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Under construction: Minority girls becoming technologically fluent in an urban after-school program

A dissertation submitted in partial satisfaction of the

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in Education

by

Yvonne De La Peña

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ABSTRACT OF THE DISSERTATION

Under construction: Minority girls becoming technologically fluent

in an urban after-school program

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Doctor of Philosophy in Education

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Professor Aimée Dorr, Chair

Technological fluency involves having a deep understanding of information technology as well as an identity as someone who engages with technology in meaningful and complex ways. Hence, it is more fruitful to think about individuals not as developing technological fluency but rather as becoming technologically fluent. Although physical access to technology is increasing for all youth, a meaningful gap still exists in regard to opportunities for them to engage with it in complex and meaningful ways (Warschauer & Matuchniak, 2010) and hence become technologically fluent. My dissertation work focused on one such opportunity.

Specifically, this dissertation explores the acquisition of sophisticated technological knowledge and skills by fourteen low-income Latinas between the ages of 11- and 18-years old, their identity development in regard to engaging with technology, and the characteristics of the learning environment within which their engagements with technology occurred. At the heart of my research was a theoretically framed learning environment consisting of a programming workshop offered at a community technology center located in a low-income community of Los Angeles, California. Data sources included interviews, focus groups, observations, and artifacts.

Analyses showed that the learning environment's characteristics motivated and supported the participants in their development of several of the technological capabilities, concepts, and skills included in the framework for technological fluency put forward by the National Research Council (1999), and in particular programming knowledge and skills. Moreover, although a significant change in participants' identity was not observed at the end of the workshop, the diversity of experiences, learning outcomes, and self-beliefs reflected in the data suggested that participants' identity, as much as their development of technological knowledge and skills, was at play as they engaged in the workshop. This dissertation highlights a learning environment that successfully supported young Latinas as they became technologically fluent and attested to the feasibility of community technology centers as a viable alternative for making complex and meaningful technological activities accessible to girls.

The dissertation of Yvonne De La Peña is approved.

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2012

Dedication Page

I dedicate this dissertation to all the women who fought, continue to fight, and will fight for my right as a woman to be educated.

I dedicate this dissertation to all the women who fought, continue to fight, and will fight for my right as a woman to be interested in technology.

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Chapter I

Introduction

In their report, Being Fluent with Information Technology, the National Research Council (1999) mentioned that a more “effective use of whatever technology is available” is among the many advantages of having an understanding of information technology. The NRC also pointed out that given the rapid changes that information technology goes through, skills associated with specific applications are not sufficient any more. To prosper in the information age, it is now necessary to acquire deeper understanding, to acquire fluency. Acquiring fluency involves acquiring sufficient foundational understanding to enable one to acquire new technological skills on the fly and whenever needed. In addition, the NRC argued that acquiring fluency is a lifetime process during which an individual is motivated to use current technological knowledge and skills to acquire new knowledge and skills.

At the same time, researchers have been advocating for a re-definition of the concept of “digital divide” to include not only physical access to technology but also experiences with technology and the different socio-economic and cultural aspects of these experiences. They have argued that although physical access to technology is increasing for all youth, a meaningful gap still exists in regard to opportunities to engage with it in complex and meaningful ways (for a review, see Warschauer & Matuchniak, 2010). That this gap still exists is especially relevant to the subject of technological fluency and its development, as it is within complex and meaningful engagements that the development of technological fluency is most likely to occur (Barron, 2004; Barron, Walter, Kennedy Martin, & Schatz, 2010; Resnick, Rusk, & Cook, 1998). If youth lack opportunities to engage with technology in complex and meaningful ways, they will have fewer opportunities to develop their technological fluency.

Lack of access to opportunities to engage with technology in complex and meaningful ways and develop technological fluency can be due in part to physical and structural constraints, in particular for minority and low-income youth (for a review, see Warschauer & Matuchniak, 2010); however, it could also be influenced by something closer to home, namely, identity. Although not always explicit in the conversations of what technological fluency is and the types of technological activities that promote it, developing technological fluency is intricately related to identity. If developing technological fluency is a lifetime process during which an individual chooses to engage in complex technological activities, then it is an individual's sense of competence and values as part of his/her identity that provide the motivation and confidence to do so (Eccles, 2009). Hence, when thinking about individuals and their technological fluency, it is more fruitful to think about individuals not as developing technological fluency but rather as becoming technologically fluent. Becoming technologically fluent involves having a deep understanding of information technology as well as developing an identity as someone who engages with technology in meaningful and complex ways.

