day 3 began with a discussion about algorithm efficiency and abstraction (content) (LO:3a). Then, the instructor introduced the Cargo-Bot [3] iPad app, within the context of algorithm efficiency and abstraction, to participants (content).

Cargo-Bot is a game that is designed to teach algorithmic thinking and programming concepts. The goal of the game is to tell a robot arm how to move colored boxes around on a platform, using commands provided in a toolkit to duplicate a goal pattern. A screenshot of the Cargo-Bot game is displayed in Figure 3.5. With each level, more programming concepts, such as conditional statements and looping, are introduced and the game becomes more challenging. In order to accomplish a goal, one must think like a computer. The game requires one to think logically and be able to abstract details away. Like a computer, game-play in Cargo-Bot has very little margin for error, so one little typo can have severely unintended results. Once an error occurs, which can range from a box being placed in the wrong location to the robot arm crashing into an object,

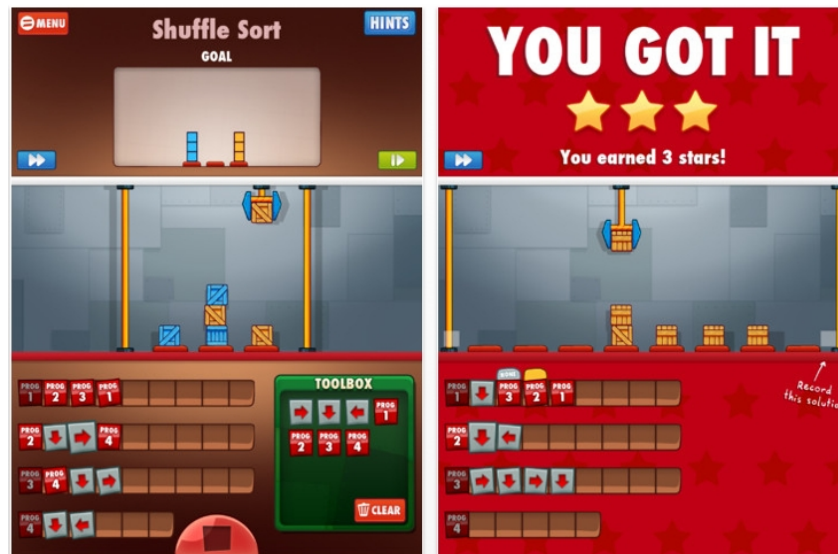


Figure 3.5: Screenshots of the Cargo-Bot iPad app [3].

one has to debug the algorithm in order to correct the error and accomplish the goal. In addition to being goal oriented, Cargo-Bot encourages players to create optimized algorithms by providing one star for accomplishing the goal and up to two additional stars for optimization, as displayed in Figure 3.5.

Following the introduction to Cargo-Bot, participants worked in groups to accomplish the goals of the game (LO:2c, 6a). The instructor often assisted participants as Cargo-Bot introduced new concepts (guided practice). At the end of day 4, participants were given two screen shots of a Cargo-Bot algorithm and were asked the following assessment question (assessment): Which algorithm uses abstraction? (LO:3b)

**Day 4 and Day 5 Part 1-Algorithms**

The purpose of day 4 was to enable participants to gain experience designing an algorithm to accomplish a goal. Day 4 began with a review of day 3 and with participants sharing their responses to the assessment question asked on day 3 (prerequisite, feedback). Next, the instructor informed the participants of the day 4 learning objectives (objective). On day 4, participants continued working in groups to accomplish the goals of the Cargo-Bot game (LO:6a). The groups worked independently, with assistance provided by the instructor as needed (independent practice). If a group received three stars on a goal that other groups struggled to accomplish, they would present their solution to the other group and show them the steps they took to accomplish the goal (LO:4c, 5a).

The purpose of day 5 was to wrap-up the workshop session. The groups spent a few minutes at the beginning of day 5 completing more levels in the Cargo-Bot game (independent practice). As levels were completed with three stars, groups presented their Cargo-Bot algorithm solutions to their peers.

**Day 5 Part 2**

The second half of day 5 was the same for both the HCI and Algorithms groups. Participants were informed of the high school coursework they should take in order to prepare to major in computer science. Then participants were instructed to complete the post-workshop surveys. Again, they were told to be honest and to read each survey item

carefully. The workshop concluded with focus group interviews.

## **3.5 Data Collection**

This section discusses the instrumentation used to collect data and other data sources in the study. A background questionnaire was given to participants prior to the study, to be completed at home. It was completed by the parents/guardians of the participants along with the signed permission form, and returned to the instructor during the study. Both the Computer Confidence Survey and the Computational Thinking Survey were given to participants on the first and the last day of the workshop. Focus group interviews were conducted on the last day of the workshop, after the activities and post-workshop surveys were completed. Written responses and physical artifacts generated from the HCI workshop activities were also data sources.

### **3.5.1 Participant Background Information**

The background questionnaire was completed by the parents/guardians of the participants. It contained one fill in the blank question requesting the child's age, and eight multiple choice questions. The multiple choice questions asked the child's grade level, ethnicity, types of computer devices they use at home, availability of Internet access at home, the highest education level completed by the child's mother and father, the child's free/reduced lunch status, and the child's school grades. The background questionnaire

can be found in Appendix B.

### 3.5.2 Computer Confidence Survey

The Computer Confidence subscale of Loyd and Gressard's Computer Attitude Scale (Appendix B) [143, 144, 145] was used to measure computer confidence. The Computer Attitude Scale consists of forty items that are divided into four subscales: Computer Anxiety, Computer Confidence, Computer Liking, and Computer Usefulness. Each subscale consists of ten items that are rated on a 4-point Likert scale ranging from "Strongly Agree" to "Strongly Disagree." The items of each subscale include both positively and negatively worded items that are distributed throughout the instrument [144].

The Computer Attitude Scale originally was a 30 item instrument consisting of only three subscales: Computer Anxiety, Computer Confidence, and Computer Liking. The scale was originally rated on a 6-point Likert scale ranging from strongly agree to strongly disagree. When it was administered to 155 8th-12th grade students, the alpha coefficient reliability for each subscale was .86 (Computer Anxiety), .91 (Computer Confidence), and .91 (Computer Liking) [143]. When the Computer Attitude Scale was administered to 114 K-12 teachers with ages ranging from 23-60, the number of items increased to forty with the addition of the Computer Usefulness subscale. Also, the original 6-point Likert used to rate the items was changed to a 4-point Likert scale. The alpha coefficient reliability for each subscale were .90 (Computer Anxiety), .89 (Computer Confidence), .89

(Computer Liking), and .82 (Computer Usefulness) [144]. The Computer Attitude Scale that was administered to 561 seventh and eighth grade students only used the Computer Anxiety, Computer Confidence, and Computer Liking subscales. The alpha coefficient values were .90 (Computer Anxiety), .89 (Computer Confidence), and .89 (Computer Liking) [145].

Wu [146] used the Computer Confidence subscale to measure the Computer Self-efficacy of 441 fifth and seventh grade students. The instrument was rated on a 5-point Likert scale. Two of the ten items in the subscale were removed during data analysis because data revealed that the items may have not have been worded clearly or may have been inappropriate for the age group. These items included "Generally, I feel OK about trying something new on the computer" and "I am sure I could learn a new computer programming language (like Logo or Java)." Wu [146] also changed the two items worded "would do" to "could do" to coincided with Bandura's self-efficacy theory, and slightly modified the wording of other questions to make them age appropriate. The resulting alpha coefficient reliability was .83. Although reliable, Wu's modifications do not change the wording of every question to coincide with the way Bandura says they should be worded when evaluating self-efficacy [147].

Loyd and Gressard [143] indicated that the high reliability subscales for each of the coefficients suggest that the subscales are sufficiently stable enough to be used as separate scores. Since the original instrument is proven to be reliable and Wu's modifications did not base the wording of every question on Bandura's framework [147], this

research used Loyd and Gressard's [143] 4-point Computer Confidence subscale to measure Computer Confidence. When administered to the thirty-seven 6th-8th grade girls, the Cronbach's alpha for the ten items were .75, which indicates a reasonable internal consistency.

### 3.5.3 Computational Thinking Survey

The Computational Thinking Survey (Appendix B) is a thirty item survey developed specifically for this study. The ratings are on a 4-point scale ranging from "Strongly Agree" to "Strongly Disagree." The survey design is based on Bandura's Social Cognitive Theory of Self-Efficacy framework [147] and the five computational thinking practices developed by The College Board [158]. Self-efficacy, or "people's beliefs in their capabilities to produce given attainments" [147], is domain specific and varies in magnitude. Therefore, it cannot be measured with a generic test because the scale must be specific to the domain of interest. It is important that knowledge of the domain is clearly defined and that self-efficacy scales link to the various components of a domain so that the scale can assess the multifaceted ways that self-efficacy operates within the domain [147]. Specific domains, like computational thinking, can be broken up into multiple practices such as connecting computing , developing computational artifacts, abstracting, analyzing problems and artifacts, communicating, and working effectively in teams [60, 158]. Each computational thinking practice was represented by five items on the survey to make it specific to the computational thinking domain. Computational thinking practices

were used to minimize the technical details of computer science in the items and focus on computer science concepts in which middle school students can relate. The phrasing of the survey items were also based on Bandura's framework [147]. To ensure that capability was measured rather than intention, the items were phrased in terms of "can do" rather than "will do," as recommended by Bandura [147].

### **Validity**

The Computational Thinking Survey was validated using content and criterion-related validity. Content validity is the extent to which the content represents the domain being evaluated [166, 167]. Content validity was established through the computational thinking literature [60, 158]. The computational thinking practices are divided into sub-components and learning objectives. These sub-components and learning objectives were used to identify the practical components of the computational thinking practices in order to create survey items. Content validity was also established through reading level. To ensure that the reading level was age-appropriate, survey items were reworded until the Flesch-Kincaid Grade Level was a grade level 5.

Criterion-related validity demonstrates the accuracy of a measure by comparing it with another measure that has demonstrated to be valid [166, 167]. This usually involves establishing a correlation coefficient between the instrument and the external outside criterion [150]. The concurrent form of criterion-related evidence was used, where the criterion-related data are gathered nearly at the same time that the instrument is



administered [168]. The Computer Confidence Survey [143, 144, 145] described in the previous section was used as a criterion to measure criterion-related validity, since the Computational Thinking Survey was based on Bandura's framework [147]. Confidence and self-efficacy are related in that they both refer to belief in one's capabilities, but self-efficacy is the belief in one's capabilities to achieve a desired outcome [42]. There was a significant correlation between the computational thinking and the computer confidence survey scores ( $r=.572, n=37, p<.01$ ).

### **Reliability**

Internal consistency reliability, which determines the consistency among items within the instrument through a single administration, was used to establish reliability. Cronbach's Alpha is the recommended method for instruments with all multiple choice items to determine internal consistency or inter-item reliability [150]. The reliability of the instrument is considered high if it has a reliability coefficient score above .80 [150]. When administered to thirty-seven 6th-8th grade girls, the Cronbach's alpha for the thirty items were .91, which indicates a good internal consistency.

### **3.5.4 Focus Group Interviews**

Focus group interviews were conducted with participants on the last day of the workshop. With the standardized open-ended interview approach, interview questions were

determined in advance. The standardized open-ended interview approach was also subsidized with the informal conversational interview approach to improve flexibility and contextual relevance. The interview questions are listed below.

- What do think about the workshop?
- What did you like the most about the workshop?
- What did you like the least about the workshop?
- What do you think will make the workshop better?
- What did you think about computer science before the workshop?
- What did you think about computer science after the workshop?
- Do you think that computer science is important? Why or why not?
- What did you think about working with your group?
- Would you recommend this workshop to a friend?
- Would you like to learn more about computer science?
- Do you want a computer science career? Why or why not?

### 3.5.5 HCI Activities

Written responses and physical artifacts, that resulted from the user interface evaluation and the user interface design activities, were used as data sources. During the user interface evaluation activity, participants worked in groups to review two iPad apps that were designed to organize homework assignments [161, 162]. They were then asked to record what they liked the most and least about each app. After learning about user interface design principles, they were asked to write down the name of their least favorite app, and how they would change it to make it better based on the user interface design principles. During the user interface design activity, the participants worked in groups to create paper-prototypes of an iPhone social networking app. These social networking paper prototypes contained multiple iPhone screens that represented various states of the user interface.

## 3.6 Researcher's Stance

As a participant observer, the role of the researcher will be discussed to acknowledge any personal beliefs or biases. The researcher designed the workshop content, was the instructor in both the HCI and Algorithms workshops, distributed and collected the surveys, and facilitated the focus group interviews. Unfortunately, limited resources prevented having the benefits of additional workshop instructors and focus group interview facilitators. With a strong background in HCI, it is natural for the researcher to portray

more excitement for one domain than the other. Therefore, the researcher had to make a conscious effort to design both workshops to be engaging and fun, and to display equal levels of excitement towards both domains in the classroom. The researcher also had a lot in common with the participants, being an African American female who grew up in the same geographical location as the participants in the study. She also was often referred to as being or looking young.

### **3.7 Summary**

This research used a mixed methods approach to explore the attitudes of African American middle school females toward computer science, and identify the factors that influence these attitudes. The study participants were primarily African American middle school female summer day camp attendees, in the Southeast Hampton Roads area of Virginia. Using the ADDIE instructional design model, two computational thinking workshops were developed that focused on HCI topics and Algorithms. Quantitative and qualitative data were collected from multiple sources, such as a background questionnaire, a Computer Confidence Survey, a Computational Thinking Survey, focus group interviews, and written responses and physical artifacts generated from the HCI workshop activities. The next chapter will discuss how the data were analyzed.

# Chapter 4

## Results

### 4.1 Introduction

This chapter presents the quantitative and qualitative results. Data were collected through five sources: a background questionnaire, Computer Confidence Survey, Computational Thinking Survey, focus group interviews, and the written responses and physical artifacts derived from the HCI workshop activities. Quantitative data were analyzed through inferential statistics while qualitative data were analyzed using content analysis.

## 4.2 Participant Background Information

A total of seventy-three girls participated in the workshops. The parents/guardians of thirty-seven of those workshop participants signed consent forms, enabling them to participate in the research study. The research study participants consisted of primarily African American middle school females, ages 11-13, who attended the summer camps of two national outreach organizations located in the Southeast Hampton Roads area of Virginia. Among the participants, 81.1% were African American, 2.7% were Native American, 2.7% were Asian, and 13.5% were of multiple ethnicities. Table D.1 in Appendix D provides further details concerning the characteristics of the participants.

## 4.3 Computer Confidence and Computational Thinking

Participants completed the Computer Confidence and the Computational Thinking Surveys on the first and the last day of the workshop. There were exceptions for six participants, who completed the post-workshop survey on day 4 because they knew they would be absent on the last day of the workshop. Pre-workshop data were collected from thirty-seven participants and post-workshop data were collected from thirty-two participants. This difference is due to five participants not attending the last day of the workshop where the post-workshop surveys were administered. The survey data were analyzed using inferential statistics in SPSS. An alpha level of .05 was used for all statistical tests.

Descriptive statistics for the Computer Confidence and Computational Thinking Surveys are shown in Tables D.2 and D.3 in Appendix D.

### 4.3.1 Handling Missing Data

When completing the Computer Confidence and Computational Thinking Surveys, several participants left some survey items incomplete. Little's MCAR (Missing Completely at Random) chi-square statistic [169] was run to determine if participants accidentally, rather than randomly, missed survey items. The results indicated that  $p=.462$ . Since  $p>0.05$ , the null hypothesis ( $H_0$ ) that the data is missing completely at random cannot be rejected. With the data being missing completely at random, Expectation-Maximization (EM) [170], a general method for obtaining Maximum Likelihood (ML) estimates when data is missing, was used to impute fifteen missing data points.

### 4.3.2 Pre- and Post-Workshop Survey Score Comparisons

A paired samples t-tests was used to see if there was a significant difference between the pre- and post-workshop survey scores for the Computer Confidence instrument, and the pre- and post-workshop survey scores for the Computational Thinking instrument. Shapiro-Wilk test (see 4.1) and Normal Q-Q plots (see Figures D.1, D.2, D.3, D.4, D.5, and D.6 in Appendix D) were used to assess the normality assumption of six sets of raw scores in Table 4.1. The plots revealed that all six sets of raw scores tended to follow a normal

distribution.

		Shapiro-Wilk		
		Statistic	df	Sig.
All	Pre-workshop Computer Confidence	.964	32	.358
	Post-workshop Computer Confidence	.967	32	.409
	Pre-workshop Computational Thinking	.966	32	.409
	Post-workshop Computational Thinking	.972	32	.549
HCI	Pre-workshop Computer Confidence	.962	20	.582
	Post-workshop Computer Confidence	.946	20	.306
	Pre-workshop Computational Thinking	.967	20	.694
	Post-workshop Computational Thinking	.970	20	.748
Algorithms	Pre-workshop Computer Confidence	.980	12	.982
	Post-workshop Computer Confidence	.948	12	.609
	Pre-workshop Computational Thinking	.973	12	.939
	Post-workshop Computational Thinking	.955	12	.715

Table 4.1: Test of normality of pre- and post-workshop survey scores

Since the data were normally distributed, a paired samples t-test was used to compare the computer confidence and computational thinking pre- and post-workshop survey scores. The results are shown in Table 4.2. Effect size was also calculated using Cohen's  $d$  [171]. Cohen [171] sets a benchmark of a small ( $d=0.2$ ), moderate ( $d=0.5$ ), and large ( $d=0.8$ ) effect size, but warns that these benchmarks are relative and should be grounded in the context of the effect, such as the measurement instruments and the general norms of the research area [172]. The overall pre-workshop computational thinking survey scores were significantly less than ( $p<0.01$ ) the post-workshop survey scores. In order to fur-



ther investigate the main effect, separate paired samples t-tests were run for both the HCI and Algorithms groups. The pre-workshop computational thinking survey scores for the HCI group were significantly less than ( $p < 0.05$ ) the post-workshop survey scores. Both significant pairs (2 and 4) represent a moderate practical significance ( $d = .554$  and  $d = .605$  respectively) according to Cohen [171]. There was no significant difference between the pre- and post-workshop computer confidence survey scores.

			N	Mean	Std. Dev.	Std. Error	t	df	Sig. (2-tailed)	Cohen's d	Post-hoc Power
ALL	Pair 1	Post-workshop CC	32	32.44	4.892	.865	1.204	31	.238	.213	.215
		Pre-workshop CC		31.44	5.605	.991					
	Pair 2	Post-workshop CT	32	93.28	14.514	2.566	3.136	31	.004**	.554	.859
		Pre-workshop CT		85.41	17.387	3.074					
HCI	Pair 3	Post-workshop CC	20	32.00	5.321	1.190	1.839	19	.082	.411	.415
		Pre-workshop CC		30.10	6.129	1.371					
	Pair 4	Post-workshop CT	20	90.35	14.773	3.303	2.705	19	.014*	.605	.728
		Pre-workshop CT		82.60	17.291	3.866					
ALG	Pair 5	Post-workshop CC	12	33.17	4.196	1.211	-.375	11	.715	-.108	.064
		Pre-workshop CC		33.67	3.869	1.117					
	Pair 6	Post-workshop CT	12	98.17	13.231	3.819	1.659	11	.125	.479	.329
		Pre-workshop CT		90.08	17.244	4.978					

Table 4.2: Paired samples t-test of pre- and post-workshop survey scores

Note: ALG=Algorithms, CC=Computer Confidence, CT=Computational Thinking

\*\*  $p < .01$ , \*  $p < .05$

### 4.3.3 Participant Characteristics and Survey Score Predictions

Stepwise multiple regression was performed for four cases. Each of the pre-workshop and gain survey scores were the dependent variables, and the four cases used the partic-

participant characteristics as the independent variables (see Table 4.3). The gain survey scores were calculated by subtracting the post-workshop survey scores from the pre-workshop survey scores.

Case	Dependent Variable	Independent Variables
1	Pre-workshop Computer Confidence	Desktop, Laptop, Tablet, Smart Phone, Video Game Console, Other Device, Home Internet, Father's Education, Mother's Education, Socioeconomic Status, School Grades
2	Gain Computer Confidence	
3	Pre-workshop Computational Thinking	
4	Gain Computational Thinking	

Table 4.3: Stepwise multiple regression analysis variables

In Case 1, stepwise multiple regression was conducted to evaluate whether any participant characteristics could be used to predict pre-workshop computer confidence survey scores. The prediction model contained two of the eleven predictors, and was reached in two steps with no variables removed. The model was statistically significant,  $F(2, 28)=7.666$ ,  $p<.01$ , and accounted for approximately 31% of the variance of pre-workshop computer confidence survey scores (Adjusted  $R^2=.308$ ). Pre-workshop computer confidence survey scores were predicted by a lower socioeconomic status and higher school grades. The regression coefficients of the predictors are shown in Table 4.4. Socioeconomic status accounted for approximately 27% of the variance of pre-workshop computer confidence survey scores, beyond the variance accounted for by school grades. School grades accounted for approximately 26% of the variance of pre-workshop computer confidence survey scores, beyond the variance accounted for by socioeconomic sta-

tus.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	32.765	1.280		25.589	.000**
	Socioeconomic Status	-4.122	1.905	-.373	-2.163	.039*
2	(Constant)	25.294	2.696		9.381	.000**
	Socioeconomic Status	-6.002	1.789	-.543	-3.354	.002**
	School Grades	1.954	.640	.494	3.051	.005**

Table 4.4: Stepwise multiple regression analysis coefficients (Case 1)

Note: Dependent Variable: Pre-workshop computer confidence survey scores,  $n=31$

\*\*  $p < .01$ , \*  $p < .05$

In Case 2, stepwise multiple regression was conducted to evaluate whether any participant characteristics could be used to predict gain computer confidence survey scores. The prediction model contained three of the eleven predictors, and was reached in three steps with no variables removed. The model was statistically significant,  $F(3, 22)=9.943$ ,  $p < .001$ , and accounted for approximately 52% of the variance of gain computer confidence survey scores (Adjusted  $R^2=.518$ ). Gain computer confidence survey scores were predicted by a higher socioeconomic status, lower school grades, and the use of a smart phone at home. The regression coefficients of the predictors are shown in Table 4.5. Socioeconomic status accounted for approximately 30% of the variance of gain computer confidence survey scores, beyond the variance accounted for by the other two predictors. School grades accounted for approximately 23% of the variance of gain computer confidence survey scores, beyond the variance accounted for by the other two

predictors. Smart phone use at home accounted for approximately 17% of the variance of gain computer confidence survey scores, beyond the variance accounted for by the other two predictors.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.133	1.049		-1.080	.291
	Socioeconomic Status	5.497	1.613	.571	3.408	.002**
2	(Constant)	4.321	2.332		1.853	.077
	Socioeconomic Status	6.346	1.491	.659	4.256	.000**
	School Grades	-1.387	.542	-.396	-2.558	.018
3	(Constant)	3.680	2.163		1.701	.103
	Socioeconomic Status	5.642	1.406	.586	4.013	.001**
	School Grades	-1.605	.508	-.459	-3.162	.005**
	Smart Phone	3.213	1.410	.334	2.278	.033*

Table 4.5: Stepwise multiple regression analysis coefficients (Case 2)

Note: Dependent Variable: Gain computer confidence survey scores,  $n=26$

\*\*  $p < .01$ , \*  $p < .05$

In Case 3, stepwise multiple regression was conducted to evaluate whether any participant characteristics could be used to predict pre-workshop computational thinking survey scores. There was no discernible linear relationship between pre-workshop computational thinking survey scores and any of the participant characteristics  $F(11, 19)=1.153$ ,  $p=.378$ , and accounted for approximately 5% of the variance of pre-workshop computational thinking survey scores (Adjusted  $R^2=.053$ ).

In Case 4, stepwise multiple regression was conducted to evaluate whether any participant characteristics could be used to predict gain computational thinking survey scores. The prediction model contained two of the eleven predictors, and was reached in two steps with no variables removed. The model was statistically significant,  $F(2, 23)=6.717$ ,  $p<.01$ , and accounted for approximately 31% of the variance of gain computational thinking survey scores (Adjusted  $R^2=.314$ ). Gain computational thinking survey scores were primarily predicted by a higher mother's education and the use of a video game console at home. The regression coefficients of the predictors are shown in Table 4.6. Mother's education accounted for approximately 11% of the variance of gain computational thinking survey scores, beyond the variance accounted for by video game console use at home. Video game console use at home accounted for approximately 21% of the variance of gain computational thinking survey scores, beyond the variance accounted for by mother's education.

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-7.491	5.950		-1.261	.219
	Mother's Education	4.652	1.683	.491	2.765	.011*
2	(Constant)	-15.813	6.752		-2.342	.028*
	Mother's Education	4.148	1.586	.438	2.616	.015*
	Video Game Console	12.321	5.723	.361	2.153	.042*

Table 4.6: Stepwise multiple regression analysis coefficients (Case 4)

Note: Dependent Variable: Gain computational thinking survey scores,  $n=26$

\*\*  $p<.01$ , \*  $p<.05$

## 4.4 Focus Group Interviews

Content analysis was used to analyze the data obtained from twenty-six focus group interview participants. Audio recordings of the focus group interviews were transcribed verbatim in a Microsoft Excel [173] document. Inductive processes were used to analyze the interview transcripts [151, 174]. Inductive analysis, which involves discovering patterns, themes, and categories in the data, guided the creation of a codebook for content analysis [151].

### 4.4.1 Creation of the Codebook

Four cycles of coding were done in order to create a codebook to guide the qualitative analysis. The codebook sections were based on Macqueen et al.'s [175] work, which contained a column stating the codes, a brief and full definition, inclusion and exclusion criteria, and example text. However, the inclusion and exclusion criteria were only indicated for code definitions with anticipated ambiguity, due to the context of the interview transcripts. The first cycle of the coding process began with "Open Coding" where the transcripts were broken down into discrete parts. This was done by highlighting coding segments in the participant's own voice. Next, "Descriptive Coding" [176, 177, 178, 179] was used to summarize segments of text in a word or short phrase to form topics. Finally, some descriptive codes were combined with "Magnitude Coding" [176, 178] to refine the topics, suggesting the direction of a particular phenomenon. Magnitude codes were posi-

tive (+), negative (-), or neutral, which excluded the symbolic prefix. The resulting words and short phrases became the foundation of the codebook. The codebook is shown in Table C.1 in Appendix C. Forty-two codes were generated, with twenty-four of those codes being unique codes when magnitudes were excluded.

#### 4.4.2 Coding Scheme Validation

A total of four coders, including the researcher, were used to validate the coding scheme. Three of the coders were computer science undergraduate students who participated as part of a service learning course requirement. The coders were instructed to read two documents. The first document described the daily activities of the computer science workshops to put the transcript content into context. The second document, obtained from an online course, introduced them to coding qualitative data [180]. We also met to review the codes and their definitions. The coders were provided with 667 units in an Microsoft Excel [173] spreadsheet to code individually using the coding manual. Examples of the coding units are found in Figure C.1 in Appendix C. Following the individual coding sessions, the researcher met with each coder to discuss their experiences and any discrepancies.

Intercoder reliability was calculated following the debriefing session, where the coded transcripts were reviewed by the coders for errors. Krippendorff's *alpha* ( $\alpha$ ) is "the most general agreement measure with appropriate reliability interpretations in content

analysis" [181]. This statistic is applicable to any number of values per variable, any number of observers (coders), both small and large sample sizes, supports several scales of measurement, and accommodates for missing values.

Hayes and Krippendorff's SPSS Macro [182, 183], KALPHA, was used to calculate Krippendorff's *alpha* [181]. Krippendorff's *alpha* calculated a reliability of  $\alpha=0.7213$ . When magnitudes were excluded from the codes, the reliability was  $\alpha=0.7324$ . According to Krippendorff [181], reliabilities above  $\alpha=0.800$  are very reliable. The lowest conceivable limit is  $\alpha=0.667$ . Anything between  $\alpha=0.667$  and  $\alpha=0.800$  can draw tentative conclusions and can still be acceptable. Therefore, the  $\alpha$  obtained is an acceptable value.

### 4.4.3 Emerging Themes

As a result of the coding, six themes emerged that provide insight into the attitudes of primarily African American middle school girls and how the workshop influenced these attitudes. These themes included perceptions of computer science, collaboration, workshop activities, computer science and the real world, empowerment, and future plans in computer science.

#### Perceptions of Computer Science

There were eighteen participants who expressed the perceptions they had about computer science before the workshop. They either reported that they had a negative percep-



tion of computer science before the workshop or did not really know what it was. There were differences in the types of opinions participants had based on their socioeconomic backgrounds. Participants from low socioeconomic backgrounds generally considered computer science to be boring before the workshop and one participant thought it was for “geek people.” Participants from higher socioeconomic backgrounds also believed that computer science was boring. However, they made additional statements like computer science was “nerdy” or “for nerds,” “hard,” and “pretty stupid.” One participant said that “at first, I thought computer science was going to be like really hard and you have to be like super smart and stuff for it.”

Before the workshop, there were seven participants who misunderstood or did not know what computer science was about. Four participants from low and medium/high socioeconomic backgrounds associated computer science with doing the traditional sciences, like life sciences, on the computer, and also associated it with math. One participant stated “I thought it was going to be like a bunch of math and junk, and like you gotta type it into a computer and make some stuff.” Of the participants who misunderstood what computer science was about, two participants stated that computer science was “boring” and “pretty stupid.” A few participants from low socioeconomic backgrounds admitted to not knowing anything about computer science.

There were eighteen participants who expressed the perceptions they had about computer science after the workshop. A majority of the participants had positive perceptions of computer science after the workshop. Participants described the workshop

as “fun,” “cool,” “exciting,” “easy,” “important,” and “not boring.” Three of the seven participants who did not know about computer science, or misunderstood what it was, indicated that they knew what it was about. One participant stated “I think of it as like doing programs and stuff, and getting to know the computer.” Three participants had a negative perception of computer science after the workshop, with two saying that it can “sometimes be hard.” One participant from the Algorithms group thought that computer science was too rigid, stating “I...just don’t want to hear people telling me like, you have to do this, you have to do that in order to be right. I don’t want no body telling me that.” However, all participants who had negative perceptions of computer science after the workshop indicated that they also had positive perceptions of computer science after the workshop, were interested in learning more about computer science, and/or were interested in a computer science career.

### **Collaboration**

There were twenty participants who spoke of their experiences working in a group with their peers. A majority of the participants enjoyed working in their groups, saying that it was “helpful,” “fun,” “great,” “awesome,” “encouraging,” and “a good experience.” Those who thought it was helpful referred to the work getting done quicker with statements like “you can get more work through faster and quicker, and it won’t be no rush.” Others who thought it was encouraging told how they supported one another, stating that “we all listened to each other and supported each other, and helped each other if we

had bad answers” and “when I didn’t know the answers, I could always like ask someone for the answers.” While one participant had fun working in their group, they stated that “at the same time, if they don’t cooperate, we not gone have, we not gone have the team effort.”

There were four participants who indicated a lack of “team effort” or displeasure with team members. Half of these participants were in the HCI group and the other half were in the Algorithms group. Social dynamics were the reasons for the negative collaboration experiences in the HCI group. One participant indicated that “my partner, she tried to hold my iPad...and she didn’t think I could use it so she had hauled the iPad from me but I had got it back though” while the other stated that “most people got annoying.” The lack of ability for teammates to work together to accomplish the goals of the activity was the reason for the negative collaboration experiences in the Algorithms group. One participant stated that “my partner didn’t help me none at all” while another participant stated that “people didn’t catch up quick enough.”

### **Workshop Activities**

There were twenty participants who stated their opinions about the workshop activities. Of those participants, seventeen had positive opinions of the workshop activities. They enjoyed “looking at the videos,” “using the iPad,” “playing the Cargo-Bot game,” “taking pictures,” “answering questions,” and “the slide show.” Ten of the participants with positive opinions of the workshop activities revealed evidence of feeling a sense of ac-

complishment. Participants spoke of how they “made their own apps,” “made a social network,” “put programs together,” “controlled the robots,” “handled computers,” and “told the computer what to do.”

There were eight participants with negative opinions of the workshop activities. A majority of those with negative opinions did not like the research aspect of the workshop (e.g. completing the surveys and writing for data collection) and the workshop activities that were not very interactive (e.g. the introduction, looking at the screen). Others did not like some aspects of the interactive activities such as “writing because I don’t know how to draw” and the algorithm design activity on day two of the Algorithms workshop. Both of these activities also involved writing. Five of the participants who had negative opinions, also had positive opinions of the workshop activities. Two of the five participant indicated a sense of accomplishment.

### **Computer Science and the Real World**

There were eight participants who indicated that they were able to connect computer science to the real world. Participants thought that computer science was useful, as revealed in the following statements:

- “It helps scientists, and it helps firefighters, and it helps police officers, and other people in the world.”
- “Like if you have a job, and its like really important, and you gotta give like a pre-

sentation, you can do like visual aid, like you can touch it and make sure that its professional and stuff.”

- “It is a way to chat and communicate with other people.”
- “It can get us farther places in life and we can go to better colleges and stuff.”

They also made references to robots helping people with statements like “it [computer science] helps us go back into the past in some ways and it can always help with things in the future like robots pads and stuff, and mechanical houses and stuff, and robots that can do everything for you that might take over the world.”

### **Empowerment**

There were eight participants who revealed a sense of empowerment after the workshop. A majority of the participants believed they could create something after the workshop, as indicated by the following statements:

- “You can create a lot of things for other people to use like for school, and you can create apps and stuff.”
- “I can make a dance game, Michael Jackson owww!”
- “I can download this on my iPad at home and make my own apps, and maybe one day will come true.”

- “I think one day somebody, I might make another Facetime, Facetime 2.”
- “I want to make something like all the kids, all like the preteen kids and all, like just like Facebook, but its like more like you can endurance morelike you can, like everybody experience it.”

Some participants spoke about the ability to do computer science, stating that they “learned that anybody can do computer science” and “like you can actually want to be a computer science technologist and try to make like some more apps and more things.” Other participants spoke about being able to troubleshoot computer problems on their own, with statements like “if you like need help with computers you just can do it on your own self” and “now when I go home, if I ever have trouble on the computer, I have more of a feeling of what to do.” There were also participants who referenced learning, saying “if you want to learn about computer science you can do it now” and “if they have a class about computers at my school, I am definitely going to sign up for it...if they don’t have a class, I am going to make them give us a class.”

### **Future Plans in Computer Science**

There were seventeen participants who expressed their willingness to learn more about computer science and/or have a computer science career. Of the seventeen participants, ten participants indicated that they were interested in learning more about computer science and six participants said that they might be interested in learning more about com-

puter science. When asked if they wanted a computer science career, four participants wanted a career in computer science, three participants were considering a career in computer science, and two participants did not want a career in computer science. Both of the participants who did not want a computer science career did say that they wanted to learn more about computer science.

## **4.5 HCI Activity Findings**

In the HCI workshops, data were generated from the user interface evaluation and the user interface design activities. The participants completed these activities in groups of two to three people. The following sections describe the outcomes of these activities based on written responses and content analysis of the physical artifacts.

### **4.5.1 User Interface Evaluation**

There were eighteen groups, two to three girls each, who participated in the user interface evaluation activity. The assignment was to identify strengths and weakness of the user interfaces of two iPad apps designed to record homework assignments [161, 162], and associate them with usability principles. Prior to learning about usability principles, participants wrote what they liked and disliked about each app.

Their likes and dislikes focused on several usability principles, including learn-

ability, efficiency, memorability, overall satisfaction (e.g. aesthetics, features), and errors. When evaluating learnability, the groups liked apps that were “easy,” “simple,” “self-explanatory,” and “didn’t take long to figure out.” They disliked apps that were “hard to use,” “frustrating,” “confusing,” “complicated,” with “no directions,” and those that caused them to be “delayed figuring it out.” The participants liked that one of the apps had “less steps,” which made it efficient. One group disliked how they didn’t remember things very well. The groups were satisfied with apps that were “fun,” “helpful,” “cool,” and “nice,” and were dissatisfied with apps that were “boring.” Regarding aesthetics, participants liked the color, font, organization, and the way the app was setup. They disliked the boring look and how the keyboard blocked the input box. Although the app looking plain was both a like and a dislike, most of the groups did not like the plain look of one of the apps. Since participants were evaluating apps designed to record homework assignments, the features that they liked and disliked were related to this context. Participants liked the ability to record homework, mark it as complete, add notes, review assignments, add subjects, set reminders, set a due date, and keep stuff up to date. The groups disliked the inability to edit assignments, mark assignments as complete, and the fact that an upgrade was required to get additional features. The inability to edit assignments also applies to errors because the participants wanted to be able to edit the assignment if they made a mistake, instead of being forced to delete the assignment and start over.

After recording their likes and dislikes about the apps, participants learned



about five usability principles: learnability, efficiency, memorability, errors, and satisfaction. They were then asked to select their least favorite app, tell what they would change about it to make it better, and name the appropriate corresponding usability principle. For example, if a group's least favorite app did not allow them to edit homework assignments and they wanted to change it, they would associate it with the errors usability principle. The groups correctly associated the characteristics that they disliked about their least favorite app with all of the usability principles except memorability, which they did not mention.

#### **4.5.2 User Interface Design**

There were nineteen groups, of two to three girls each, who participated in the user interface design activity. The participants were only instructed to create a low-fidelity prototype of an iPhone app that included text chat, video chat, and/or audio chat features. Participants were encouraged to use abstraction when designing their user interfaces in order to alleviate the pressure that may be associated with having to draw detailed objects, due to the varying drawing abilities of the participants. However, some groups went above and beyond the assigned instructions in an effort to make their apps appear as realistic as possible. The resulting user interface design prototypes were analyzed using content analysis in order to identify themes. The themes that emerged were personalization, attention to detail, and consideration of social implications.

## Personalization

All nineteen groups personalized their apps by naming them. These names were inspired by three main categories: functionality, existing applications, and personal interests. Other categories included apps named based on the target audience and apps that used a theme. The list of app names with their associated categories can be found in Table 4.7. The app name, “Musicana,” is an existing app that does not have any social networking features; therefore, it was listed in two categories.

Categories	App Names
Functionality	“Lets Talk,” “Fun Chat App,” “U Talk,” “Text Live,” “Chat Buddy,” “VTV App” (Voice, Video, Text App)
Existing applications	“Instaface,” “Insta-kik,” “InstaBook,” “Talk-Time,” “Facetime,” “ooVoo.com,” “Mypage.com,” “Mingle,” “Musicana”
Personal interest	“Musicana,” “Fashion Killa”
Audience	“Kids Meet”
Theme	“Chirp Messaging” where contacts were called “Chirpers”

Table 4.7: HCI activity social networking app names divided by category

## Attention to Detail

There were eighteen out of nineteen groups that used varying levels of abstraction when creating their user interface designs. All groups, to some degree, followed the iPhone template guides that indicated the location of the navigation bar, keyboard, and tab bar. Although participants were encouraged to use abstraction, some used it more than others.

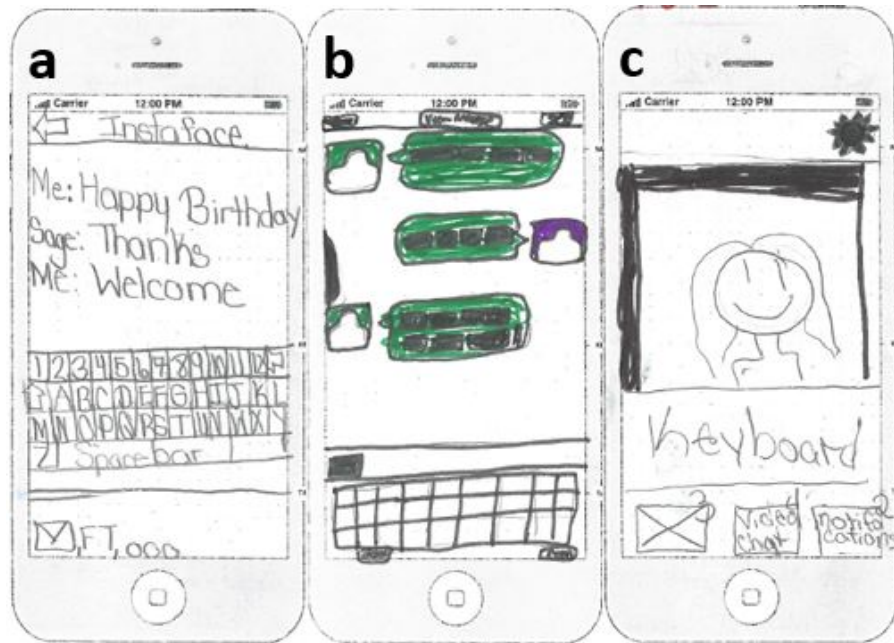


Figure 4.1: Low (a), medium (b), and high (c) levels of abstraction when representing the iPhone keyboard

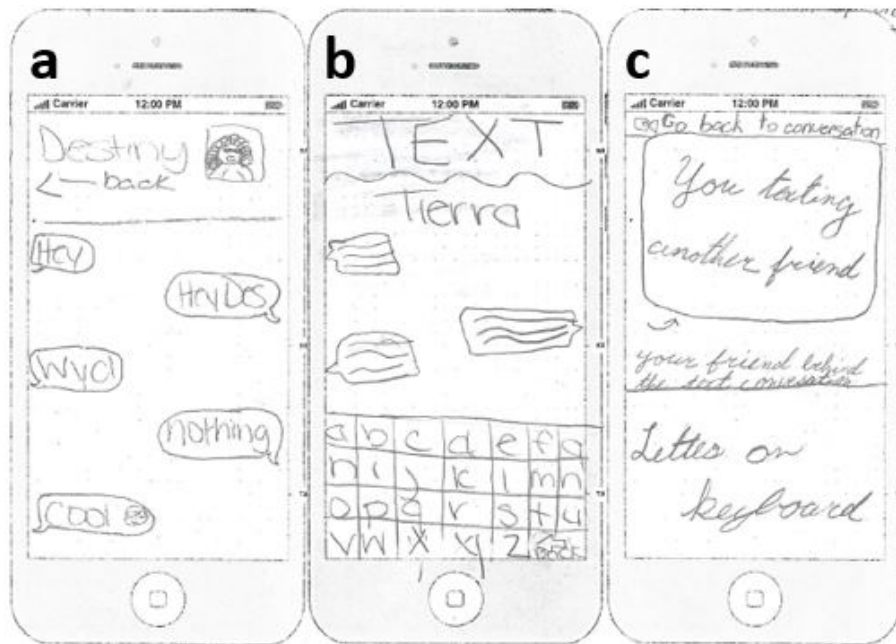


Figure 4.2: Low (a), medium (b), and high (c) levels of abstraction when representing text



Figure 4.3: Low (a), medium (b), and high (c) levels of abstraction when representing people

Those who chose not to use much abstraction did more work but their prototypes looked more realistic. The areas in which the groups varied in the levels of abstraction used included drawings of the iPhone keyboard, text, and people.

Figures 4.1, 4.2, and 4.3 show examples of varying levels of abstraction used in each area. In Figure 4.1, abstraction is defined by the representation of buttons and text on the keyboard. Writing actual alphanumeric characters on the keyboard is considered a low level or lack of abstraction (Figure 4.1a). Drawing an outline of the buttons on the keyboard is considered a medium level of abstraction (Figure 4.1b). Drawing only a general area to represent the keyboard, with no details, is considered to be a high level of abstraction (Figure 4.1c). In Figure 4.2, abstraction is defined by the representation

of the text-based features, like text chatting, on the user interfaces. The use of actual alphanumeric characters when representing lines of text indicates a low level or lack of abstraction (Figure 4.2a). A medium level of abstraction uses squiggly lines or some other way to represent lines of text (Figure 4.2b). A user interface that only has a label stating where text should be located is considered to be a high level of abstraction (Figure 4.2c). In Figure 4.3, the level of abstraction is defined by the amount of detail depicted in images of people. Very detailed images of people represent a low level or lack of abstraction. Figure 4.3a depicts a detailed hairstyle, jewelry, and background objects. Drawings of people with generic features and clothing indicate a medium level of abstraction (Figure 4.3b). A high level of abstraction uses stick figures to represent people (Figure 4.3c). Although the levels of abstraction used by each group were not exclusive, a majority of the groups generally chose to use a low level of abstraction when designing their user interfaces.

### **Consideration of Social Implications**

There were seventeen out of nineteen groups that took social implications into consideration when designing their user interfaces. The participants thought about how people would gain access to their app, additional features, troubleshooting, safety, and satisfaction. To help people gain access to their app, one group advertised that the app was available to use on multiple devices and specified where the app could be downloaded, while another group created a screen with a button to download their app. A few groups also indicated the price of their app. The additional features that groups represented in

their user interfaces were account registration/sign-in, user profiles, editing, searching, language options, emoticons, and an ignore button for incoming chats. For troubleshooting, a few groups either provided usage instructions for their apps or incorporated a help button into their designs. One group incorporated a background check button into their design, indicating that they thought beyond the immediate tangible aspect of the design process and thought about the safety of the users of their app. To evaluate user satisfaction and to advertise the results to other potential users, a group added rating stars to the download screen of their app.

## **4.6 Summary**

This chapter discussed the results of the quantitative and qualitative data analysis. Quantitative results were obtained from the background questionnaire, Computer Confidence Survey, and the Computational Thinking Survey. The quantitative data analysis revealed that there was a significant difference between the pre- and post-workshop computational thinking survey scores. When divided by workshop type, the difference between the pre- and post-workshop computational thinking survey scores were only significant for the HCI group. Quantitative analysis also revealed that socioeconomic status and school grades were predictors of pre-workshop computer confidence survey scores, and socioeconomic status, school grades, and smart phone use at home were predictors of gain computer confidence survey scores. Predictors of gain computational thinking sur-

vey scores were the mother's education and video game console use at home.