Thinking in terms of individuals becoming technologically fluent instead of just developing technological fluency could prove especially fruitful in our efforts to address the underrepresentation of women in technology and in particular in computing. Despite the advances women have made in obtaining college degrees, they are still underrepresented in this field (Cohon & Aspray, 2006; Freeman, 2004; Peter, Horn, & Carroll, 2005). Past research has shown that both previous computing experience (Barron, 2004; Kolikant & Ben-Ari, 2008 Margolis & Fisher, 2004) and identity (Farmer, 2008; Margolis & Fisher, 2004; Rosenthal, London, Levy, & Lobel, 2011) play a role in students' computing engagements. However, although girls may be as likely as boys to use a computer on any given day (Roberts, Foehr, & Rideout, 2005), they more often engage in less complex technological activities (Ito et al., 2008; Roberts, Foehr, & Rideout, 2005; Warschauer & Matuchniak, 2010). Hence their opportunities to become technologically fluent in terms of developing both a deep understanding of information technology and an identity as someone who is able– and for whom it is appropriate– to engage with technology in meaningful and complex ways are diminished.

Becoming Technologically Fluent through Computer Programming

Creating a computer program is a technological activity that can provide an opportunity for girls to become technologically fluent. First, in addition of programming knowledge being a component of technological fluency, designing and creating a computer program is a technological activity that allows for the development of many of the other skills, concepts, and capabilities included in the NRC's (1999) intellectual framework for technologically fluency (see Figure 1, p. 14). For example, Campe, Werner, and Denner (2005) described a study that looked at girls programming their own digital games during an after-school program. Based on their findings, they argued that most of the girls developed technological fluency capabilities such as sustained reasoning and managing complexity and technological fluency concepts such as algorithmic thinking and information organization.

Second, programming is an activity that can provide girls with opportunities to see themselves as capable to take part in complex computer activities. A programming activity allows for the observation of immediate results and privileges the process of solving a problem over trying to find the right solution. Programming problems "only have better or worse answers, not right and wrong answers" (McCracken, 2005, p. 159). Hence, by engaging in a programming activity, a girl can come to feel technologically competent by understanding not only how technology functions but also that competence in relation to technology is developed over time.

Third, programming has been seen traditionally as the realm of a certain kind of person, someone decisive and eager to control, characteristics most often associated with boys (Cohoon & Aspray, 2006; Margolis & Fisher, 2002; Turkle, 2005). However, a meaningful personal experience with programming may give girls the opportunity to question this stereotype and play a positive role in their development of an identity as someone for whom it is appropriate to engage with technology in meaningful and complex ways.

Becoming Technologically Fluent Outside of School

Frequently, access to activities that promote technological fluency and to programming in particular is very limited for youth and almost nonexistent for girls and minorities (for a review, see Warschauer & Matuchniak, 2010). In the past, schools would offer some programming classes teaching languages such as Basic, Logo, or Pascal. However, for a number of reasons, schools are feeling pressured to remove courses that do not fulfill graduation requirements and/or are not directly assessed in state accountability measures, leaving access to programming classes only to a selected few (Margolis, Holme, Estrella, Goode, & Nao, Stumme, 2003). One approach to increasing girls' access to activities that could give them the opportunity to become technologically fluent is to identify alternative venues, such as community technology centers (CTCs), that will make these activities more readily available to them. CTCs are promising environments to investigate because of their connection to culturally diverse communities, focus on projects based on members' own interests, and ability to provide safe and supportive environments to work on subjects that often elude youth at school. Moreover, through their after-school programs, CTCs can serve as places where youth can access resources important to the development of identity (Eccles & Templeton, 2002; Hirsch, 2005; London, Pastor, Servon, Rosner, & Wallace, 2010).

Context and Importance of the Study

My dissertation work explores the development of technological fluency, including the acquisition of programming skills and concepts, by fourteen low-income Latinas between the ages of 11- and 18-years old, their development of identity as users of computers, and the characteristics of the learning environment within which their programming activities occurred. At the heart of my research was a theoretically framed learning environment consisting of a programming workshop offered at a CTC located in a low-income community of Los Angeles, California. Four areas of inquiry informed the design, implementation, and investigation of the learning environment: the learning sciences, computer science education research, identity development, and women and technology. At the time this study took place, all fourteen participants frequently attended the CTC and the researcher had been volunteering for a year in a variety of activities (e.g., homework lab, reading club, computer lab) prior to the implementation of the programming workshop.