Qualitative results were obtained from focus group interviews, and the written responses and physical artifacts derived from the HCI workshop activities. The analysis of the focus group interviews revealed six themes among workshop participants. These themes included perceptions of computer science, collaboration, workshop activities, computer science and the real world, empowerment, and future plans in computer science. The analysis of the written responses derived from the user interface evaluation activity revealed that the participants were able to identify the strengths and weaknesses of two iPad app user interfaces, and associate them with usability principles. The physical artifacts showed evidence of participants deeply engaging in the user interface design activity, building upon existing knowledge to create social networking app prototypes. The prototypes display evidence of personalization, attention to detail, and consideration of social implications. The following chapter will present a discussion of the results and conclusions.

# Chapter 5

## Discussion and Conclusions

### 5.1 Introduction

This chapter presents the research discussion and conclusions. It will discuss how the research findings answer the following research questions:

1. To what extent does the computer science intervention influence the computer confidence and computational thinking scores of African American middle school females?
2. To what extent do participant characteristics predict the computer confidence and computational thinking scores of African American middle school females?
3. How does a computer science intervention influence the attitudes of African Amer-



ican middle school females toward computer science?

4. What are the factors that influence the attitudes of African American middle school females toward computer science?

Prior research will be discussed in relation to the answers to the research questions. Finally, this chapter will present the areas for further study, the conclusions, and recommendations for educators.

## 5.2 Revisiting the Research Questions

This section answers the research questions and discusses how they are related to prior research. Research question 1 discusses the differences between the pre- and post-workshop computer confidence survey scores, and the pre- and post-workshop computational thinking survey scores. It also shows how the results differ by the intervention content domain. Research question 2 provides insight into the characteristics that can be used to predict computer confidence survey scores and computational thinking survey scores. Research question 3 focuses on the influence of the workshop on the attitudes of African American middle school females toward computer science. Research question 4 identifies the factors that influence the attitudes of African American middle school females toward computer science.

### 5.2.1 Research Question 1

The computer science intervention had no significant influence on the computer confidence survey scores, and had a positive significant influence on the computational thinking survey scores of African American middle school females. When the computational thinking survey scores were divided by content domain, only the HCI workshop had a positive significant influence on the computational thinking survey scores of African American middle school females. Although the difference between the pre- and post-workshop computational thinking survey scores of the algorithms group were nonsignificant, it can be stated that the computer science intervention either had little to no influence on the computational thinking survey scores of African American middle school females or it had a negative influence.

### 5.2.2 Research Question 2

Socioeconomic status, mother's education, school grades, and the use of mobile phones and video game consoles at home were predictors of the computer confidence survey scores and computational thinking survey scores of African American middle school females. Participants from low socioeconomic backgrounds and who had higher grades were predicted to have greater computer confidence survey scores before the workshop. Participants from medium/high socioeconomic backgrounds, with lower grades, and who used a smart phone at home were predicted to have greater gains in computer con-

confidence survey scores after the workshop. Study participants whose mother had a higher level of education and who used a video game console at home were predicted to have greater gains in computational thinking survey scores after the workshop.

### **Computer Confidence**

Prior to the workshop, the participants' socioeconomic status and school grades influenced computer confidence scores. Participants from low economic backgrounds were predicted to have greater computer confidence survey scores before the workshop. This finding is consistent with the participant statements in the focus group interviews. In the post-workshop focus group interviews, the participant responses about their perceptions of computer science before the workshop were primarily divided along the lines of their socioeconomic background. While participants from low socioeconomic backgrounds generally thought that computer science was boring or admitted to not knowing what it was, several participants from medium/high socioeconomic backgrounds believed that computer science was hard before the workshop.

Bandura [42] speaks of a similar phenomenon in his discussion on vicarious learning, where those without much of a model to base their perception on will tend to positively approach unfamiliar situations. Bradley et al. [184] also speaks of parental modeling and found that parental modeling was negatively correlated with crowding (a high ratio of persons living in the household to number of rooms in the home), and positively correlated with income and mother's education, for African American fami-

lies. This indicates that those from low socioeconomic backgrounds may be less likely to model their parents when compared to those from higher socioeconomic backgrounds, supporting the findings in this study. Furthermore, according to Bradley et al. [184], having access to a cognitively stimulating learning materials is negatively correlated with crowding, and positively correlated with income and mother's education in African American families. They also found that, in African American families, income and mother's education are positively correlated with having access to a variety of experiences [184]. This reveals that participants from medium/high socioeconomic backgrounds were more likely to have some type of exposure to computer science prior to the workshop. However, knowledge of their experiences or their models are beyond the scope of this research.

Participants with higher grades were predicted to have greater computer confidence before the workshop. Good grades are evidence of performance accomplishments. Bandura [42] states that past successes or performance accomplishments positively influences how people feel about themselves and approach situations.

The participants' socioeconomic status, school grades, and whether or not they used a smart phone at home influenced the gains in computer confidence survey scores after the workshop. Those participants from medium/high socioeconomic backgrounds and those with lower grades were predicted to have greater gains in computer confidence survey scores after the workshop. This indicates that participation in the workshop served as an equalizer, leveling the playing field. The workshop gave those from medium/high socioeconomic backgrounds other models (e.g. workshop instructor and

peers), while facilitating an environment where participants with lower school grades could have performance accomplishments. Evidence of performance accomplishments were found through the analysis of the focus group interview transcripts. Participants used action words to describe the workshop activities. For example, they stated that they “made” their own apps, “made” a social network, “put” programs together, “controlled” the robot, “handled” computers, and “told” the computer what to do. Participants who used a smart phone at home were predicted to have gains in computer confidence survey scores after the workshop. Smart phones are a very specific application of technology associated with fun and games, and very relatable to the African American community. African Americans actually use mobile phones more often than non-minorities [11].

### **Computational Thinking**

The workshop participants’ mother’s education and whether or not they used a video game console influenced the gains in computational thinking survey scores after the workshop. Workshop participants whose mother had a higher level of education were predicted to have greater gains in computational thinking survey scores after the workshop. Mother’s education is positively correlated with parental modeling in African American families [184]. This demonstrates the significant role that parents, especially mothers, play in the lives of adolescents. Meszaros [185] along with other researchers [73, 68, 74, 66, 67, 68, 69] found that mothers have an influence on their daughter’s career choice. Participants who used a video game console at home were predicted to have

greater gains in computational thinking survey scores after the workshop. Like with mobile phone use, African Americans also spend more time playing video games than non-minorities [11]. The data collected from the focus group interviews revealed that the participants were able to connect computer science to their everyday devices after the workshop. Statements like “I can make a dance game,” “I might make another facetime,” and “I can download this on my iPad at home and make my own apps, and maybe one day will come true,” revealed evidence of empowerment within the workshop participants.

### **5.2.3 Research Question 3**

The computer science workshop had a positive influence on the attitudes of African American middle school girls. The primary ways in which it influenced their attitudes were that it reduced the negative stereotypes that participants had toward computer science, it empowered participants to do independent computer science work, it enabled participants to make a connection between computer science and the real world, and it enabled participants to consider learning more about computer science and/or consider pursuing a computer science career.

### **Reduction of Negative Stereotypes**

During the post-workshop focus group interviews, participants voiced the stereotypes they had about computer science. Their perceptions of computer science before the workshop tended to be divided along the lines of socioeconomic background. Participants from low socioeconomic backgrounds generally thought that computer science was boring, just like traditional math and science, or they had no idea what it was before they were exposed to it through the workshop. While participants from medium/high socioeconomic backgrounds also thought that computer science was boring and/or just like traditional math and science, they had additional negative preconceived notions about computer science. Before the workshop, participants from medium/high socioeconomic backgrounds also thought that it was “for nerds” or “kinda nerdy,” “gonna be hard,” “really hard,” and “pretty stupid.” These negative stereotypes that the participants had toward computer science are found in the literature [94, 19, 101, 102, 103, 83]. Similar differences in those from low socioeconomic backgrounds and those from medium/high socioeconomic backgrounds are also found in the answer to research question 2. It may also be explained by the participants from low socioeconomic backgrounds more positively approaching unfamiliar situations due to a lack of a model to base their perceptions on [42, 184]. Those from low socioeconomic backgrounds also are less likely to have access to cognitive stimulating learning materials and a variety of experiences [184].

Exposure to computer science through the workshop balanced perceptions about

computer science between the participants from different socioeconomic backgrounds, with a majority of the participants indicating that they had positive perceptions of computer science after the workshop. They thought that computer science was “fun,” “important,” “cool,” “exciting,” “easy,” and “interesting.” Although a majority of participants from both socioeconomic groups had positive perceptions about computer science after the workshop, a few participants indicated that computer science was too rigid or said that “some stuff was hard.” All of the participants who had negative perceptions of computer science after the workshop indicated that they also had positive perceptions of computer science after the workshop, were interested in learning more about computer science, and/or were interested in a computer science career.

### **Connection of Computer Science and the Real World**

The workshop participants were able to make a connection between computer science and the real world. Their statements ranged from the role of computers in their present lives to visualizing computers and their place in the future. A participant viewed computer science as “a way to chat and communicate with other people.” The perception of computer science as a form of communication motivates women to enter computer science [35]. Looking toward her professional future, a participant stated that computer science “can get us farther places in life and we can go to better colleges and stuff.” Another participant indicated that software generated by computer scientist can provide a visual aide, making a presentation look more professional. Indicating how computer sci-



ence can be used to assist those in other occupations, a participant stated how computer science “helps scientists, and it helps firefighters, and it helps police officers, and other people in the world.” Another participant visualized the future of computer science doing everything for people and taking over the world through robots. This indicates that participants saw the relevance of computer science to their everyday lives.

### **Empowerment**

The participants showed evidence of being empowered and inspired to do independent computer science work and displayed evidence of plans to continue an education in computer science. Participants indicated that becoming a computer scientist is obtainable and that “anybody can do computer science.” Participants spoke of creating a game, social networking apps, and other apps that people can use for purposes such as school. They also stated that they were confident in their abilities to learn more about computer science and troubleshoot their own problems. This indicates that the workshop did play a role in increasing the participants’ confidence to do computer science work.

### **Future in Computer Science**

The majority of participants who responded to questions about a future in computer science either considered learning more about computer science or were interested in a computer science career. While most of the participants still had other career interests, they stated that computer science could be a backup plan. This shows that at a minimum,

participants began to consider computer science to be a viable option for their futures as a result of the workshop.

#### **5.2.4 Research Question 4**

There were four main factors that influenced the attitudes of African American middle school females toward computer science. These factors, largely determined by the answers to research questions 1-3, included the participation in an intervention, the intervention content domain, the facilitation of performance accomplishments, and participant characteristics.

##### **Participating in an Intervention**

In this research, participating in an intervention (the workshop) positively influenced the participants' attitudes toward computer science. It reduced the negative stereotypes that participants had toward computer science. Participants were able to make a connection between computer science and the real world. It empowered participants and inspired them to do independent computer science work. The intervention also resulted in participants entertaining the idea of learning more about computer science and/or pursuing a computer science career.

### **Intervention Content Domain**

The intervention contained two different content domains, HCI and Algorithms. These two content domains tended to differ in terms of their influence on the participants' computational thinking survey scores and in the challenges to collaboration that participants experienced. The HCI user interface design and evaluation domain had a positive significant influence on the participants' computational thinking survey scores, while the Algorithms domain did not significantly influence computational thinking survey scores. Although participants in both domains had challenges in collaboration, the challenges of participants in the Algorithms content domain were directly related to the workshop activity. However, the challenges to collaboration in the HCI content domain were related to the social dynamics of the groups.

The differences in the survey results and collaboration experiences of participants in the HCI and Algorithms content domains may be attributed to ineffectual use of preexisting skills versus skill deficits, as described by Bandura [42]. In the HCI group, participants were able to utilize preexisting skills, such as drawing, and their familiarity with technology. Although the Algorithms group was also familiar with the technology, applying algorithmic thinking to a computer device is a skill that many were first introduced to during the workshop. Challenges to participants in the HCI group reflected an ineffectual use of preexisting skills, while challenges to participants in the Algorithms group reflected a skill deficit. According to Bandura [42], those with an ineffectual use

of preexisting skills perform better by convincing them that they have what they need to succeed. The focus group interview results indicate that participants in the HCI workshop were positively influenced by encouragement provided by both the instructor and their peers. Evidence of encouragement was not revealed in the responses of the Algorithms workshop participants.

The lack of self-reported encouragement in the Algorithms workshop participants may be due to the different needs of those with skill deficits. While some participants were able to complete levels in the Cargo-Bot game, there were others who were unable to overcome the challenges because they were unable to make a connection between existing knowledge and the skills required to successfully complete the tasks in the game. Since the required skill set is not directly related to the preexisting skills that the participants had, greater attention to scaffolding in the instructional design would have been useful to teach new skills within the context of pre-existing skill sets. Bandura [42] states that those with skill deficits perform better when they are convinced that they are capable of acquiring the necessary skills and when the activity is structured in scaffolded steps to ensure early successes rather than repeated failures. In the Algorithms group, some participants experienced early successes while others did not. This was made apparent when participants stated that “people won’t getting it like I was getting it,” “people didn’t catch up quick enough,” and “my partner didn’t help me.” Participants who did not experience early successes indicated that they liked the Cargo-Bot game [3] the least, saying they “hate[d] it” and it was “confusing.” In this case, as indicated by Bandura [42],

persuading students of their capabilities took more than positive appraisals and required a more scaffolded approach.

**Scaffolding in Algorithms** The integration of scaffolding posed a challenge due in part to the nature of the Algorithms domain and workshop activity. In algorithms, the computer either accomplishes the desired task or it does not. If it does not accomplish the desired task, it could be difficult for a novice to fix the errors. If it does accomplish the desired task, a new challenge presents itself to ensure that the algorithm is the most efficient. Solutions are essentially black and white, right or wrong, with little or no room for creativity. A participant indicated in the focus group interviews that she was aware of this rigidity in Algorithms when she stated “[I] just don’t want to hear people telling me like, you have to do this, you have to do that in order to be right. I don’t want nobody telling me that.” This notion was demonstrated in the Cargo-Bot game [3] that the participants played. The robots moved the carts to the correct location without hitting anything when the algorithm worked correctly. Once participants accomplished this task, they often faced the other challenge of earning three stars for their algorithm. Earning three stars indicated that the algorithm was the most efficient for accomplishing the goal. Even with the success of creating the correct algorithm, they faced failure if they did not earn three stars for efficiency. There was an attempt to provide scaffolding through the activity on day 2, where participants had to reproduce a picture based on an algorithm provided by their peers. This activity was designed to teach participants how to breakdown in-

structions into small components. Their peers, in turn, would act like computers, with no logic, and follow each instruction step-by-step. This was designed to demonstrate the sensitivity of computers to the instructions provided by humans. However, the success of the algorithm design activity did not translate into the success of the Cargo-Bot game [3], where the sources of the errors were more difficult to find and fix for the novice participants.

**Scaffolding in HCI** Unlike with Algorithms, scaffolding in HCI was better facilitated because the activity was somewhat open-ended and participants were able to transfer their existing drawing and technology skills (e.g. knowledge of using a social media app) to designing an iPhone app using the iPad. The user interface evaluation activity was designed to make participants aware of the nature of user interface design in order to provide the participants with the technical guidelines in which they needed to design their own social networking app prototypes. The prototyping lesson began with a discussion about abstraction in user interface design and prototyping. Participants worked in groups to create a low-fidelity prototype of an iPhone that included text chat, video chat, and/or audio chat features. They were reminded to utilize the user interface design principles they learned about the previous day. In addition to giving participants pencils and markers, participants were also given paper that contained images of multiple iPhones with blank screens (see Figure 3.1) that they used to design their user interfaces. The template contained guides for the navigation bar, keyboard, and tab bar, along with

a grid for guidance and accuracy. These iPhone design templates were provided to help the participants visualize an actual phone and to guide the participants in drawing the appropriate shapes and sizes of the iPhone components. With an understanding of the technical aspects of usability and design, participants were free to focus on creativity during the user interface design activity. The addition of using the POP app [2] on the iPad enabled participants to further visualize their designs, evaluate them, and make revisions if desired.

The data obtained from the HCI activities revealed that the activities were successful. Even before participants became aware of the usability principles introduced in the workshop, they demonstrated that they had some understanding of usability concepts through the likes and dislikes that they identified in each app. The participants' likes and dislikes were associated with four of the five user interface design principles. These included learnability, efficiency, satisfaction, and errors. When evaluating learnability, participants spoke of how easy or hard the app was to use. Efficiency was evaluated in terms of the number of steps it took to complete a task. Satisfaction focused on the usefulness, aesthetics, features, and overall enjoyment of using the app. When evaluating errors, participants focused on their ability to correct their mistakes by editing an assignment they created in the app. After formally learning about the five user interface design principles, participants were able to correctly associate the characteristics they disliked about their least favorite app with the correct usability principles. When designing their social networking prototypes, participants did not appear to be caught

up in the technical nuances of drawing and incorporating social networking features into their apps. Instead, they went above and beyond the instructions given to them to make their apps appear as realistic as possible. This included personalizing their apps by giving them names, giving attention to detail by minimizing the use of abstraction, and by letting a consideration of social implications inspire the addition of extra features to their apps. This indicates that the concept of usability came somewhat natural to participants through building upon their familiarity with using apps and their existing knowledge of recording homework assignments. Then, building upon the participants' newfound awareness of usability principles, and their familiarity with drawing and social networking, they were able to successfully design a prototype of a social networking app in a short amount of time. The HCI activities presented computer science as a form of communication, provided participants with an opportunity to be creative, and provided the ability to apply computer science to societal concerns, which are all factors that the literature says motivates women to pursue computer science careers [35, 36, 106, 19]. Scaffolding minimized challenges and freed the participants to think outside of the box when completing the activities.

### **Facilitation of Performance Accomplishments**

According to Bandura [42], successfully completing the assigned tasks can be the most influential source of self-efficacy information. Within the context of this research, the tasks were creating a prototype of a social networking application and solving problems in the



Cargo-Bot game. The main task for the HCI group was to create a low-fidelity prototype of a social networking app using the POP app [2]. The Algorithms group played the Cargo-Bot game [3], where they had to duplicate a goal pattern by providing the robot with the appropriate instructions for moving colored boxes on a platform.

There are several factors that can facilitate or hinder performance accomplishments, including the adequacy of the resources available and assistance provided by others [42]. In this research, performance accomplishments were facilitated by technology resources provided to do the assignments (e.g. the iPads) and by getting assistance from others through working in groups.

A majority of the participants mentioned how much they enjoyed using the iPads, with some indicating that their favorite part of the workshop was using the iPads. One participant stated “I didn’t even like it [the workshop] until we got on the iPads,” while another participant stated “it [the workshop] started getting fun cause we started working with the iPads.” The iPads made the workshop “fun,” “nice,” and “exciting,” according to participants.

The technology enabled the participants to connect design to computer science. This was revealed when the participants referred to the activity as “putting programs together,” and referred to their user interfaces as social networking “apps” rather than just drawings on sheets of paper or a collection of pictures. In the algorithms group, participants not only enjoyed using the iPads, they believed that the iPad technology could be used as a motivator to get their peers interested in the workshop. The technology

helped the participants to visualize the robot receiving and following instructions. The participants were able to understand concepts of the game, such as “how you pick up the block and move it to the next” and “how we really had to be specific on how we did the game.” They were also able to translate the concept of controlling the robot to “handling computers” and “telling the computer what to do.” The use of the iPads enhanced the participants’ abilities to understand concepts and accomplish the assigned tasks in both groups.

Participants were instructed to work in small groups, where they were able to receive assistance from peers. A majority of the participants enjoyed working in groups, describing the experience as “fun,” “good,” “great,” “awesome,” and “encouraging.” Participants also thought collaborating with their peers was very helpful, realizing that it assisted in their performance accomplishments. They indicated that “when I didn’t know the answers, I could always like ask someone for the answers.” Group members “listened to each other,” “supported each other,” “shared ideas,” “helped each other if we had bad answers,” and made “something with all of our ideas.” This enabled participants to “get stuff done quicker,” get “a lot done,” and do “a good job.” However, collaborating with peers did not always facilitate performance accomplishments. There were instances when “people got annoying,” “partners didn’t listen to ideas,” and when partners did not provide assistance when needed. In these instances, the lack of assistance from peers may have hindered performance accomplishments.

### **Participant Characteristics**

The participant characteristics, including socioeconomic status, mother's education, school grades, and the use of mobile phones and video game consoles at home, influenced their attitudes toward computer science through their computer confidence survey scores and computational thinking survey scores. Additionally, socioeconomic status also influenced the participants' perceptions of computer science before the intervention, as indicated by the focus group interview analysis results. The perceptions of those from low socioeconomic backgrounds were either nonexistent or negative; however, they were not as critical as those from medium/high socioeconomic backgrounds. Those from low socioeconomic backgrounds may have also had a more positive approach to the intervention [42, 184].

### **5.3 Interesting Research Directions**

There are opportunities for further work in four areas. First, further research can investigate how to incorporate scaffolding into the Algorithms content domain and make the activities open-ended. This will provide the Algorithms content domain with a structure and openness that already exists at the foundation of the HCI user interface design and evaluation content domain. Second, the research findings suggest that participants from medium/high socioeconomic backgrounds may have had preexisting models in which they based their negative attitudes about computer science on. Further research can in-

investigate the models that children from medium/high socioeconomic backgrounds tend to follow in relation to computer science, and the types of computer science exposures they typically have prior to and during middle school. Third, the attitudes of the mothers of African American middle school girls toward computer science should be investigated due to the influence that mothers have on the career choice of their daughters. Finally, it would be interesting to implement a long term study with African American middle school girls and follow them through high school to see if attitudes towards computer science change and learn when they stabilize.

## 5.4 Conclusions

This research investigates the attitudes of African American middle school girls toward computer science and the factors that influence these attitudes. While there is literature dedicated to attracting and retaining women in computer science, it tends to focus on White women, which leaves the voices of Black or African American women unheard. This is unfortunate since Black or African American women are pursuing computer science careers at even smaller rates than White women. Reporting on this understudied population is what makes this research significant.

The research study revealed that introducing African American middle school girls to computer science through user interface design and evaluation produces good outcomes. The user interface design and evaluation activities built upon the existing

knowledge and interests of the participants. The participants were already users of mobile devices, knew how to draw, were familiar with recording homework assignments, and were interested in social networking. The interface design and evaluation activities taught the participants a new way to combine and utilize their existing skill set. With a foundation based on preexisting skills, performance accomplishments were obtainable for participants. These performance accomplishments are a source of self-efficacy [41], which can lead to increased interest in computer science. The interface design and evaluation activities also facilitated the understanding of computer science concepts. Understanding computer science concepts came somewhat natural to the participants through their existing skill set. However, the activities built upon existing knowledge to refine these computer science concepts and provide a context for using these concepts. The successes found in the HCI-related activities of user interface design and evaluation were pretty consistent with other studies [39, 186]. However, unlike the study conducted by Craig and Horton [186], the HCI-related component of this study received better reception by the study participants than the other computer science topic taught in the intervention.

The home life of African American middle school girls is influential in their attitudes toward computer science. The factors of socioeconomic background and mother's education influencing attitudes are consistent with existing literature [66, 67, 68, 69, 78]. These factors can be equated to degrees of exposure to different experiences [184]. While one would expect those with more experiences to initially have more positive attitudes to-

ward computer science, that is not necessarily the case with this demographic. This is inconsistent with literature that states that those from high socioeconomic backgrounds are more likely to choose male dominated occupations and have high self-efficacy expectations [78]. At home, computer science may not necessarily be encouraged in the homes of African American middle school girls from privileged backgrounds. However, this group does benefit the most from computer-related interventions. Perhaps, this is because they began with more negative attitudes initially when compared to their counterparts from underprivileged backgrounds. School grades also were a factor and consistent with current literature [75, 76, 77]. Father's education did not appear to be a factor. Although this is inconsistent with older literature [70, 71], it is consistent with more current work [66, 67].

The use of video games and smart phones at home positively influences African American middle school girls' attitudes toward computer science. Smart phone use appearing as a factor is consistent with the literature stating that women, regardless of race are the most intense cell phone users [187]. Since the literature states that males are the most intense video game players regardless of race [187], it was a bit surprising that video games were also revealed as a factor for the African American middle school female study participants. This indicates that perhaps, African American females play video games more than their White female counterparts. Additionally, playing video games were found to be a negative predictor of academic performance in the literature [187]. However, playing video games were beneficial to the self-reported beliefs of the

participants in this study. Video games and smart phones are key to attracting African Americans, who often use these devices [11], to computer science. Therefore, the type of device does not matter as much as using a device that people often interact with and enjoy using in order to attract them to computer science. Using devices in an intervention, in which participants are most familiar, aids in the scaffolding process where new skills are learned within the context existing skill sets.

Generally, African American middle school girls have the same attitudes toward computer science as other women discussed in the literature. Before any formal intervention, the study participants thought that computer science was “boring,” “difficult,” and “for nerds.” This is consistent with what other studies have found when primarily studying White women [102, 103, 83]. One stereotype found in the literature, that was not really apparent in the African American female study participants, was that computer science was only for males. When it was revealed in the workshop that some girls thought computer science was only for boys, one participant was quite surprised and did not consider that way of thinking to be rational. Since the gender-role aspect was not the focus of this study, definite conclusions cannot be drawn. However, literature that explored self-esteem in middle school girls found differences between African American, White, and Hispanic girls [24]. They found that the self-esteem of African American middle school girls is high and the same as their male counterparts throughout middle school. In White middle school girls, self-esteem declines between 6th-8th grade and is lower than their male counterparts. The self-esteem of Hispanic middle school girls is low throughout

middle school and is lower than their male counterparts. This indicates that there are differences between middle school girls based on ethnicity.

## 5.5 Recommendations

Based on the results of this study, there are several avenues educators can take to increase the interest of African American middle school girls in computer science.

- Actively recruit African American middle school girls from uncommon sources such as community and religious organizations.
  - Educate parents about computer science, especially mothers.
  - The sooner the intervention is offered, the better.
  - Integrate interventions into existing, non computer science focused, organizations.
- Meet the African American middle school girls where they are (scaffolding, use familiar topics, technology).
  - Teach them how to re-purpose the technology they are most familiar with (smart phones, video game consoles, etc.).
  - Start by having participants use existing skills to mimic existing familiar applications, and build from there.



- Use the embedded structure of HCI as a model when introducing other computer science concepts.
  - Keep activity goals user focused.
  - Make sure goals are something participants can relate to.
  - Make performance accomplishments obtainable with very gradual increases in challenges.

# Bibliography

# Bibliography

- [1] M. Stephens, "Free Printable iPhone 5 Templates (PDF)," 2012. [Online]. Available: <http://www.matthewstephens.com/>
- [2] WOOMOO, "POP prototyping on paper." [Online]. Available: <https://popapp.in/>
- [3] Two Lives Left, "Cargo-Bot," 2013. [Online]. Available: <http://twolivesleft.com/CargoBot/>
- [4] National Science Foundation, "Women, Minorities & Persons With Disabilities in Science and Engineering," Tech. Rep., 2015. [Online]. Available: <http://www.nsf.gov/statistics/wmpd/>
- [5] C. Ashcraft and S. Blithe, "Women in IT: The facts," National Center for Women and Information Technology. National Center for Women and Information Technology, 2009. [Online]. Available: <http://www.ncwit.org/resources/women-it-facts>
- [6] C. Ashcraft and A. Breitzman, "Who invents IT? An analysis of women's participation in information technology patenting." National Center for Women & Infor-

- mation Technology, 2007. [Online]. Available: <https://www.ncwit.org/resources/who-invents-it-womens-participation-information-technology-patenting-2012-update>
- [7] L. Gratton, E. Kelan, A. Voigt, L. Walker, and H. Wolfram, "Innovative potential: men and women in teams," The Lehman Brothers Centre for Women in Business, Tech. Rep., 2007.
- [8] Consumer Electronics Association, "10th Annual Household CE Ownership and Market Potential Study," Tech. Rep., 2008.
- [9] —, "13th Annual Household CE Ownership and Market Potential Study," Tech. Rep., 2011.
- [10] S. Whiting, C. Campbell, and C. Pearson-McNeil, "Resilient, Receptive and Relevant: The African-American Consumer 2013 Report," Nielsen and the National Newspaper Publishers Association, Tech. Rep., 2013.
- [11] S. Yardi and A. Bruckman, "Income, race, and class: exploring socioeconomic differences in family technology use," in *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12)*, New York, NY, 2012, pp. 3041–3050.
- [12] K. T. Johnson, "Process, Preference and Performance: Considering Ethnicity and Socio-Economic Status in Computer Interface Metaphor Design," Doctor of Philosophy, Virginia Tech, 2008.

- [13] M. F. Fox, G. Sonnert, and I. Nikiforova, "Successful Programs for Undergraduate Women in Science and Engineering: Adapting versus Adopting the Institutional Environment," *Research in Higher Education*, vol. 50, no. 4, pp. 333–353, Jan. 2009.
- [14] D. Clayton and T. Lynch, "Ten years of strategies to increase participation of women in computing programs: the Central Queensland University experience: 1999–2001," *ACM SIGCSE Bulletin*, vol. 34, no. 2, pp. 89–93, 2002.
- [15] D. Clayton, M. Cranston, N. Laver, and T. Lynch, "WICNET: Supporting women computing students using an electronic mail list," in *Proceedings of the Fourth Australian Women in Computing Workshop (WIC '97)*. University of Melbourne: University of Melbourne, 1997, pp. 28–37.
- [16] J. M. Cohoon, "Recruiting and retaining women in undergraduate computing majors," *ACM SIGCSE Bulletin*, vol. 34, no. 2, p. 48, Jun. 2002.
- [17] J. Cuny and W. Aspray, "Recruitment and retention of women graduate students in computer science and engineering: results of a workshop organized by the computing research association," *ACM SIGCSE Bulletin*, vol. 34, no. 2, pp. 168–174, 2002.
- [18] P. J. Denning and A. McGettrick, "Recentering computer science," *Communications of the ACM*, vol. 48, no. 11, p. 15, Nov. 2005.
- [19] A. Fisher and J. Margolis, "Unlocking the clubhouse: the Carnegie Mellon experience," *ACM SIGCSE Bulletin*, vol. 34, no. 2, p. 7, 2002.

- [20] J. Margolis and A. Fisher, *Unlocking the Clubhouse: Women in Computing*. MIT Press, 2002, vol. 34, no. 2.
- [21] N. Buzzetto-More and N. Rustagi, "Unlocking the Barriers to Women and Minorities in Computer Science and Information Systems Studies: Results from a Multi-Methodological Study Conducted at Two Minority Serving Institutions," *Journal of Information Technology Education*, vol. 9, 2010.
- [22] H. L. Legum and C. H. Hoare, "Impact of a Career Intervention on At-Risk Middle School Students' Career Maturity Levels," *Professional School Counseling*, vol. 8, no. 2, pp. 148–155, 2004.
- [23] C. Hill, C. Corbett, and A. S. Rose, *Why So Few? Women in Science, Technology, Engineering, and Mathematics*. American Association of University Women (AAUW), 2010.
- [24] S. K. Adams, J. Kuhn, and J. Rhodes, "Self-Esteem Changes in the Middle School Years: A Study of Ethnic and Gender Groups," *Research in Middle Level Education*, vol. 29, no. 6, pp. 1–9, 2006.
- [25] J. M. Wing, "Computational thinking and thinking about computing," *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences*, vol. 366, no. 1881, pp. 3717–25, Oct. 2008.

- [26] P. Denning, D. Comer, D. Cries, M. Mulder, A. Tucker, A. Turner, and P. Young, *Report on the ACM Task Force on the Core of Computer Science*. New York, NY: ACM Press, 1988.
- [27] P. Denning, D. Comer, D. Gries, M. Mulder, A. Tucker, A. Turner, and P. Young, "Computing as a discipline," *Communications of the ACM*, vol. 32, no. 1, pp. 9–23, Feb. 1989.
- [28] R. Shackelford, J. H. Cross, G. Davies, J. Impagliazzo, R. Kamali, R. LeBlanc, B. Lunt, A. McGettrick, R. Sloan, and H. Topi, "Computing curricula 2005," *ACM SIGCSE Bulletin*, vol. 38, no. 3, p. 311, Jun. 2006.
- [29] T. Hewett, R. Baecker, S. Card, T. Carey, J. Gasen, M. Mantei, G. Perlman, G. Strong, and W. Verplank, "ACM SIGCHI Curricula for Human-Computer Interaction," 1996. [Online]. Available: <http://old.sigchi.org/cdg/>
- [30] D. Boud and G. Feletti, *The Challenge of Problem Based Learning*. Kogan Page, 1991.
- [31] A. Bandura, *Self-Efficacy in Changing Societies*. Cambridge University Press, 1995.
- [32] J. Cohoon, S. Nigai, and J. Kaye, "Gender and computing conference papers," *Communications of the ACM*, vol. 54, no. 8, pp. 72–80, 2011.
- [33] B. Zafar, "College major choice and the gender gap," *Federal Reserve Bank of New York Staff Report*, vol. 364, 2009.

- [34] L. Cassel, A. Clements, G. Davies, and M. Guzdial, "Computer science curriculum 2008: An interim revision of CS 2001," Association for Computing Machinery and IEEE Computer Society, Tech. Rep. December, 2008.
- [35] H. K. Tillberg and J. M. Cohoon, "Attracting Women to the CS Major," *Frontiers: A Journal of Women Studies*, vol. 26, no. 1, pp. 126–140, 2005.
- [36] S. Rosser, *Teaching the Majority: Breaking the Gender Barrier in Science, Mathematics, and Engineering*. New York, NY: Teachers College Press, Columbia University, 1995.
- [37] E. G. Creamer, C. J. Burger, and P. S. Meszaros, "Characteristics of High School and College Women Interested in Information Technology," *Journal of Women and Minorities in Science and Engineering*, vol. 10, no. 1, pp. 67–78, 2004.
- [38] M. Tang, W. Pan, and M. D. Newmeyer, "Factors influencing high school students' career aspirations," *Professional School Counselling*, vol. 11, no. 5, pp. 285–295, 2008.
- [39] S. Yardi, P. Krolikowski, T. Marshall, and A. Bruckman, "An HCI approach to computing in the real world," *ACM Journal on Educational Resources in Computing*, vol. 8, no. 3, 2008.
- [40] A. Bandura, *Social Foundation of Thought and Action-A social-cognitive theory*. Englewood Cliffs, NJ: Prentice Hall, 1986.
- [41] —, "Self-efficacy," in *In V. S. Ramachandran (Ed.), Encyclopedia of human behavior*. New York, NY: Academic Press, 1994, pp. 71–81.



- [42] ———, *Self-Efficacy: The Exercise of Control*. New York, NY: W. H. Freeman and Company, 1997.
- [43] R. W. Lent, S. D. Brown, and G. Hackett, "Toward a Unifying Social Cognitive Theory of Career and Academic Interest, Choice, and Performance," *Journal of Vocational Behavior*, vol. 45, no. 1, pp. 79–122, 1994.
- [44] S. Wiedenbeck, "Factors affecting the success of non-majors in learning to program," in *Proceedings of the first international workshop on Computing education research*. New York, New York, USA: ACM, 2005, pp. 13–24.
- [45] S. Wiedenbeck, D. LaBelle, and V. Kain, "Factors affecting course outcomes in introductory programming," in *16th Annual Workshop of the Psychology of Programming Interest Group*, no. April. Citeseer, 2004, pp. 97–110.
- [46] A. Bandura, "Self-efficacy: toward a unifying theory of behavioral change." *Psychological review*, vol. 84, no. 2, pp. 191–215, Mar. 1977.
- [47] ———, "Self-efficacy mechanism in human agency," *American psychologist*, vol. 37, no. 2, pp. 122–147, 1982.
- [48] P. Askar and D. Davenport, "An Investigation of Factors Related to Self-Efficacy for Java Programming Among Engineering Students," *Turkish Online*, vol. 8, no. 1, pp. 26–32, 2009.

- [49] J. Cohoon, "Toward improving female retention in the computer science major," *Communications of the ACM*, vol. 44, no. 5, pp. 108–114, 2001.
- [50] —, "Just get over it or just get on with it: retaining women in undergraduate computing," *Women and Information Technology Research on Underrepresentation*, J. McGrath Cohoon and William Aspray eds. *The MIT Press, Cambridge MA*, pp. 205–237, 2006.
- [51] L. Shashaani, "Gender-Differences in Computer Experience and its Influence on Computer Attitudes," pp. 347–367, 1995.
- [52] D. Barr, J. Harrison, and L. Conery, "Computational Thinking: A Digital Age Skill for Everyone," *Learning & Leading with Technology*, vol. 38, no. 6, pp. 20–23.
- [53] J. M. Wing, "Computational thinking," *Communications of the ACM*, vol. 49, no. 3, p. 33, Mar. 2006.
- [54] M. Guzdial, "Education Paving the way for computational thinking," *Communications of the ACM*, vol. 51, no. 8, p. 25, Aug. 2008.
- [55] S. Grover and R. Pea, "Computational Thinking in K12 : A Review of the State of the Field," *Educational Researcher*, vol. 42, no. 1, pp. 38–43, 2013.
- [56] V. Barr and C. Stephenson, "Computational thinking to K-12: What is involved and what is the role of the computer science education community?" *ACM Inroads*, vol. 2, no. 1, pp. 48–54, 2011.

- [57] I. Lee, F. Martin, J. Denner, B. Coulter, W. Allan, J. Erickson, J. Malyn-Smith, and L. Werner, "Computational thinking for youth in practice," *ACM Inroads*, vol. 2, no. 1, p. 32, 2011.
- [58] P. S. Buffum, A. G. Martinez-Arocho, M. H. Frankosky, F. J. Rodriguez, E. N. Wiebe, and K. E. Boyer, "CS principles goes to middle school: learning how to teach big data," *Proceedings of the 45th ACM technical symposium on Computer science education*, pp. 151–156, 2014.
- [59] H. Webb and M. B. Rosson, "Using Scaffolded Activities to Teach Computational Thinking to Middle School Girls," in *International Conference on Frontiers in Education: Computer Science and Computer Engineering*, 2012.
- [60] "Computer Science: Principles Computational Thinking Practices Big Ideas, Key Concepts, and Supporting Concepts," 2011.
- [61] American Association of University Women. Educational Foundation. Commission on Technology, Gender and T. Education, "Tech-savvy: Educating girls in the new computer age," *American Association of University Women*, 2000.
- [62] E. C. Arch and D. E. Cummins, "Structured and unstructured exposure to computers: Sex differences in attitude and use among college students," *Sex Roles*, vol. 20, no. 5-6, pp. 245–254, 1989.

- [63] L. M. Nichols, "The Influence of Student Computer-Ownership and In-Home Use on Achievement in an Elementary School Computer Programming Curriculum," pp. 407–421, 1992.
- [64] P. S. Meszaros, E. Creamer, and S. Lee, "Understanding the role of parental support for IT career decision making using the theory of self-authorship," *International Journal of Consumer Studies*, vol. 33, no. 4, pp. 392–395, 2009.
- [65] C. Burger, S. Lee, A. Laughlin, P. S. Meszaros, and E. Creamer, "Female Student Views about IT Careers In High School and College," in *American Society for Engineering Education*, 2007.
- [66] D. M. Zuckerman, "Family background, sex-role attitudes, and life goals of technical college and university students," *Sex Roles*, vol. 7, no. 11, pp. 1109–1126, 1981.
- [67] ———, "Sex-Role Related Goals and Attitudes of Minority Students: A Study of Black College Women and Reentry Students," *Journal of College Student Personnel*, vol. 22, no. 1, pp. 23–30, 1981.
- [68] L. M. Rainey and L. D. Borders, "Influential factors in career orientation and career aspiration of early adolescent girls." *Journal of Counseling Psychology*, vol. 44, no. 2, pp. 160–172, 1997.
- [69] J. L. Kerpelman, M. F. Shoffner, and S. Ross-Griffin, "African American mothers' and daughters' beliefs about possible selves and their strategies for reaching the

- adolescents' future academic and career goals," *Journal of Youth and Adolescence*, vol. 31, no. 4, pp. 289–302, 2002.
- [70] C. E. Werts, "Career Choice Patterns," *Sociology of Education*, vol. 40, no. 4, pp. 348–358, 1967.
- [71] F. Burlin, "The relationship of parental education and maternal work and occupational status to Occupational Aspiration in adolescent females," *Journal of Vocational Behavior*, vol. 9, no. 1, pp. 99–104, 1976.
- [72] P. S. Meszaros, E. Creamer, C. Burger, and J. Matheson, "Mothers and Millenials : Career Talking Across the Generations," *Family Communication in the Information Age*, vol. 16, no. 1, pp. 1–10, 2005. [Online]. Available: <http://www.kon.org/archives/forum/16-1/meszaros.html>
- [73] K. M. O'Brien and R. E. Fassinger, "A causal model of the career orientation and career choice of adolescent women." *Journal of Counseling Psychology*, vol. 40, no. 4, pp. 456–469, 1993.
- [74] K. M. O'Brien, S. M. Friedman, L. C. Tipton, and S. G. Linn, "Attachment, separation, and women's vocational development: A longitudinal analysis." *Journal of Counseling Psychology*, vol. 47, no. 3, pp. 301–315, 2000.
- [75] P. Meszaros and C. Amelink, "A Cross-Institutional Comparison of Educational Factors Promoting or Discouraging the Intent to Remain in Engineering," in *American Society for Engineering Education*, 2009.

- [76] C. T. Amelink and P. S. Meszaros, "A comparison of educational factors promoting or discouraging the intent to remain in engineering by gender," *European Journal of Engineering Education*, vol. 36, no. 1, pp. 47–62, 2011.
- [77] C. M. Watson, T. Quatman, and E. Edler, "Career aspirations of adolescent girls: Effects of achievement level, grade, and single-sex school environment," *Sex Roles*, vol. 46, no. 9-10, pp. 323–335, 2002.
- [78] J. S. Hannah and S. E. Kahn, "The relationship of socioeconomic status and gender to the occupational choices of grade 12 students," *Journal of Vocational Behavior*, vol. 34, no. 2, pp. 161–178, 1989.
- [79] J. C. Hansen, "The Measurement of Vocational Interests," in *Personnel Selection and Classification*, M. G. Rumsey, C. B. Walker, and J. H. Harris, Eds. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc., 1994, ch. 17, pp. 293–316.
- [80] M. Barg, A. Fekete, T. Greening, O. Hollands, J. Kay, J. H. Kingston, and K. Crawford, "Problem-Based Learning for Foundation Computer Science Courses," *Computer Science Education*, vol. 10, no. 2, pp. 109–128, Aug. 2000.
- [81] L. Cavedon, J. Harland, and L. Padgham, "Problem based learning with technological support in an AI subject: description and evaluation," in *Proceedings of the 2nd Australasian conference on Computer science education*. Melbourne, Australia: ACM, 1997, pp. 191–200.

- [82] P. J. Denning, "Great principles in computing curricula," *ACM SIGCSE Bulletin*, vol. 36, no. 1, pp. 336–341, Mar. 2004.
- [83] S. Yardi and A. Bruckman, "What is computing? bridging the gap between teenagers' perceptions and graduate students' experiences," *Proceedings of the third international workshop on Computing education research*, pp. 39–49, 2007.
- [84] H. Koppelman and B. van Dijk, "Teaching abstraction in introductory courses," *Proceedings of the fifteenth annual conference on Innovation and technology in computer science education - ITiCSE '10*, p. 174, 2010.
- [85] G. Scragg and J. Smith, "A study of barriers to women in undergraduate computer science." *ACM SIGCSE Bulletin*, vol. 30, no. 1, pp. 82–86, Mar. 1998.
- [86] E. Bunderson and M. Christensen, "An Analysis of Retention Problems for Female Students in University Computer Science Programs." *Journal of Research on Computing in Education*, vol. 28, no. 1, pp. 1–18, 1995.
- [87] Building Engineering and Science Talent, "A Bridge for All: Higher Education Design Principles to Broaden Participation in Science, Technology, Engineering, and Mathematics," 2004.
- [88] L. Darlington, "Factors that Influence the Satisfaction and Persistence of Undergraduates in Computer Related Majors," Doctor of Philosophy, Virginia Polytechnic Institute and State University, 2008.

- [89] A. Astin and H. Astin, "Undergraduate Science Education: The Impact of Different College Environments on the Educational Pipeline in the Sciences. Final Report." California University, Los Angeles, CA, Tech. Rep., 1992.
- [90] M. F. Fox, "Women, Science, and Academia: Graduate Education and Careers," *Gender & Society*, vol. 15, no. 5, pp. 654–666, Oct. 2001.
- [91] E. Seymour and N. Hewitt, *Talking About Leaving: Why Undergraduates Leave the Sciences*. Boulder, CO: Westview Press, 1997.
- [92] J. Hearn and S. Olzak, "The role of college major departments in the reproduction of sexual inequality," *Sociology of Education*, vol. 54, no. 3, pp. 195–205, 1981.
- [93] J. Cohoon, M. Gonsoulin, and J. Layman, "Mentoring computer science undergraduates," *Human Perspectives in the Internet Society: Culture, Psychology and Gender*, vol. 4, pp. 199–208, 2004.
- [94] V. Clarke and G. Joy Teague, "Characterizations of computing careers: Students and professionals disagree," *Computers & Education*, vol. 26, no. 4, pp. 241–246, 1996.
- [95] D. Sturm and M. Moroh, "Gender and Computer Science Majors: Perceptions and Reality." City University of New York College of Staten Island, Tech. Rep., 1995.
- [96] A. Christopher Strenta, R. Elliott, R. Adair, M. Matier, and J. Scott, "Choosing and leaving science in highly selective institutions," *Research in Higher Education*, vol. 35, no. 5, pp. 513–547, Sep. 1994.



- [97] L. Murphy, R. McCauley, S. Westbrook, B. Richards, B. Morrison, and T. Fossum, "Women catch up: gender differences in learning programming concepts," *SIGCSE Bulletin*, vol. 38, no. 1, p. 17, 2006.
- [98] T. Vilner and E. Zur, "Once she makes it, she is there: gender differences in computer science study," in *Proceedings of the 11th annual SIGCSE conference on Innovation and technology in computer science education*. ACM, 2006, pp. 227–231.
- [99] L. Blum, C. Frieze, O. Hazzan, and M. B. Dias, "A cultural perspective on gender diversity in computing," in *Reconfiguring the Firewall: Recruiting Women to Information Technology across Cultures and Continents*, C. Burger, E. Creamer, and P. Meszaros, Eds. Wellesley, Massachusetts: A. K. Peters, 2007, ch. 5, pp. 109–133.
- [100] R. Varma, "Computing Self-Efficacy among Women in India," *Journal of Women and Minorities in Science and Engineering*, vol. 16, pp. 257–274, 2010.
- [101] P. J. Denning, "The field of programmers myth," *Communications of the ACM*, vol. 47, no. 7, p. 15, Jul. 2004.
- [102] C. Weinberger, "Just ask! Why surveyed women did not pursue IT courses or careers," *Technology and Society Magazine, IEEE*, vol. 23, no. 2, pp. 28–35, 2004.
- [103] F. Wilson, "Can compute, won't compute: women's participation in the culture of computing," *New Technology, Work and Employment*, vol. 18, no. 2, pp. 127–142, Jul. 2003.

- [104] S. Beyer, K. Rynes, J. Perrault, K. Hay, and S. Haller, "Gender differences in computer science students," *Proceedings of the 34th SIGCSE technical symposium on Computer science education - SIGCSE '03*, p. 49, 2003.
- [105] R. Varma, "Women in Information Technology: A Case Study of Undergraduate Students in a Minority-Serving Institution," *Bulletin of Science, Technology & Society*, vol. 22, no. 4, pp. 274–282, Aug. 2002.
- [106] J. Margolis, A. Fisher, and F. Miller, "The anatomy of interest: Women in undergraduate computer science," *Women's Studies Quarterly*, vol. 28, no. 1/2, pp. 104–127, 2000.
- [107] B. Brown, "Self-efficacy beliefs and career development," *ERIC Clearinghouse on Adult Career, and Vocational Education*, no. 205, 1999.
- [108] W. Cukier, D. Shortt, and I. Devine, "Gender and information technology: implications of definitions," *ACM SIGCSE Bulletin*, vol. 34, no. 4, pp. 142–148, 2002.
- [109] J. Aisbett, R. Fardell, and B. Regan, "Preparing for the Future of information Technology: a Degree that encourages cognitive and perceptual Development," *Higher Education*, pp. 791–799, 2004.
- [110] D. Vernon and R. Blake, "Does problem-based learning work? A meta-analysis of evaluative research." *Academic Medicine*, pp. 550–563, 1993.

- [111] A. Ellis, J. Tarhio, L. Carswell, A. Bernat, D. Deveaux, P. Frison, V. Meisalo, J. Meyer, U. Nulden, and J. Rugelj, "Resources, tools, and techniques for problem based learning in computing," *Working Group reports of the 3rd annual SIGCSE/SIGCUE ITiCSE conference on Integrating technology into computer science education - ITiCSE-WGR '98*, pp. 41–56, 1998.
- [112] A. Fekete, T. Greening, and J. Kingston, "Conveying technical content in a curriculum using problem based learning," in *Proceedings of the 3rd Australasian conference on Computer science education*. ACM, 1998, pp. 198–202.
- [113] N. Schultz and H. P. Christensen, "Seven-step problem-based learning in an interaction design course," *European Journal of Engineering Education*, vol. 29, no. 4, pp. 533–541, Dec. 2004.
- [114] O. Tan, "Problem-based Learning Approach to Human Computer Interaction," *World Academy of Science, Engineering and Technology*, vol. 76, pp. 462–465, 2011.
- [115] F. Reynolds, "Initial experiences of interprofessional problem-based learning: a comparison of male and female students' views." *Journal of interprofessional care*, vol. 17, no. 1, pp. 35–44, Feb. 2003.
- [116] R. Edwards, *Mature women students: separating or connecting family and education*. London: Taylore & Francis, 1993.

- [117] B. Litner, A. Rossiter, and M. Taylor, "The Equitable Inclusion of Women in Higher Education : Some Consequences for Teaching," *Women in Higher Education*, vol. 3, no. 4, pp. 286–302, 1992.
- [118] G. Wisker, *Empowering women in higher education*. London: Kogan Page, 1996.
- [119] N. Cerezo, "Problem-Based Learning in the Middle School: A Research Case Study of the Perceptions of At-Risk Females." *RMLE Online: Research in Middle Level Education*, vol. 27, no. 1, pp. 1–13, 2004.
- [120] M. Lundeberg and S. Moch, "Influence of social interaction on cognition: Connected learning in science," *The Journal of Higher Education*, vol. 66, no. 3, pp. 312–335, 1995.
- [121] M. Belenky, B. Clinchy, N. Goldberger, and J. Tarule, *Women's ways of knowing: the development of self, voice, and mind*. New York: Basic Books, 1986.
- [122] M. A. Gawelek, M. Mulqueen, and J. M. Tarule, "Woman to women: understanding the needs of our female students," in *Gender and Academe: Feminist Pedagogy and Politics*, S. M. Deats and L. T. Lenker, Eds. Lanham, MD: Rowman and Littlefield Publishers, 1994, ch. 13.
- [123] C. Gilligan, *In a different voice: psychological theory and women's development*. Cambridge, MA: Harvard University Press, 1982.

- [124] N. Colwill and S. Vinnicombe, "Women's Training Needs," in *Women at Work: Psychological and Organizational Perspectives*, J. Firth-Cozens and M. West, Eds. Buckingham: Open University Press, 1991, pp. 42–50.
- [125] J. M. Carroll and W. a. Kellogg, "Artifact as theory-nexus: hermeneutics meets theory-based design," in *Proceedings of the SIGCHI conference on Human factors in computing systems Wings for the mind - CHI '89*, no. May. New York, New York, USA: ACM Press, 1989, pp. 7–14.
- [126] G. Guida and G. Lamperti, "AMMETH: a methodology for requirements analysis of advanced human-system interfaces," *IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans*, vol. 30, no. 3, pp. 298–321, 2000.
- [127] J. D. Gould and C. Lewis, "Designing for usability: key principles and what designers think," *Communications of the ACM*, vol. 28, no. 3, pp. 300–311, 1985.
- [128] G. de Haan, G. van der Veer, and J. van Vliet, "Formal modelling techniques in human-computer interaction," *Acta Psychologica*, vol. 78, pp. 27–67, 1991.
- [129] M. B. Rosson and J. M. Carroll, *Usability Engineering: Scenario-Based Development of Human-Computer Interaction*. New York, NY: Morgan Kaufmann, 2002.
- [130] M. Scriven, "The methodology of evaluation," in *Perspectives of Curriculum Evaluation*, R. Tyler, R. Gagne, and M. Scriven, Eds. Chicago, IL: Rand McNally, 1967, pp. 39–83.

- [131] K. Bussey and A. Bandura, "Social cognitive theory of gender development and differentiation." *Psychological Review*, vol. 106, no. 4, p. 676, 1999.
- [132] D. Compeau and C. Higgins, "Computer self-efficacy: Development of a measure and initial test," *MIS quarterly*, vol. 19, no. 2, pp. 189–211, 1995.
- [133] B. Hasan, "The influence of specific computer experiences on computer self-efficacy beliefs," *Computers in Human Behavior*, vol. 19, no. 4, pp. 443–450, 2003.
- [134] C. a. Murphy, D. Coover, and S. V. Owen, "Development and Validation of the Computer Self-Efficacy Scale," *Educational and Psychological Measurement*, vol. 49, no. 4, pp. 893–899, Dec. 1989.
- [135] A. Quade, "Development and validation of a computer science self-efficacy scale for CS0 courses and the group analysis of CS0 student self-efficacy," *Proceedings ITCC 2003. International Conference on Information Technology: Coding and Computing*, pp. 60–64, 2003.
- [136] P. J. Denning, "The social life of innovation," *Communications of the ACM*, vol. 47, no. 4, p. 15, Apr. 2004.
- [137] G. Torkzadeh and X. Koufteros, "Factorial Validity of a Computer Self-Efficacy Scale and the Impact of Computer Training," *Educational and Psychological Measurement*, vol. 54, no. 3, pp. 813–821, Sep. 1994.

- [138] V. Ramalingam and S. Wiedenbeck, "Development and validation of scores on a computer programming self-efficacy scale and group analyses of novice programmer self-efficacy," *Journal of Educational Computing Research*, vol. 19, no. 4, pp. 367–381, 1998.
- [139] I. T. Miura, "The relationship of computer self-efficacy expectations to computer interest and course enrollment in college," *Sex Roles*, vol. 16, no. 5-6, pp. 303–311, Mar. 1987.
- [140] "STEM Assessment Tools." [Online]. Available: <http://www.engr.psu.edu/awe/>
- [141] R. M. Marra and B. Bogue, "Women engineering students' self-efficacy longitudinal multi-institution study," in *Proceedings of the 2006 women in engineering programs and advocates network conference*, Pittsburgh, PA, 2006.
- [142] T. Dahlberg, T. Barnes, K. Buch, and K. Bean, "Applying service learning to computer science: attracting and engaging under-represented students," *Computer Science Education*, vol. 20, no. 3, pp. 169–180, Sep. 2010.
- [143] B. H. Loyd and C. Gressard, "Reliability and Factorial Validity of Computer Attitude Scales," *Educational and Psychological Measurement*, vol. 44, no. 2, pp. 501–505, Jun. 1984.
- [144] B. H. Loyd and D. E. Loyd, "The Reliability and Validity of an Instrument for the Assessment of Computer Attitudes," *Educational and Psychological Measurement*, vol. 45, no. 4, pp. 903–908, Dec. 1985.

- [145] B. H. Loyd, D. E. Loyd, and C. P. Gressard, "Reliability and Factorial Validity of Computer Attitude Scales," *The Journal of Early Adolescence*, vol. 7, no. 1, pp. 13–19, Mar. 1987.
- [146] Z. Wu, "Computing Interests of Early Adolescents: Gender, Attitudes, Self-Efficacy, and Outcome Expectations," Doctor of Philosophy, University of Virginia, 2009.
- [147] A. Bandura, "Guide for constructing self-efficacy scales," *Self-efficacy beliefs of adolescents*, vol. 5, pp. 307–337, 2006.
- [148] J. W. Creswell and V. L. P. Clark, *Designing and Conducting Mixed Methods Research*, 2nd ed. Sage Publications, 2011.
- [149] D. T. Campbell and J. C. Stanley, *Experimental and Quasi-Experimental Designs for Research*. Chicago: Rand McNally College Publishing Company, 1963.
- [150] J. A. Gliner and G. A. Morgan, *Research Methods in Applied Settings: An Integrated Approach to Design and Analysis*. Mahwah, NJ: Lawrence Erlbaum Associates, 2000.
- [151] M. Q. Patton, *Qualitative Evaluation and Research Methods*, 3rd ed. Thousand Oaks, CA: Sage Publications, 2002.
- [152] G. Crombie and P. I. Armstrong, "Effects of Classroom Gender Composition on Adolescents' Computer-Related Attitudes and Future Intentions," *Journal of Educational Computing Research*, vol. 20, no. 4, pp. 317–327, Jan. 1999.



- [153] R. M. Branch, *Instructional Design: The ADDIE Approach*. Boston, MA: Springer, 2010.
- [154] WGBH Educational Foundation, "Dot Diva," 2010. [Online]. Available: <http://dotdiva.org/>
- [155] T. Bell, "Programming Languages-Marching Orders," 2012. [Online]. Available: <http://csunplugged.org/programming-languages/>
- [156] B. S. Bloom, M. D. Engelhart, E. J. Furst, W. H. Hill, and D. R. Krathwohl, *Taxonomy of Educational Objectives: Handbook I: Cognitive Domain*, B. S. Bloom, Ed. New York: David McKay Company, Inc., 1956.
- [157] D. R. Krathwohl, B. S. Bloom, and B. B. Masia, *Taxonomy of Educational Objectives: Handbook II: Affective Domain*. New York: David McKay Company, Inc., 1964.
- [158] The College Board, "Computer Science : Principles Big Ideas and Key Concepts Learning Objectives and Evidence Statements," 2011.
- [159] R. M. Gagné, W. W. Wager, K. C. Golas, J. M. Keller, and J. D. Russell, *Principles of instructional design*, 5th ed. Belmont, CA: Thomson Wadsworth, 2005.
- [160] Code.org, "Code Stars - Short Film," 2013. [Online]. Available: <https://www.youtube.com/watch?v=dU1xS07N-FA>

- [161] Eco Designs, "The Homework App-Your Class Assignment Planner." [Online]. Available: <https://itunes.apple.com/us/app/homework-app-your-school-homework/id561371952?mt=8>
- [162] R. Neri, "myHomework." [Online]. Available: <https://myhomeworkapp.com/?r=itunes>
- [163] J. Nielsen, *Usability Engineering*. San Francisco, CA: Morgan Kaufmann Publishers, 1994.
- [164] M. Rettig, "Prototyping for tiny fingers," *Commun. ACM*, vol. 37, no. 4, pp. 21–27, 1994. [Online]. Available: <http://doi.acm.org/10.1145/175276.175288>
- [165] C. Snyder, *Paper Prototyping: The Fast and Easy Way to Design and Refine User Interfaces*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2003.
- [166] E. G. Carminer and R. A. Zeller, *Reliability and Validity Assessment*. Thousand Oaks, CA: Sage Publications, 1979.
- [167] S. Messick, "Validity," in *Educational Measurement*, R. L. Linn, Ed. Washington, DC: American Council on Education and the National Council on Measurement in Education, 1989.
- [168] N. E. Wallace and J. R. Fraenkel, *Educational Research: A Guide to the Process*, 2nd ed. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 2001.

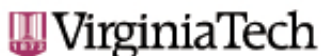
- [169] R. J. Little, "A test of missing completely at random for multivariate data with missing values," *Journal of the American Statistical Association*, vol. 83, no. 404, pp. 1198–1202, 1988.
- [170] A. Dempster, N. Laird, and D. Rubin, "Maximum likelihood from incomplete data via the EM algorithm," *Journal of the Royal Statistical Society. . . .*, vol. 39, no. 1, pp. 1–38, 1977.
- [171] J. Cohen, *Statistical power analysis for the behavioural sciences*, 2nd ed. New York: Academic Press, 1988.
- [172] A. Field, *Discovering Statistics Using IBM SPSS Statistics*, 4th ed., M. Carmichael, Ed. Los Angeles, CA: Sage Publications, 2013.
- [173] "Microsoft Excel," Redmond, Washington, 2013.
- [174] A. Strauss and J. Corbin, *Basics of qualitative research: techniques and procedures for developing grounded theory*, 2nd ed. Sage Publications, 1998.
- [175] K. M. Macqueen, E. Mclellan, K. Kay, and B. Milstein, "Codebook Development for Team-Based Qualitative Analysis," *Field Methods*, vol. 10, no. 2, pp. 31–36, May 1998.
- [176] J. Saldaña, *The Coding Manual for Qualitative Researchers*, 2nd ed. Thousand Oaks, CA: Sage Publications, 2013.

- [177] ———, *Longitudinal qualitative research: analyzing change through time*. Walnut Creek, CA: AltaMira Press, 2003.
- [178] M. B. Miles and A. M. Huberman, *Qualitative data analysis: an expanded sourcebook*, 2nd ed. Thousand Oaks, CA: Sage Publications, 1994.
- [179] H. F. Wolcott, *Transforming qualitative data: description, analysis, and interpretation*. Thousand Oaks, CA: Sage Publications, 1994.
- [180] "Chapter 8: Coding of Qualitative Data." [Online]. Available: <http://peoplelearn.homestead.com/PhD/QualCORE2.html>
- [181] K. Krippendorff, *Content Analysis: An Introduction to Its Methodology*, 2nd ed. Thousand Oaks, CA: Sage Publications, 2004.
- [182] A. F. Hayes and K. Krippendorff, "Answering the Call for a Standard Reliability Measure for Coding Data," *Communication Methods and Measures*, vol. 1, no. 1, pp. 77–89, Apr. 2007.
- [183] "IBM SPSS Statistics for Windows," Armonk, NY, 2013.
- [184] R. H. Bradley, R. F. Corwyn, B. M. Caldwell, L. Whiteside-Mansell, G. a. Wasserman, and I. T. Mink, "Measuring the Home Environments of Children in Early Adolescence," *Journal of Research on Adolescence*, vol. 10, no. 3, pp. 247–288, 2000.

- [185] P. S. Meszaros, A. Laughlin, E. G. Creamer, and C. J. Burger, "Parental Support for Female IT Career Interest and Choice," *Encyclopedia of Gender and Information Technology*, pp. 963–969, 2006.
- [186] M. Craig and D. Horton, "Gr8 Designs for Gr8 Girls : A Middle-School Program and its Evaluation," *ACM SIGCSE Bulletin*, vol. 41, no. 1, pp. 221–225, 2009.
- [187] L. A. Jackson, Y. Zhao, A. Kolenic, H. E. Fitzgerald, R. Harold, and A. Von Eye, "Race, gender, and information technology use: the new digital divide." *Cyberpsychology & behavior : the impact of the Internet, multimedia and virtual reality on behavior and society*, vol. 11, no. 4, pp. 437–442, 2008.

# **Appendix A**

## **Institutional Review Board Package**



**Office of Research Compliance**  
 Institutional Review Board  
 North End Center, Suite 4120, Virginia Tech  
 300 Turner Street NW  
 Blacksburg, Virginia 24061  
 540/231-4606 Fax 540/231-0959  
 email [irb@vt.edu](mailto:irb@vt.edu)  
 website <http://www.irb.vt.edu>

#### MEMORANDUM

**DATE:** July 1, 2013  
**TO:** Ashley Renee Robinson, Manuel A Perez-Quinonez, Glenda R Scales  
**FROM:** Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)  
**PROTOCOL TITLE:** Computational Thinking Workshop  
**IRB NUMBER:** 13-262

Effective June 27, 2013, the Virginia Tech Institutional Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<http://www.irb.vt.edu/pages/responsibilities.htm>

(Please review responsibilities before the commencement of your research.)

#### PROTOCOL INFORMATION:

Approved As: **Expedited, under 45 CFR 46.110 category(ies) 6,7**  
 Protocol Approval Date: **May 13, 2013**  
 Protocol Expiration Date: **May 12, 2014**  
 Continuing Review Due Date\*: **April 28, 2014**

\*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

#### FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

*Invent the Future*

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY  
 An equal opportunity, affirmative action institution

Date*	OSP Number	Sponsor	Grant Comparison Conducted?

\* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.





**Institutional Review Board  
Research Protocol**

Once complete, upload this form as a Word document to the IRB Protocol Management System: <https://secure.research.vt.edu/irb>

**Section 1: General Information**

**1.1 DO ANY OF THE INVESTIGATORS OF THIS PROJECT HAVE A REPORTABLE CONFLICT OF INTEREST?** (<http://www.irb.vt.edu/pages/researchers.htm#conflict>)

- No
- Yes, explain:

**1.2 WILL THIS RESEARCH INVOLVE COLLABORATION WITH ANOTHER INSTITUTION?**

- No, go to question 1.3
- Yes, answer questions within table

IF YES
<p><b>Provide the name of the institution</b> [for institutions located overseas, please also provide name of country]:</p>
<p><b>Indicate the status of this research project with the other institution's IRB:</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Pending approval</li> <li><input type="checkbox"/> Approved</li> <li><input type="checkbox"/> Other institution does not have a human subject protections review board</li> <li><input type="checkbox"/> Other, explain:</li> </ul>
<p><b>Will the collaborating institution(s) be engaged in the research?</b> (<a href="http://www.hhs.gov/ohrp/policy/engage08.html">http://www.hhs.gov/ohrp/policy/engage08.html</a>)</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> No</li> <li><input type="checkbox"/> Yes</li> </ul>
<p><b>Will Virginia Tech's IRB review all human subject research activities involved with this project?</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> No, provide the name of the primary institution:</li> <li><input type="checkbox"/> Yes</li> </ul> <p><i>Note: primary institution = primary recipient of the grant or main coordinating center</i></p>

**1.3 IS THIS RESEARCH FUNDED?**

- No, go to question 1.4
- Yes, answer questions within table

IF YES
<p><b>Provide the name of the sponsor</b> [if NIH, specify department]:</p>
<p><b>Is this project receiving federal funds?</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> No</li> <li><input type="checkbox"/> Yes</li> </ul> <p><b>If yes,</b></p>

**Does the grant application, OSP proposal, or “statement of work” related to this project include activities involving human subjects that are not covered within this IRB application?**

No, all human subject activities are covered in this IRB application

Yes, however these activities will be covered in future VT IRB applications, these activities include:

Yes, however these activities have been covered in past VT IRB applications, the IRB number(s) are as follows:

Yes, however these activities have been or will be reviewed by another institution’s IRB, the name of this institution is as follows:

Other, explain:

**Is Virginia Tech the primary awardee or the coordinating center of this grant?**

No, provide the name of the primary institution:

Yes

**1.4 DOES THIS STUDY INVOLVE CONFIDENTIAL OR PROPRIETARY INFORMATION (OTHER THAN HUMAN SUBJECT CONFIDENTIAL INFORMATION), OR INFORMATION RESTRICTED FOR NATIONAL SECURITY OR OTHER REASONS BY A U.S. GOVERNMENT AGENCY?**

*For example – government / industry proprietary or confidential trade secret information*

- No
- Yes, describe:

**1.5 DOES THIS STUDY INVOLVE SHIPPING ANY TANGIBLE ITEM, BIOLOGICAL OR SELECT AGENT OUTSIDE THE U.S.?**

- No
- Yes

**Section 2: Justification**

**2.1 DESCRIBE THE BACKGROUND, PURPOSE, AND ANTICIPATED FINDINGS OF THIS STUDY:**

In computer science education, an emphasis has been placed on the lack of women in computing. The purpose of the research is to determine the extent to which exposure to Human-Computer Interaction (HCI) influences the computational thinking self-efficacy of middle school girls and how their computational thinking self-efficacy varies by ethnicity and socioeconomic status. It is anticipated that exposure to HCI will increase self-efficacy.

**2.2 EXPLAIN WHAT THE RESEARCH TEAM PLANS TO DO WITH THE STUDY RESULTS:**

*For example - publish or use for dissertation*

The research team plans to publish the study results and use them for a dissertation.

**Section 3: Recruitment**

**3.1 DESCRIBE THE SUBJECT POOL, INCLUDING INCLUSION AND EXCLUSION CRITERIA AND NUMBER OF SUBJECTS:**

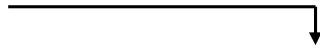
*Examples of inclusion/exclusion criteria - gender, age, health status, ethnicity*

The subjects will include approximately 200 6<sup>th</sup>-8<sup>th</sup> grade students of various ethnicities.

**3.2 WILL EXISTING RECORDS BE USED TO IDENTIFY AND CONTACT / RECRUIT SUBJECTS?**

*Examples of existing records - directories, class roster, university records, educational records*

- No, go to question 3.3
- Yes, answer questions within table



IF YES
<p><b>Are these records private or public?</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Public</li> <li><input type="checkbox"/> Private, describe the researcher's privilege to the records:</li> </ul>
<p><b>Will student, faculty, and/or staff records or contact information be requested from the University?</b></p> <ul style="list-style-type: none"> <li><input type="checkbox"/> No</li> <li><input type="checkbox"/> Yes, visit the following link for further information: <a href="http://www.policies.vt.edu/index.php">http://www.policies.vt.edu/index.php</a> (policy no. 2010)</li> </ul>

**3.3 DESCRIBE RECRUITMENT METHODS, INCLUDING HOW THE STUDY WILL BE ADVERTISED OR INTRODUCED TO SUBJECTS:**

Subjects will be recruited at Boys and Girls Clubs and YMCAs. The study will be advertised through word of mouth, pending approval from the child care directors and instructors at the various sites.

**3.4 PROVIDE AN EXPLANATION FOR CHOOSING THIS POPULATION:**

*Note: the IRB must ensure that the risks and benefits of participating in a study are distributed equitably among the general population and that a specific population is not targeted because of ease of recruitment.*

This population will be recruited at the Boys and Girls Clubs and YMCAs because these organizations contain middle school girls with a variety of career interest, rather than girls who are solely interested in careers in the STEM fields.

**Section 4: Consent Process**

For more information about consent process and consent forms visit the following link: <http://www.irb.vt.edu/pages/consent.htm>

*If feasible, researchers are advised and may be required to obtain signed consent from each participant unless obtaining signatures leads to an increase of risk (e.g., the only record linking the subject and the research would be the consent document and the principal risk would be potential harm resulting in a breach of confidentiality). Signed consent is typically not required for low risk questionnaires (consent is implied) unless audio/video recording or an in-person interview is involved. If researchers will not be obtaining signed consent, participants must, in most cases, be supplied with consent information in a different format (e.g., in recruitment document, at the beginning of survey instrument, read to participant over the phone, information sheet physically or verbally provided to participant).*

**4.1 CHECK ALL OF THE FOLLOWING THAT APPLY TO THIS STUDY'S CONSENT PROCESS:**

- Verbal consent will be obtained from participants
- Written/signed consent will be obtained from participants
- Consent will be implied from the return of completed questionnaire. Note: The IRB recommends providing consent information in a recruitment document or at the beginning of the questionnaire (if the study only involves implied consent, skip to Section 5 below)
- Other, describe:

**4.2 PROVIDE A GENERAL DESCRIPTION OF THE PROCESS THE RESEARCH TEAM WILL USE TO OBTAIN AND MAINTAIN INFORMED CONSENT:**

The research team will send the informed consent forms to the organizations, prior to the study, so that child care directors and teachers can send them home to the parents. The consents forms will be due, from the parents, prior to the start of the study. Assent will also be requested from the student prior to the study. A verbal script will describe the study and request that they verbally agree to participate.

**4.3 WHO, FROM THE RESEARCH TEAM, WILL BE OVERSEEING THE PROCESS AND OBTAINING CONSENT FROM SUBJECTS?**

Ashley Robinson will be overseeing the process and obtaining consent from subjects.

**4.4 WHERE WILL THE CONSENT PROCESS TAKE PLACE?**

Consent will take place at the participating Boys and Girls Clubs and YMCAs.

**4.5 DURING WHAT POINT IN THE STUDY PROCESS WILL CONSENTING OCCUR?**

*Note: unless waived by the IRB, participants must be consented before completing any study procedure, including screening questionnaires.*

Consenting will occur prior to the study process.

**4.6 IF APPLICABLE, DESCRIBE HOW THE RESEARCHERS WILL GIVE SUBJECTS AMPLE TIME TO REVIEW THE CONSENT DOCUMENT BEFORE SIGNING:**

*Note: typically applicable for complex studies, studies involving more than one session, or studies involving more of a risk to subjects.*

Not applicable

**Section 5: Procedures**

**5.1 PROVIDE A STEP-BY-STEP THOROUGH EXPLANATION OF ALL STUDY PROCEDURES EXPECTED FROM STUDY PARTICIPANTS, INCLUDING TIME COMMITMENT & LOCATION:**

Subjects will participate in an interactive computer science workshop. The workshop will be 1 hour a day for five days. The workshop will take place at the participating organization facilities. Subjects will complete pre and post study surveys. Following the workshop, participants will participate in a follow-up focus group interview.

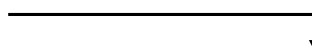
**5.2 DESCRIBE HOW DATA WILL BE COLLECTED AND RECORDED:**

Data will be collected and recorded through surveys and audio/video recording follow-up interviews.

**5.3 DOES THE PROJECT INVOLVE ONLINE RESEARCH ACTIVITIES (INCLUDES ENROLLMENT, RECRUITMENT, SURVEYS)?**

*View the "Policy for Online Research Data Collection Activities Involving Human Subjects" at <http://www.irb.vt.edu/documents/onlinepolicy.pdf>*

- No, go to question 6.1
- Yes, answer questions within table



**IF YES**  
Identify the service / program that will be used:

[www.survey.vt.edu](http://www.survey.vt.edu), go to question 6.1

Blackboard, go to question 6.1

Center for Survey Research, go to question 6.1

Other

**IF OTHER:**  
 Name of service / program:  
 URL:  
 This service is...

Included on the list found at: <http://www.irb.vt.edu/pages/validated.htm>

Approved by VT IT Security

An external service with proper SSL or similar encryption (https://) on the login (if applicable) and all other data collection pages.

None of the above (note: only permissible if this is a collaborative project in which VT individuals are only responsible for data analysis, consulting, or recruitment)

**Section 6: Risks and Benefits**

**6.1 WHAT ARE THE POTENTIAL RISKS (E.G., EMOTIONAL, PHYSICAL, SOCIAL, LEGAL, ECONOMIC, OR DIGNITY) TO STUDY PARTICIPANTS?**

There are no more than minimal risk involved with participating in this study.

**6.2 EXPLAIN THE STUDY’S EFFORTS TO REDUCE POTENTIAL RISKS TO SUBJECTS:**

To reduce potential risks to subjects, subjects will be allowed to take a break when needed or withdraw from the study ant any time. Child care providers and investigators will also be around to provided assistance when needed.

**6.3 WHAT ARE THE DIRECT OR INDIRECT ANTICIPATED BENEFITS TO STUDY PARTICIPANTS AND/OR SOCIETY?**

The anticipated benefits of this study to participants are that it will introduce them to the computer science discipline and empower them to pursue a computer-related discipline as a career choice.

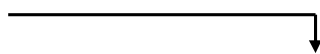
**Section 7: Full Board Assessment**

**7.1 DOES THE RESEARCH INVOLVE MICROWAVES/X-RAYS, OR GENERAL ANESTHESIA OR SEDATION?**

- No
- Yes

**7.2 DO RESEARCH ACTIVITIES INVOLVE PRISONERS, PREGNANT WOMEN, FETUSES, HUMAN IN VITRO FERTILIZATION, OR MENTALLY DISABLED PERSONS?**

- No, go to question 7.3
- Yes, answer questions within table



**IF YES**

This research involves:

Prisoners

<input type="checkbox"/> Pregnant women <input type="checkbox"/> Fetuses <input type="checkbox"/> Human in vitro fertilization <input type="checkbox"/> Mentally disabled persons
--

**7.3 DOES THIS STUDY INVOLVE MORE THAN MINIMAL RISK TO STUDY PARTICIPANTS?**

*Minimal risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily activities or during the performance of routine physical or psychological examinations or tests. Examples of research involving greater than minimal risk include collecting data about abuse or illegal activities. Note: if the project qualifies for Exempt review (<http://www.irb.vt.edu/pages/categories.htm>), it will not need to go to the Full Board.*

- No
- Yes

**IF YOU ANSWERED "YES" TO ANY ONE OF THE ABOVE QUESTIONS, 7.1, 7.2, OR 7.3, THE BOARD MAY REVIEW THE PROJECT'S APPLICATION MATERIALS AT ITS MONTHLY MEETING. VIEW THE FOLLOWING LINK FOR DEADLINES AND ADDITIONAL INFORMATION: <http://www.irb.vt.edu/pages/deadlines.htm>**

**Section 8: Confidentiality / Anonymity**

For more information about confidentiality and anonymity visit the following link: <http://www.irb.vt.edu/pages/confidentiality.htm>

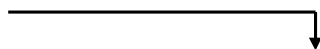
**8.1 WILL PERSONALLY IDENTIFYING STUDY RESULTS OR DATA BE RELEASED TO ANYONE OUTSIDE OF THE RESEARCH TEAM?**

*For example – to the funding agency or outside data analyst, or participants identified in publications with individual consent*

- No
- Yes, to whom will identifying data be released?

**8.2 WILL ANY STUDY FILES CONTAIN PARTICIPANT IDENTIFYING INFORMATION (E.G., NAME, CONTACT INFORMATION, VIDEO/AUDIO RECORDINGS)?**

*Note: if collecting signatures on a consent form, select "Yes."*

- No, go to question 8.3
- Yes, answer questions within table 

IF YES
<p><b>Describe if/how the study will utilize study codes: The study will utilize study codes by separating the participant's names from the study data and utilizing numbers.</b></p>
<p><b>If applicable, where will the key [i.e., linked code and identifying information document (for instance, John Doe = study ID 001)] be stored and who will have access? The key will be stored in a locked cabinet in Knowledge Works II and only the investigators will have access.</b></p> <p><i>Note: the key should be stored separately from subjects' completed data documents and accessibility should be limited.</i></p>
<p><i>The IRB strongly suggests and may require that all data documents (e.g., questionnaire responses, interview responses, etc.) do not include or request identifying information (e.g., name, contact information, etc.) from participants. If you need to link subjects' identifying information to subjects' data documents, use a study ID/code on all data documents.</i></p>

**8.3 WHERE WILL DATA BE STORED?**

Examples of data - questionnaire, interview responses, downloaded online survey data, observation recordings, biological samples

The study data will be stored in another locked cabinet in Knowledge Works II, separate from the key.

8.4 WHO WILL HAVE ACCESS TO STUDY DATA?

Only the investigators will have access to the study data.

8.5 DESCRIBE THE PLANS FOR RETAINING OR DESTROYING THE STUDY DATA

The study data will be destroyed in five years.

8.6 DOES THIS STUDY REQUEST INFORMATION FROM PARTICIPANTS REGARDING ILLEGAL BEHAVIOR?

- No, go to question 9.1
- Yes, answer questions within table

**IF YES**

**Does the study plan to obtain a Certificate of Confidentiality?**

- No
- Yes (Note: participants must be fully informed of the conditions of the Certificate of Confidentiality within the consent process and form)

*For more information about Certificates of Confidentiality, visit the following link:*  
<http://www.irb.vt.edu/pages/coc.htm>

**Section 9: Compensation**

For more information about compensating subjects, visit the following link: <http://www.irb.vt.edu/pages/compensation.htm>

9.1 WILL SUBJECTS BE COMPENSATED FOR THEIR PARTICIPATION?

- No, go to question 10.1
- Yes, answer questions within table

**IF YES**

**What is the amount of compensation?**

---

**Will compensation be prorated?**

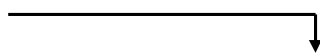
- Yes, please describe:
- No, explain why and clarify whether subjects will receive full compensation if they withdraw from the study?

*Unless justified by the researcher, compensation should be prorated based on duration of study participation. Payment must not be contingent upon completion of study procedures. In other words, even if the subject decides to withdraw from the study, he/she should be compensated, at least partially, based on what study procedures he/she has completed.*

**Section 10: Audio / Video Recording**

For more information about audio/video recording participants, visit the following link: <http://www.irb.vt.edu/pages/recordings.htm>

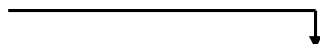
**10.1 WILL YOUR STUDY INVOLVE VIDEO AND/OR AUDIO RECORDING?**

- No, go to question 11.1
- Yes, answer questions within table 

IF YES
<b>This project involves:</b> <input type="checkbox"/> Audio recordings only <input type="checkbox"/> Video recordings only <input checked="" type="checkbox"/> Both video and audio recordings
<b>Provide compelling justification for the use of audio/video recording: Audio/video recording will be used for interviews.</b>
<b>How will data within the recordings be retrieved / transcribed? The data within the recordings will be retrieved and transcribed using a computer in a secured room.</b>
<b>How and where will recordings (e.g., tapes, digital data, data backups) be stored to ensure security? The recordings will be stored on a password restricted computer, accessible only by the investigators.</b>
<b>Who will have access to the recordings? Only the investigators will have access to the recordings.</b>
<b>Who will transcribe the recordings? Ashley Robinson will transcribe the recordings.</b>
<b>When will the recordings be erased / destroyed? The recordings will be erased / destroyed in five years.</b>

**Section 11: Research Involving Students**

**11.1 DOES THIS PROJECT INCLUDE STUDENTS AS PARTICIPANTS?**


- No, go to question 12.1
- Yes, answer questions within table 

IF YES
<b>Does this study involve conducting research with students of the researcher?</b> <input checked="" type="checkbox"/> No <input type="checkbox"/> Yes, describe safeguards the study will implement to protect against coercion or undue influence for participation:  <i>Note: if it is feasible to use students from a class of students not under the instruction of the researcher, the IRB recommends and may require doing so.</i>
<b>Will the study need to access student records (e.g., SAT, GPA, or GRE scores)?</b> <input checked="" type="checkbox"/> No <input type="checkbox"/> Yes



**11.2 DOES THIS PROJECT INCLUDE ELEMENTARY, JUNIOR, OR HIGH SCHOOL STUDENTS?**

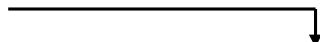
No, go to question 11.3

Yes, answer questions within table 

IF YES
<p><b>Will study procedures be completed during school hours?</b></p> <p><input checked="" type="checkbox"/> No  <input checked="" type="checkbox"/> Yes</p> <p><b>If yes,</b></p> <p><b>Students not included in the study may view other students' involvement with the research during school time as unfair. Address this issue and how the study will reduce this outcome: Students who are not included in the study will still participate in the workshop because it will be a part of the class curriculum. However, no written or verbal data will be collected from those students. When working in groups, the students participating in the study will be separated from students that are not participating in the study.</b></p> <p><b>Missing out on regular class time or seeing other students participate may influence a student's decision to participate. Address how the study will reduce this outcome: Students will not be missing out on regular class time if they choose or choose not to participate in the study. Answering survey and interview questions will be the only difference between participants and non-participants.</b></p>
<p><b>Is the school's approval letter(s) attached to this submission?</b></p> <p><input type="checkbox"/> Yes  <input type="checkbox"/> No, project involves Montgomery County Public Schools (MCPS)  <input checked="" type="checkbox"/> No, explain why: <b>The organizations need to see the IRB first. I will submit the approval letter as soon as possible.</b></p> <p><i>You will need to obtain school approval (if involving MCPS, click here: <a href="http://www.irb.vt.edu/pages/mcps.htm">http://www.irb.vt.edu/pages/mcps.htm</a>). Approval is typically granted by the superintendent, principal, and classroom teacher (in that order). Approval by an individual teacher is insufficient. School approval, in the form of a letter or a memorandum should accompany the approval request to the IRB.</i></p>

**11.3 DOES THIS PROJECT INCLUDE COLLEGE STUDENTS?**

No, go to question 12.1

Yes, answer questions within table 

IF YES
<p><b>Some college students might be minors. Indicate whether these minors will be included in the research or actively excluded:</b></p> <p><input type="checkbox"/> Included  <input type="checkbox"/> Actively excluded, describe how the study will ensure that minors will not be included:</p>
<p><b>Will extra credit be offered to subjects?</b></p> <p><input type="checkbox"/> No  <input type="checkbox"/> Yes</p> <p><b>If yes,</b></p> <p><b>What will be offered to subjects as an equal alternative to receiving extra credit without participating in this study?</b></p>

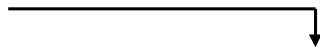
**Include a description of the extra credit (e.g., amount) to be provided within question 9.1 (“IF YES” table)**

## Section 12: Research Involving Minors

### 12.1 DOES THIS PROJECT INVOLVE MINORS (UNDER THE AGE OF 18 IN VIRGINIA)?

*Note: age constituting a minor may differ in other States.*

- No**, go to question 13.1  
 **Yes**, answer questions within table



**IF YES**

**Does the project reasonably pose a risk of reports of current threats of abuse and/or suicide?**

No  
 Yes, thoroughly explain how the study will react to such reports:

*Note: subjects and parents must be fully informed of the fact that researchers must report threats of suicide or suspected/reported abuse to the appropriate authorities within the Confidentiality section of the Consent, Assent, and/or Permission documents.*

---

**Are you requesting a waiver of parental permission (i.e., parent uninformed of child’s involvement)?**

No, **both** parents/guardians will provide their permission, if possible.  
 No, **only one** parent/guardian will provide permission.  
 Yes, describe below how your research meets **all** of the following criteria (A-D):

- Criteria A - The research involves no more than minimal risk to the subjects:
- Criteria B - The waiver will not adversely affect the rights and welfare of the subjects:
- Criteria C - The research could not practicably be carried out without the waiver:
- Criteria D - (Optional) Parents will be provided with additional pertinent information after participation:

---

**Is it possible that minor research participants will reach the legal age of consent (18 in Virginia) while enrolled in this study?**

No  
 Yes, will the investigators seek and obtain the legally effective informed consent (in place of the minors’ previously provided assent and parents’ permission) for the now-adult subjects for any ongoing interactions with the subjects, or analysis of subjects’ data? If yes, explain how:

*For more information about minors reaching legal age during enrollment, visit the following link:  
<http://www.irb.vt.edu/pages/assent.htm>*

---

*The procedure for obtaining assent from minors and permission from the minor’s guardian(s) must be described in **Section 4** (Consent Process) of this form.*

## Section 13: Research Involving Deception

For more information about involving deception in research and for assistance with developing your debriefing form, visit our website at <http://www.irb.vt.edu/pages/deception.htm>

### 13.1 DOES THIS PROJECT INVOLVE DECEPTION?

- No**, go to question 14.1
- Yes**, answer questions within table

IF YES
<b>Describe the deception:</b>
<b>Why is the use of deception necessary for this project?</b>
<b>Describe the debriefing process:</b>
<p><b>Provide an explanation of how the study meets <u>all</u> the following criteria (A-D) for an alteration of consent:</b></p> <p>Criteria A - The research involves no more than minimal risk to the subjects:                      Criteria B - The alteration will not adversely affect the rights and welfare of the subjects:                      Criteria C - The research could not practicably be carried out without the alteration:                      Criteria D - (Optional) Subjects will be provided with additional pertinent information after participation (i.e., debriefing for studies involving deception):</p> <p><i>By nature, studies involving deception cannot provide subjects with a complete description of the study during the consent process; therefore, the IRB must allow (by granting an alteration of consent) a consent process which does not include, or which alters, some or all of the elements of informed consent.</i></p> <p><i>The IRB requests that the researcher use the title "Information Sheet" instead of "Consent Form" on the document used to obtain subjects' signatures to participate in the research. This will adequately reflect the fact that the subject cannot fully consent to the research without the researcher fully disclosing the true intent of the research.</i></p>

**Section 14: Research Involving Existing Data**

**14.1 WILL THIS PROJECT INVOLVE THE COLLECTION OR STUDY/ANALYSIS OF EXISTING DATA DOCUMENTS, RECORDS, PATHOLOGICAL SPECIMENS, OR DIAGNOSTIC SPECIMENS?**

*Please note: it is not considered existing data if a researcher transfers to Virginia Tech from another institution and will be conducting data analysis of an on-going study.*

- No**, you are finished with the application
- Yes**, answer questions within table

IF YES
<b>From where does the existing data originate?</b>
<b>Provide a detailed description of the existing data that will be collected or studied/analyzed:</b>
<p><b>Is the source of the data public?</b></p> <p><input type="checkbox"/> No, continue with the next question  <input type="checkbox"/> Yes, you are finished with this application</p>
<p><b>Will any individual associated with this project (internal or external) have access to or be provided with existing data containing information which would enable the identification of subjects:</b></p> <ul style="list-style-type: none"> <li>▪ <b>Directly</b> (e.g., by name, phone number, address, email address, social security number, student ID number), or</li> <li>▪ <b>Indirectly through study codes</b> even if the researcher or research team does not have access to the master list linking study codes to identifiable information such as name, student ID number, etc or</li> </ul>

<p>▪ <b>Indirectly through the use of information that could reasonably be used in combination to identify an individual</b> (e.g., demographics)</p> <p><input type="checkbox"/> No, collected/analyzed data will be completely de-identified</p> <p><input type="checkbox"/> Yes,</p> <p><b>If yes,</b></p> <p><i>Research will not qualify for exempt review; therefore, if feasible, written consent must be obtained from individuals whose data will be collected / analyzed, unless this requirement is waived by the IRB.</i></p> <p><b>Will written/signed or verbal consent be obtained from participants prior to the analysis of collected data? -select one-</b></p>
---

*This research protocol represents a contract between all research personnel associated with the project, the University, and federal government; therefore, must be followed accordingly and kept current.*

*Proposed modifications must be approved by the IRB prior to implementation except where necessary to eliminate apparent immediate hazards to the human subjects.*

*Do not begin human subjects activities until you receive an IRB approval letter via email.*

*It is the Principal Investigator's responsibility to ensure all members of the research team who interact with research subjects, or collect or handle human subjects data have completed human subjects protection training prior to interacting with subjects, or handling or collecting the data.*

-----END-----

Dear Parent or Guardian,

My name is Ashley Robinson and I am a Ph.D. computer science student at Virginia Tech. I am offering a week long computer science workshop for middle school-aged girls. This workshop will be a part of your child's summer camp program on \_\_\_\_\_. I will like to invite your child to be a part of this workshop. In the workshop, your child will work in groups to do hands-on computer science-related tasks. The workshop will be no longer than one hour a day for five days. This workshop is a part of a research study. I will like to learn about the opinions that your child has about computers. In order to learn this, you child will be given surveys to complete before and after the workshop. I will also be interviewing your child on the last day of the workshop to learn about their views.

Permission must be provided by a parent or guardian before your child can be a part of the research study. If you would like your child to participate in this study, please return the attached permission forms and survey to your child's summer camp. Your child's name will not be used in any way as part of the written report.

Thank you for your time and consideration. Please email me at [arobin@vt.edu](mailto:arobin@vt.edu) or call me at 757-335-2270 if you have any questions.

Sincerely,

Ashley Robinson  
Ph.D. Student  
Department of Computer Science  
Virginia Tech

**VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY**  
**Parental Permission for Participants**  
**in Research Projects Involving Human Subjects**

**Title of Project:**       **Computational Thinking Workshop**

**Investigator(s):**       **Ashley Robinson, Manuel Pérez-Quñones, and Glenda Scales**

**I. Purpose of this Research Project**

The purpose of the research will be to teach girls about computer science. About 200 middle school-aged girls will be a part of the workshop. The girls will be from different ethnic and socioeconomic backgrounds. The results of this research study will be written up and publicized to meet graduate school requirements.

**II. Procedures**

This research will take place at the location of your child's program. Before the workshop, parents will be asked to complete a survey attached to this permission form. On the first day of the workshop, your child will be asked to complete a computer survey so that we can understand your child a little better. During the workshop, your child will work with hands-on activities that will teach them about computer science. The workshop will be 45 minutes to 1 hour per day for five days. Your child will be expected to attend the workshop for the entire five day period. At the end of the workshop, your child will be asked to complete another computer survey. Your child will also be asked several questions to learn about their perception of the workshop and the computer science field.

**III. Risks**

The risk of being a part of the study are minimal, such as a typical day at camp. To reduce the potential risks, your child will be allowed to take a break when needed or leave the study at any time. A person doing the study will also be around to provide assistance when needed.

**IV. Benefits**

The potential benefit of being a part of this research is that your child will learn about computer science careers. No promise of benefits has been made to get your child to participate.

**V. Extent of Anonymity and Confidentiality**

The results of this study will be kept strictly private. The answers that your child provides will have their names removed from any written reports. Your child's name, voice, and image will be stored separately in locked cabinets from the answers they provide. Only the people doing the study will be able to see your child's information. Your child's information will be destroyed in five years. At no time will the people doing the study give your child's information to anyone else without your written consent.

The Virginia Tech (VT) Institutional Review Board (IRB) may view the study's data for auditing purposes. The IRB is there to protect the people who take part in research.

**VI. Compensation**

If your child is a part of this study, it will be on a voluntary basis. Neither you nor your child will receive compensation as part of this research project.

**VII. Freedom to Withdraw**

Your child is free to leave this study at any time without penalty. You and your child are free not to answer any questions that you choose or respond to what is being asked of you without penalty.

**VIII. Parental Consent**

I have read the permission form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary permission:

\_\_\_\_\_  
Child's printed name

\_\_\_\_\_  
Parent/Guardian's printed name

\_\_\_\_\_  
Parent/Guardian's signature

Date \_\_\_\_\_

Please select one of the following:

- I **will** like to be contacted in the future for follow-up activities related to this research project.

Phone number \_\_\_\_\_ Email \_\_\_\_\_

- I **will not** like to be contacted in the future for follow-up activities related to this research project.

**IX. Questions or Concerns**

If you have any general questions or concerns, you may contact:

- **Ashley Robinson** at [arobin@vt.edu](mailto:arobin@vt.edu) or (757) 335-2270
- **Manuel Pérez-Quñones** at [perez@cs.vt.edu](mailto:perez@cs.vt.edu) or (540) 231-2646
- **Glenda Scales** at [gscases@vt.edu](mailto:gscases@vt.edu) or (540) 231-9754

Should you have any questions or concerns about how the study is done or your rights as a research participant, or need to report a research-related injury or event, you may contact the VT IRB Chair, Dr. David M. Moore at [moored@vt.edu](mailto:moored@vt.edu) or (540) 231-4991.

**VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY**

**Parental Video/Audio Permission for Participants  
in Research Projects Involving Human Subjects**

**Title of Project: Computational Thinking Workshop**

**Investigator(s): Ashley Robinson, Manuel Pérez-Quiñones, and Glenda Scales**

Only the people working on the research team will see the video or hear the audio from the workshop. Photo images of your child doing workshop activities and quotes from the audio may be placed in research write-ups. The research write-ups may be published. Also, your child's name will not be associated with their image or voice. Please select one of the four options listed below.

- I give the research team permission to use my child's image and voice for a research write-up.
- I give the research team permission to use only my child's image for a research write-up.
- I give the research team permission to use only my child's voice for a research write-up.
- I do not give the research team permission to use my child's image or voice for a research write-up.

\_\_\_\_\_  
Child printed name

\_\_\_\_\_  
Parent/Guardian signature

\_\_\_\_\_  
Date



**Virginia Polytechnic Institute and State University**

**Child Informed Assent**

**Title of Project:** Computational Thinking Workshop

**Investigator(s):** Ashley Robinson, Manuel Pérez-Quñones, and Glenda Scales

**I. Explanation of Research to Child**

**Introduction:** I am going to read you some information about what I am asking you to do today. Listen carefully. I will ask you at the end if you want to do this.

**Purpose:** I want to introduce middle school girls to computer science with a workshop.

**Procedure:** In the workshop, you will work in groups to do some tasks to help you think like a person in computer science. The workshop will be no longer than one hour a day for five days. This workshop is a part of a research project. I will like to learn about how you feel about computers. You will be asked to answer some questions on paper before and after the workshop. On the last day of the workshop, the entire group will be interviewed. This interview may be recorded.

**Risk:** There is very little risk to being a part of the workshop. The risk is the same as a usual day at camp.

**Benefits:** You will learn about computer science careers.

**Confidentiality:** No one outside this project will see the video or hear the audio from the workshop. Also, I will not use your name on anything.

**Compensation:** You will not be paid for being a part of this workshop.

**Freedom to Withdraw:** You should let me know if do not want to answer questions. You may choose to not take part in the study and workshop at any time.

**Participant Responsibility:** Please be honest when answering all questions. You will not get in trouble for being honest.

**II. Asking for Child's Verbal Assent**

Do you have any questions? Will you like to be a part of this workshop?

# **Appendix B**

## **Instrumentation**

**Background Questionnaire**

Parent/Guardian, please complete the survey below.

1. What is your child's age? \_\_\_\_\_
  
2. What will your child's grade level be in September 2013? (please circle one)  
6<sup>th</sup> grade    7<sup>th</sup> grade    8<sup>th</sup> grade    other (please specify): \_\_\_\_\_
  
3. What is your child's ethnicity? (please select all that apply)
  - White or Caucasian
  - Hispanic or Latino
  - Black or African American
  - Native American or American Indian
  - Asian / Pacific Islander
  - Other (please specify) \_\_\_\_\_
  - No response
  
4. Does your child use any of the following items at home? (please select all that apply)
  - Desktop computer
  - Laptop computer
  - Tablet computer (For example: iPad, Windows, Android device, etc.)
  - Smart phone (For example: Nexus 4, Samsung Galaxy, iPhone, etc.)
  - Video game console (For example: Play Station, Wii, Nintendo 64, Nintendo DS, etc.)
  - Other Technology (please specify) \_\_\_\_\_
  - No response
  
5. Does your child have Internet access at home?
  - Yes
  - No
  - No response



## Computer Confidence Survey

Brenda H. Loyd and Clarice P. Gressard  
University of Virginia

Participant ID \_\_\_\_\_ Date \_\_\_\_\_

Below are a list of statements. There are no correct answers to these statements. Place a CHECK in the space under the label which is closest to how you feel about the statements. It should take about five minutes to complete this survey. Your answers will be kept private. Please return the survey to your instructor when you are finished.

	<b>Strongly Agree</b>	<b>Slightly Agree</b>	<b>Slightly Disagree</b>	<b>Strongly Disagree</b>
1. I'm no good with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Generally, I would feel OK about trying a new problem on the computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I don't think I would do advanced computer work.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I am sure I could do work with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I'm not the type to do well with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. I am sure I could learn a computer language.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. I think using a computer would be very hard for me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. I could get good grades in computer courses.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. I do not think I could handle a computer course.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. I have a lot of self-confidence when it comes to working with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Computational Thinking Survey

Participant ID \_\_\_\_\_ Date \_\_\_\_\_

Below are a list of statements. There are no correct answers to these statements. Place a CHECK in the space under the label which is closest to how you feel about the statements. It should take about five minutes to complete this survey. Your answers will be kept private. Please return the survey to your instructor when you are finished.

	<b>Strongly Agree</b>	<b>Slightly Agree</b>	<b>Slightly Disagree</b>	<b>Strongly Disagree</b>
1. I can know what makes a computer task easy or hard.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. I can use computers to create the answer to a problem with a group.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. I can work with a group of people to show ideas with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. I can work with a group to make computers do what I want them to do.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. I can tell other people why I use a computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. I can use computers to help people.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. I can know how computers work by looking at pictures.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8. I can work with a group to create something new with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9. I can know what computers do by looking at pictures.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10. I can make computers do what I want them to do.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11. I can create things that people can use with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12. I can draw pictures to show how computers work.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13. I can work with other people to show how computers work.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14. I can use computers to show ideas.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	<b>Strongly Agree</b>	<b>Slightly Agree</b>	<b>Slightly Disagree</b>	<b>Strongly Disagree</b>
15. I can draw pictures to show what computers do.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16. I can teach other people how to use a computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17. I can make computers work better.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18. I can choose the right answer to a computer problem.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19. I can create new things with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20. I can use computers to create the answer to a problem.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21. I can learn what tools I need to create something with a computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22. I can explain how a computer works.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23. I can have an impact on the way people live with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. I can influence the way people play with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. I can tell other people how a computer works.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. I can affect the way people work with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. I can draw pictures to show how to use a computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28. I can find the causes of computer problems.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
29. I can tell other people why they should use a computer.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30. I can make tasks easier to do with computers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Items	Computational Thinking Practices
1. I can know what makes a computer task easy or hard.	Analyzing problems and artifacts
2. I can use computers to create the answer to a problem with a group.	Collaborating
3. I can work with a group of people to show ideas with computers.	Collaborating
4. I can work with a group to make computers do what I want them to do.	Collaborating
5. I can tell other people why I use a computer.	Communicating
6. I can use computers to help people.	Connecting Computing
7. I can know how computers work by looking at pictures.	Abstracting
8. I can work with a group to create something new with computers.	Collaborating
9. I can know what computers do by looking at pictures.	Abstracting
10. I can make computers do what I want them to do.	Developing computational artifacts
11. I can create things that people can use with computers.	Developing computational artifacts
12. I can draw pictures to show how computers work.	Abstracting
13. I can work with other people to show how computers work.	Collaborating

Table B.1 : Computational thinking survey items with associated computational thinking practices



<b>Items</b>	<b>Computational Thinking Practices</b>
14. I can use computers to show ideas.	Communicating
15. I can draw pictures to show what computers do.	Abstracting
16. I can teach other people how to use a computer.	Communicating
17. I can make computers work better.	Analyzing problems and artifacts
18. I can choose the right answer to a computer problem.	Analyzing problems and artifacts
19. I can create new things with computers.	Developing computational artifacts
20. I can use computers to create the answer to a problem.	Developing computational artifacts
21. I can learn what tools I need to create something with a computer.	Developing computational artifacts
22. I can explain how a computer works.	Analyzing problems and artifacts
23. I can have an impact on the way people live with computers.	Connecting Computing
24. I can influence the way people play with computers.	Connecting Computing
25. I can tell other people how a computer works.	Communicating
26. I can affect the way people work with computers.	Connecting Computing
27. I can draw pictures to show how to use a computer.	Abstracting

Table B.1 : Computational thinking survey items with associated computational thinking practices

<b>Items</b>	<b>Computational Thinking Practices</b>
28. I can find the causes of computer problems.	Analyzing problems and artifacts
29. I can tell other people why they should use a computer.	Communicating
30. I can make tasks easier to do with computers.	Connecting Computing

Table B.1: Computational thinking survey items with associated computational thinking practices

# Appendix C

## Qualitative Coding

Code	Definition	Inclusion (I) / Exclusion (E) Criteria	Example
ACTION	Indication of what someone plans to do or thinks others should do as it relates to computer science.		I am going to take a computer class in school. I think others should get more involved with computer science.
(+)ACTIVITY	A positive reference to a workshop activity, doing things in general, work, or the presentation slides; or the desire to do more.	(I) Do not forget references to drawing and the game because they were activities. (E) Do not use when casually mentioning the word work like when saying I worked on an iPad.	I enjoyed the game.
(-)ACTIVITY	A negative reference to a workshop activity, doing things in general, work, or the presentation slides; or the desire to do less.	(I) Do not forget references to drawing and the game because they were activities. (E) Do not use when casually mentioning the word work like when saying I worked on an iPad.	I hated the game.
(+)AFFECT	A description of personal positive feelings or emotions.		I am happy.

Table C.1 : Codebook

Code	Definition	Inclusion (I) / Exclusion (E) Criteria	Example
(-)AFFECT	A description of personal negative positive feelings or emotions.		I am sad.
(+)ASSESSMENT	Positive references toward complete surveys and answering questions and/or desiring more assessment.	(E) This code should be used when making references to drawing.	I like answering questions.
(-)ASSESSMENT	Negative references toward complete surveys and answering questions and/or desiring less or no assessment.	(E) This code should be used when making references to drawing.	The surveys had too many questions.
(+)AWARENESS	References to knowledge about computer science or a correct definition.		Computer science can involve programming. I finally know what computer science is now.

Table C.1 : Codebook

Code	Definition	Inclusion (I) / Exclusion (E) Criteria	Example
(-)AWARENESS	References to a lack of knowledge about computer science or an incorrect definition.		I don't know what computer science is. Computer science is doing science work on a computer.
(+)COLLABORATION	Any positive reference to working in a group.	(I) This code should be used whenever participants are referring to working in a group, even if they do not explicitly mention it.	My team worked well together.
(-)COLLABORATION	Any negative reference to working in a group or mentioning that collaboration does not exist.	(I) This code should be used whenever participants are referring to working in a group, even if they do not explicitly mention it.	My team did not include me.
(+)CS-PROSPECT	References to a desire to pursue computer science in the future or learn more about it.	(I) This code should be used whenever participants are referring to learning more about computer science or having a future in it, even if they do not explicitly mention it.	I think I want to do computer science when I grow up.

Table C.1 : Codebook

Code	Definition	Inclusion (I) / Exclusion (E) Criteria	Example
CS-PROSPECT	A reference to being indecisive about the desire to pursue computer science in the future or learn more about it (neutral).	(I) This code should be used whenever participants are referring to learning more about computer science or having a future in it, even if they do not explicitly mention it.	I want to be a singer but may do computer science if that does not work out.
(-)CS-PROSPECT	References to not wanting to pursue computer science in the future or learn more about it.	(I) This code should be used whenever participants are referring to learning more about computer science or having a future in it, even if they do not explicitly mention it.	I don't want to do computer science when I grow up. I want to be a singer when I grow up.
EMPOWERMENT	References to the ability to solve computer problems and do computer science.		I know what to do when the computer brakes. Working in computer science is achievable if I study.
(+)FRIENDS	A positive reference to friends or the desire to invite friends.	(I) This code should be used whenever participants are referring to their friends, even if they do not explicitly mention it.	My friends are here. I want to invite more friends.

Table C.1 : Codebook

Code	Definition	Inclusion (I) / Exclusion (E) Criteria	Example
FRIENDS	A reference to being indecisive about inviting friends or not specifying whether friends are a good or bad thing (neutral).	(I) This code should be used whenever participants are referring to their friends, even if they do not explicitly mention it.	I might want to invite my friends.
(-)FRIENDS	A negative reference to friends or no desire to invite friends.	(I) This code should be used whenever participants are referring to their friends, even if they do not explicitly mention it.	I do not want to invite my friends.
GENDER	Indication of gender (male and female).		I like working with girls.
IMPACT	References to a societal or personal impact of computer science; and how it is beneficial or helpful.		If we didn't have computer science then there would be no apps.
(+)IMPORTANCE	References to knowing the importance of computer science.		Computer science is important
(-)IMPORTANCE	References to considering computer science to be important.		Computer science is not important

Table C.1 : Codebook



<b>Code</b>	<b>Definition</b>	<b>Inclusion (I) / Exclusion (E) Criteria</b>	<b>Example</b>
INCENTIVE	Any references to candy, money, or any other treat as a reward.		I liked the candy.
INSTRUCTOR	Reference to instructor.	(I) This code should be used whenever participants make references to the instructor.	The teacher was great.
(+)KNOWLEDGE	Positive references about learning and education or desiring more knowledge.		I liked that we learned a lot. I wish we could learn more.
KNOWLEDGE	Neutral references about learning and education.		It was educational.
(-)KNOWLEDGE	Negative references about learning and education or desiring less knowledge.		I did not like that we worked a lot.
MOTIVE	The reason why they came to the workshop.		I came here because my friends are here.

Table C.1 : Codebook

<b>Code</b>	<b>Definition</b>	<b>Inclusion (I) / Exclusion (E) Criteria</b>	<b>Example</b>
(+)PERCEPTION	An adjective that positively describes experiences. Could also include a noun reference.		The workshop was great. Computer science is for everyone.
(-)PERCEPTION	An adjective that negatively describes experiences. Could also include a noun reference.		The workshop was boring. Computer science is for nerds.
(+)PHYSICAL-ENVIRONMENT	Positive references to the physical setting or things in the room.		I liked the small room.
(-)PHYSICAL-ENVIRONMENT	Negative references to the physical setting or things in the room.		The room was too small.
(+)SATISFACTION	A verb that indicates pleasure in the workshop or computer science.	(I) Only use this code when participants refer to the workshop or computer science in general.	I like the workshop.
(-)SATISFACTION	A verb that indicates a lack of pleasure in the workshop or computer science.	(I) Only use this code when participants refer to the workshop or computer science in general.	I do not like the workshop.

Table C.1 : Codebook

<b>Code</b>	<b>Definition</b>	<b>Inclusion (I) / Exclusion (E) Criteria</b>	<b>Example</b>
(+)SOCIAL-ENVIRONMENT	Positive references to other people and interactions in the room.		The people in this workshop were awesome.
(-)SOCIAL-ENVIRONMENT	Negative references to other people and interactions in the room.		I did not like the children in this workshop.
(+)STUDENT-TEACHER-RATIO	Positive reference to number of instructors and students		I like the amount of students in the class.
(-)STUDENT-TEACHER-RATIO	Negative reference to number of instructors and students.		I wish there were more students in the class.
TECHNOLOGY	Any reference to a computing device (or technology like the Internet) and/or the desire to use it more.		I like iPads.
(+)TIMING	References to the workshop or activity being too short and/or the desire for the workshop to be longer. Also satisfaction with the day or time of day.		I wish the workshop could be an entire month.

Table C.1 : Codebook

Code	Definition	Inclusion (I) / Exclusion (E) Criteria	Example
(-)TIMING	References to the workshop or activity being too long and/or the desire for the workshop to be shorter. Also, desire for a different day or time of day.		One hour a day was too long for the workshop.
SCHOOL	References to school or a class in school.	(I) Use this code when participants reference school	We do this in school.

Table C.1: Codebook

Timestamp	Speaker	Site6Day5	Coder 1	Coder 2
01:37.0	8.6	I think today, I think the whole entire week was really good cause I learned a lot about computer science and I think computer science is more than what you think and you...I'm trying to make sure [mumbled under breath]...It's more than what you think cause you can like learn like you can make robots move and I think one day somebody, I might	ACTION	ACTION
02:04.0	12.6	uh...I think today is going to be the best and day that we started playing cargo bot was fun cause it taught me a lot of stuff, how to like handle	(+) ACTIVITY	(+) SATISFACTION
02:04.0	12.6	uh...I think today is going to be the best and day that we started playing cargo bot was fun cause it taught me a lot of stuff, how to like handle	(+) KNOWLEDGE	(+) KNOWLEDGE
02:19.0	9.6	9.6, I think about this workshop thing, it was fun because we got to learn about science because I didn't know a lot about science besides [inaudible] over here talking	(+) PERCEPTION	(+) PERCEPTION
02:19.0	9.6	9.6, I think about this workshop thing, it was fun because we got to learn about science because I didn't know a lot about science besides [inaudible] over here talking	(+) KNOWLEDGE	(+) KNOWLEDGE
02:19.0	9.6	9.6, I think about this workshop thing, it was fun because we got to learn about science because I didn't know a lot about science besides [inaudible] over here talking	(-) AWARENESS	(-) AWARENESS
02:31.0	15.6	Uh, I learned...15.6. I learned about um...in the game cargo bot, I learned about um...like the steps before to like abstraction and...	(+) KNOWLEDGE	(+) KNOWLEDGE
02:44.0	15.6	...steps before and after	(+) KNOWLEDGE	(+) KNOWLEDGE
02:51.0	13.6	I think it was really cool [inaudible background convo]	(+) PERCEPTION	(+) PERCEPTION
03:05.0	13.6	But anyway, um...I thought it was really cool that I could learn about this stuff and plus like when we played the game like when we had	(+) PERCEPTION	(+) PERCEPTION
03:05.0	13.6	But anyway, um...I thought it was really cool that I could learn about this stuff and plus like when we played the game like when we had	(+) KNOWLEDGE	(+) KNOWLEDGE
03:05.0	13.6	But anyway, um...I thought it was really cool that I could learn about this stuff and plus like when we played the game like when we had	(+) ACTIVITY	(+) ACTIVITY
03:05.0	13.6	But anyway, um...I thought it was really cool that I could learn about this stuff and plus like when we played the game like when we had	(+) COLLABORATION	(+) COLLABORATION
03:20.0	13.6	and we did teamwork to finish [playing? Inaudible]	(+) COLLABORATION	(+) COLLABORATION
03:23.0	13.6	and I think it was challenging and it was fun	(-) PERCEPTION	(+) SATISFACTION
03:23.0	13.6	and I think it was challenging and it was fun	(+) PERCEPTION	(+) PERCEPTION
03:30.0	7.6	I think that uh, it was really, it was really fun and we learned a lot [inaudible] and mess and um...I really learned a lot about like stuff, like how to do things like [inaudible] and mess	(+) PERCEPTION	(+) PERCEPTION
03:30.0	7.6	I think that uh, it was really, it was really fun and we learned a lot [inaudible] and mess and um...I really learned a lot about like stuff, like how to do things like [inaudible] and mess	(+) KNOWLEDGE	(+) KNOWLEDGE
03:30.0	7.6	I think that uh, it was really, it was really fun and we learned a lot [inaudible] and mess and um...I really learned a lot about like stuff, like how to do things like [inaudible] and mess	(+) KNOWLEDGE	(+) KNOWLEDGE
04:04.0	4.6	I think it was cool for you to um...teach us the education and everything so like when we go back to school, we can like tell our teachers and everything and um...I just want to thank you just for all the teaching and	(+) PERCEPTION	(+) PERCEPTION
04:04.0	4.6	I think it was cool for you to um...teach us the education and everything so like when we go back to school, we can like tell our teachers and everything and um...I just want to thank you just for all the teaching and	(+) KNOWLEDGE	(+) KNOWLEDGE
04:04.0	4.6	I think it was cool for you to um...teach us the education and everything so like when we go back to school, we can like tell our teachers and everything and um...I just want to thank you just for all the teaching and	SCHOOL	ACTION
04:38.0	8.6	I think it was a great experience...	(+) SATISFACTION	(+) KNOWLEDGE
04:43.0	8.6	cause you get to learn like more, more than anything than average [guy? Inaudible]	(+) KNOWLEDGE	(+) KNOWLEDGE

Figure C.1: Coding sample

# Appendix D

## Results

Participant Characteristics		HCI (n=23)	Algorithms (n=14)	Total (n=37)
Grade Level	6	47.8% (11)	57.1% (8)	51.4% (19)
	7	30.4% (7)	14.3% (2)	24.3% (9)
	8	21.7% (5)	28.6% (4)	24.3% (9)
Ethnicity	Black	78.3% (18)	85.7% (12)	81.1% (30)
	Other Minority	4.3% (1)	7.1% (1)	5.4% (2)
	Multiple Ethnicities	17.4% (4)	7.1% (1)	13.5% (5)
Home Use	Desktop	52.2% (12)	85.7% (12)	64.9% (24)
	Laptop	60.9% (14)	71.4% (10)	64.9% (24)
	Tablet	69.6% (16)	64.3% (9)	67.6% (25)
	Smart Phone	60.9% (14)	64.3% (9)	62.2% (23)
	Video Game Console	82.6% (19)	71.4% (10)	78.4% (29)
	Other Devices	4.3% (1)	14.3% (2)	8.1% (3)
Home Internet	No	4.3% (1)	—	2.7% (1)
	Yes	95.7% (22)	92.9% (13)	94.6% (35)
	No Response	—	7.1% (1)	2.7% (1)
Father's Education	Less than High School	8.7% (2)	—	5.4% (2)
	High School	47.8% (11)	64.3% (9)	54.1% (20)
	Associates	4.3% (1)	—	2.7% (1)
	Bachelor's	13.0% (3)	14.3% (2)	13.5% (5)
	Master's or Above	13.0% (3)	14.3% (2)	13.5% (5)
	No Response	13.0% (3)	—	8.1% (3)
Mother's Education	Less than High	8.7% (2)	—	5.4% (2)
	High School	43.5% (10)	28.6% (4)	37.8% (14)
	Certification	4.3% (1)	—	2.7% (1)
	Associates	13.0% (3)	50.0% (7)	27.0% (10)
	Bachelor's	13.0% (3)	14.3% (2)	13.5% (5)
	Master's or Above	17.4% (4)	7.1% (1)	13.5% (5)

Table D.1 : Participant characteristics

Participant Characteristics		HCI (n=23)	Algorithms (n=14)	Total (n=37)
Socioeconomic Status	Low	47.8% (11)	57.1% (8)	51.4% (19)
	Medium/High	52.2% (12)	35.7% (5)	45.9% (17)
	No Response	—	7.1% (1)	2.7% (1)
School Grades	Mostly C's and D's	4.3% (1)	7.1% (1)	5.4% (2)
	Mostly C's	8.7% (2)	—	5.4% (2)
	Mostly B's and C's	30.4% (7)	7.1% (1)	21.6% (8)
	Mostly B's	4.3% (1)	21.4% (3)	10.8% (4)
	Mostly A's and B's	43.5% (10)	35.7% (5)	40.5% (15)
	Mostly or All A's	4.3% (1)	21.4% (3)	10.8% (4)
	No Response	4.3% (1)	7.1% (1)	5.4% (2)

Table D.1: Participant characteristics



Items	Pre-workshop (n=37)			Post-workshop (n=32)		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
1. I'm no good with computers*	3.05	4.00	1.153	3.16	4.00	1.081
2. Generally, I would feel OK about trying a new problem on the computer.	2.95	3.00	1.053	3.38	4.00	.871
3. I don't think I would do advanced computer work.*	3.00	3.00	1.027	2.69	3.00	1.120
4. I am sure I could do work with computers.	3.35	4.00	.857	3.56	4.00	.669
5. I'm not the type to do well with computers.*	3.24	4.00	1.011	3.25	4.00	.984
6. I am sure I could learn a computer language.	2.78	3.00	1.084	3.03	3.00	1.092
7. I think using a computer would be very hard for me.*	3.68	4.00	.669	3.47	4.00	.950
8. I could get good grades in computer courses.	3.05	3.00	.970	3.19	3.00	.931
9. I do not think I could handle a computer course.*	3.16	4.00	.958	3.47	4.00	.915
10. I have a lot of self-confidence when it comes to working with computers.	3.00	4.00	1.130	3.25	3.00	.880
Total Survey Score	31.27	31.00	5.556	32.44	32.50	4.892

Table D.2: Computer confidence survey descriptive statistics

\* Reverse coded item

Items	Pre-workshop (n=37)			Post-workshop (n=32)		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
1. I can know what makes a computer task easy or hard.	2.68	3.00	1.180	2.72	3.00	1.085
2. I can use computers to create the answer to a problem with a group.	3.14	4.00	1.134	3.00	3.00	.984
3. I can work with a group of people to show ideas with computers.	3.11	3.00	1.048	2.97	3.00	1.092
4. I can work with a group to make computers do what I want them to do.	2.84	3.00	1.167	2.72	3.00	1.054
5. I can tell other people why I use a computer.	3.76	4.00	.597	3.41	4.00	.979
6. I can use computers to help people.	3.30	4.00	1.024	3.37	4.00	.833
7. I can know how computers work by looking at pictures.	2.35	2.00	1.230	2.81	3.00	1.120
8. I can work with a group to create something new with computers.	3.08	3.00	1.064	3.09	3.50	1.118
9. I can know what computers do by looking at pictures.	2.24	2.00	1.116	2.88	3.00	1.100
10. I can make computers do what I want them to do.	2.86	3.00	1.004	2.75	3.00	1.218

Table D.3 : Computational thinking survey descriptive statistics

Items	Pre-workshop (n=37)			Post-workshop (n=32)		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
11. I can create things that people can use with computers.	2.70	3.00	1.175	3.19	3.00	.896
12. I can draw pictures to show how computers work.	2.32	2.00	1.180	3.16	4.00	1.081
13. I can work with other people to show how computers work.	3.00	4.00	1.179	3.41	4.00	.946
14. I can use computers to show ideas.	3.46	4.00	.836	3.50	4.00	.803
15. I can draw pictures to show what computers do.	2.46	2.00	1.120	3.12	3.50	1.070
16. I can teach other people how to use a computer.	3.41	4.00	.832	3.50	4.00	.762
17. I can make computers work better.	2.27	2.00	1.146	2.87	3.00	1.008
18. I can choose the right answer to a computer problem.	2.73	3.00	1.045	3.12	3.00	1.008
19. I can create new things with computers.	2.86	3.00	1.206	3.38	3.50	.751
20. I can use computers to create the answer to a problem.	2.95	3.00	1.104	3.25	4.00	.950
21. I can learn what tools I need to create something with a computer.	3.03	3.00	1.142	3.03	3.50	1.121

Table D.3 : Computational thinking survey descriptive statistics

Items	Pre-workshop (n=37)			Post-workshop (n=32)		
	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.
22. I can explain how a computer works.	2.76	3.00	1.211	3.47	4.00	.842
23. I can have an impact on the way people live with computers.	2.65	3.00	1.060	2.78	3.00	1.008
24. I can influence the way people play with computers.	2.81	3.00	.995	3.34	4.00	.787
25. I can tell other people how a computer works.	2.73	3.00	1.194	3.19	4.00	.998
26. I can affect the way people work with computers.	2.54	2.00	1.120	3.09	4.00	1.118
27. I can draw pictures to show how to use a computer.	2.24	2.00	1.164	3.03	3.00	1.062
28. I can find the causes of computer problems.	2.46	3.00	1.120	2.63	3.00	1.040
29. I can tell other people why they should use a computer.	3.30	4.00	1.077	3.31	4.00	.931
30. I can make tasks easier to do with computers.	2.81	3.00	.938	3.19	3.00	.965
Total Survey Score	86.05	88.00	16.575	93.28	92.00	14.514

Table D.3: Computational thinking survey descriptive statistics

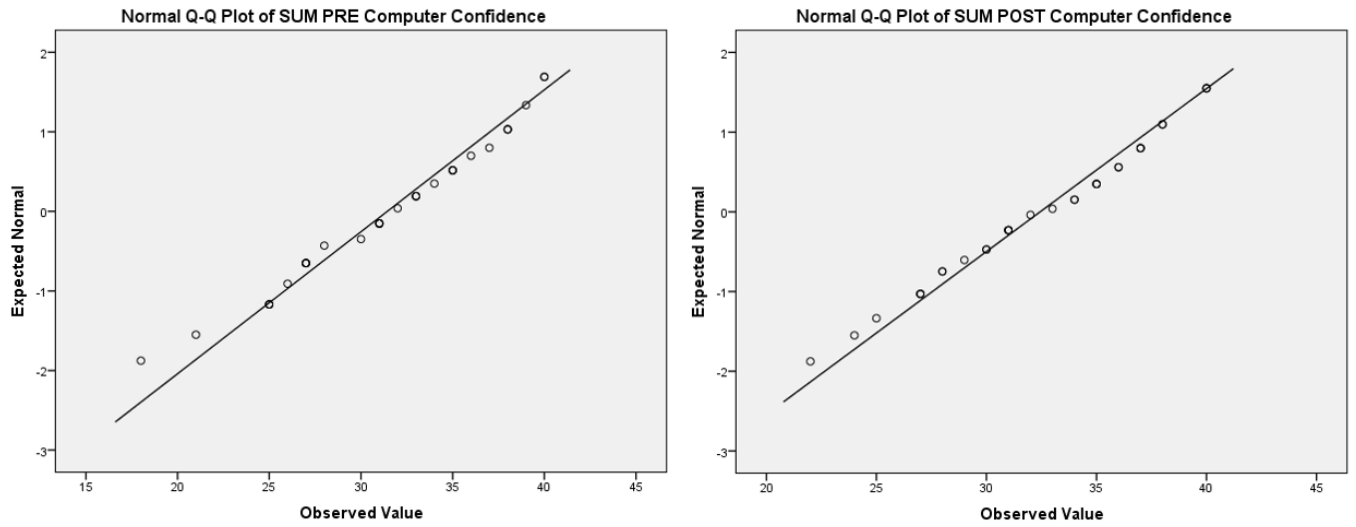


Figure D.1: Normal Q-Q plots of all pre- (left) and post-workshop (right) computer confidence survey scores

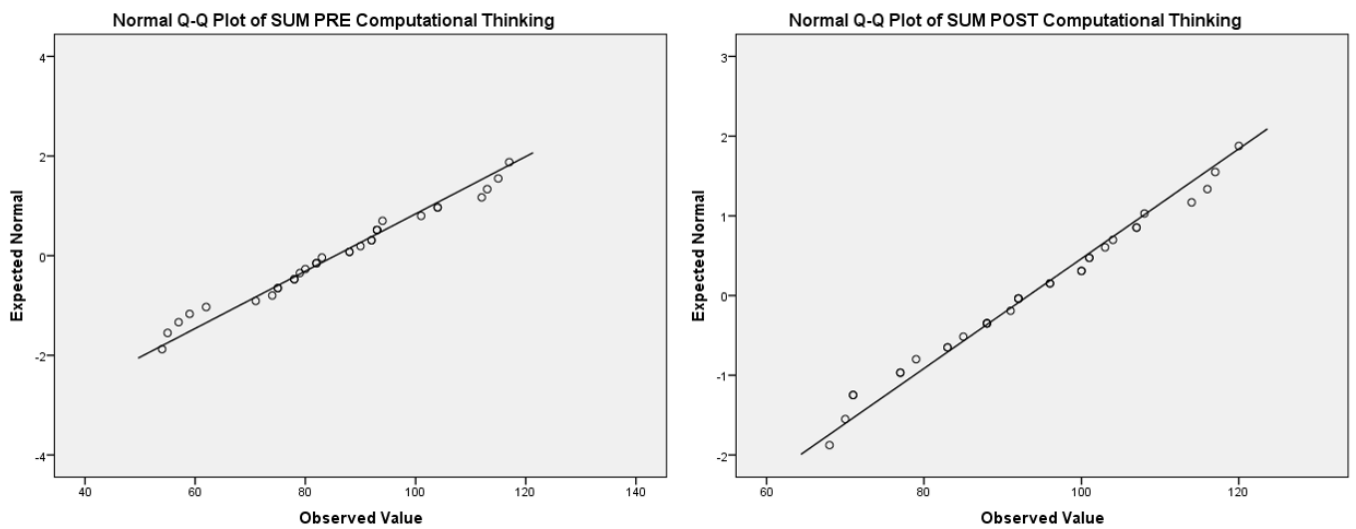


Figure D.2: Normal Q-Q plots of all pre- (left) and post-workshop (right) computational thinking survey scores

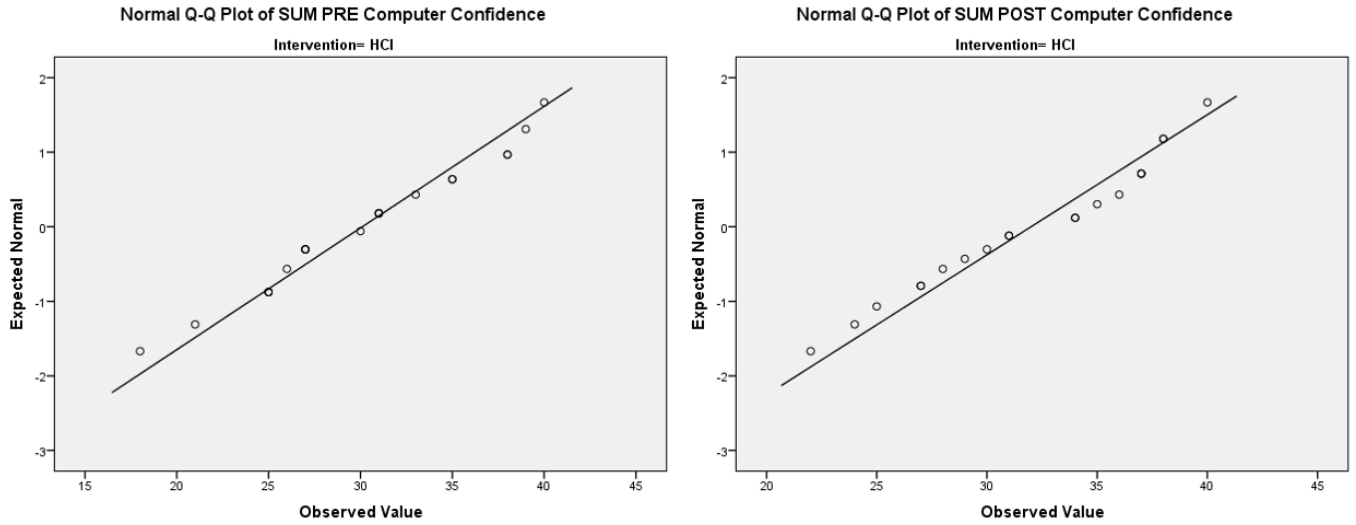


Figure D.3: Normal Q-Q plots of the HCI group’s pre- (left) and post-workshop (right) computer confidence survey scores

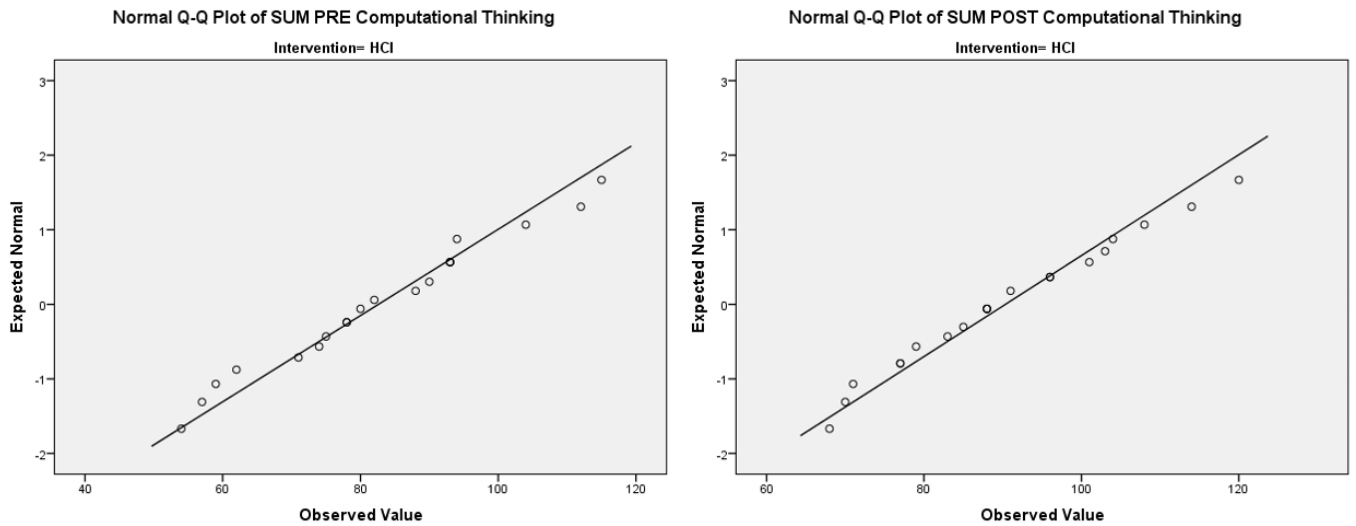


Figure D.4: Normal Q-Q plots of the HCI group’s pre- (left) and post-workshop (right) computational thinking survey scores

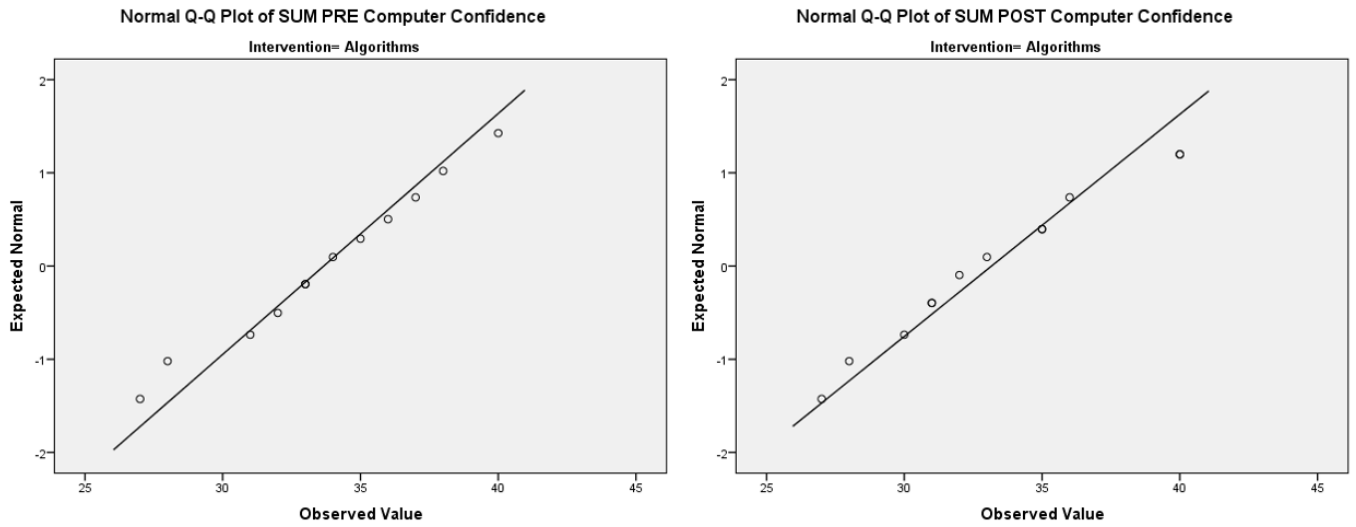


Figure D.5: Normal Q-Q plots of the Algorithms group’s pre- (left) and post-workshop (right) computer confidence survey scores

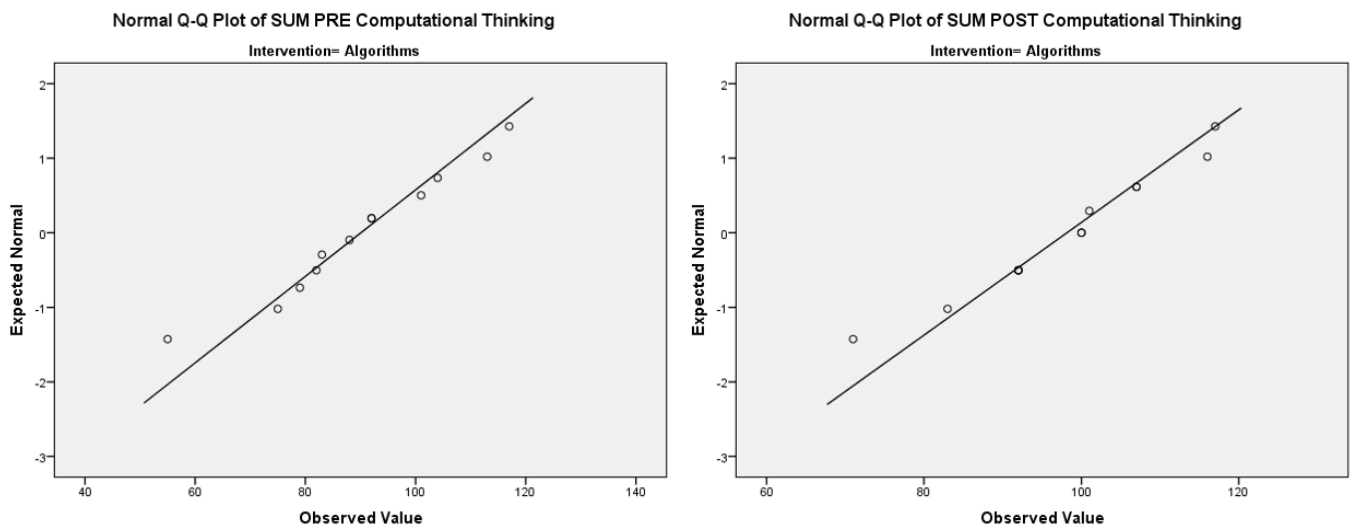


Figure D.6: Normal Q-Q plots of the Algorithms group’s pre- (left) and post-workshop (right) computational thinking survey scores

Pre-Workshop Survey	Domain	N	Mean	Std. Dev.	Std. Error	Levene's Test for Equality of Variances		T-test for Equality of Means		
						F	Sig.	t	df	Sig. (2-tailed)
Computer Confidence	HCI	23	30.43	5.938	1.238	1.209	.279	-1.179	35	.246
	Algorithms	14	32.64	4.749	1.269					
Computational Thinking	HCI	23	84.00	16.941	3.532	.389	.537	-.965	35	.341
	Algorithms	14	89.43	15.979	4.271					

Table D.4: Independent samples t-test of pre-workshop survey scores