Projects aimed at helping girls become technologically fluent and in particular getting them interested in programming are few. For example, in 2004 the AAUW Educational Foundation found that of 416 projects conducted between 1993 and 2001 and aimed at encouraging girls and women to pursue STEM fields only 14% targeted depth of knowledge activities (e.g., programming and robotics projects) while 54% focused on application skills (e.g., power point, spreadsheets) and 41% focused on awareness, motivation, and interest. Furthermore, although 30% of the projects included some sort of mentoring, an activity that could potentially influence identity (McGrath & Aspray, 2006), none of them looked at the participants' identity in relation to technology and/or programming. Findings from my dissertation study make a needed contribution by documenting and shining a light on girls', and in particular low-income Latinas, development of technological fluency, their identity vis-à-vis this development, and the characteristics of the learning environment that supported both.

Overview of Chapters

In addition to this, the introductory and first chapter, the dissertation includes ten other chapters. The second chapter provides the background to the study, including a brief description of the different arguments researchers have given advocating for individuals' development of technological fluency as well as a description of technological fluency as conceptualized by the NRC (1999). In addition, this chapter includes a description of different efforts that have been made to help students learn programming, from some of the different programming environments that have been created to approaches that have focused on the learning environment within which students develop their programming knowledge and skills. Finally, the chapter introduces the role that identity may play in the process of becoming technologically fluent.

The third chapter introduces the theoretical framework behind the study. As was mentioned before, four different areas of inquiry informed the study. This chapter briefly describes each of these areas and the ways in which findings from each of them informed the design, implementation, and investigation of the learning environment. In addition, three research questions guided the investigation of the learning environment. The first question pertained to the participants' development of technological fluency, the second question pertained to their identity, and the third question pertained to the interrelationship between their development of technological fluency and their identity. All three questions are presented in this chapter.

The fourth chapter outlines the study's research methods. Specifically, it includes a description of the participants, research site, and technology used by the participants during the workshop. In addition, the chapter includes a description of how participants were recruited and an overview of what transpired during the workshop's sessions. The chapter ends with a description of the different data sources that were used during the analysis phase of the study.

In order to pursue the study's investigation into participants' development of technological fluency and its relationship to their identity, it was first necessary to assess this development. Hence, the fifth chapter describes how participants' development of technological fluency was assessed and includes evidence of participants' development of technological fluency in regards to each of its three dimensions (i.e., technological skills, technological concepts, intellectual capabilities). The following chapter, chapter six, presents the results of the investigation as they pertain to the first research question, namely the characteristics of the learning environment that might have played a role in participants' development of technological fluency. The chapter includes a description of what data were used and how they were used to arrive at the conclusions presented.

The seventh and eight chapters present the investigation into participants' identity as users of computers and the characteristics of the learning environment as they related to the participants' identity. In particular, chapter seven describes the measure used to assess participants' identity, participants' scores before and after the workshop and any meaningful changes, and participants' responses to the individual questions in the measure. Chapter eight presents the results of the investigation as they pertain to the second research question, namely the characteristics of the learning environment that might have played a role in participants' development of an identity as technologically fluent. Similarly to chapter six, this chapter includes a description of what data were used and how the data were used to arrive at the conclusions presented.

The ninth chapter presents the investigation of the relationship between participants' development of technological fluency and their identity. This analysis utilized contingency tables to explore the relationship between participants' level of technological fluency attained and their self-concept score previous to the workshop, any meaningful changes in their self-concept, and their self-concept score after the workshop controlling for their pre workshop self-concept score.

The investigation of the characteristics of the learning environment and their role in regard to participants' development of technological fluency and their identity were conducted based on the researcher's perceptions. In order to better understand this process an analysis of participants' perceptions of their learning and the learning environment was conducted as well. The tenth chapter presents the results of this analysis and describes how participants' perceptions may compare to those of the researcher.

Finally, the eleventh chapter presents a discussion of the findings in light of existing research as well as potential limitations of the study and its findings, and recommendations for further research.

Chapter II

Background

The need for individuals to develop fluency with technology has been advocated by a number of researchers. The arguments they give are varied. Some researchers argue that we no longer live in an economy based on material goods but rather in an economy based on information. The nature of work, wealth, and poverty has changed and consequently so have the types of competence needed for successful participation (Lievrouw & Farb, 2003; McNutt, Quiero-Tajalli, Boland & Campbell, 2001; Morse, 2004). In this new information economy having the ability to access, adapt, and create new knowledge using new information and communication technology is critical for social inclusion and economic development (Warschauer, 2003).

Other researchers draw attention to the small size of the IT workforce pool. They argue that this contributes not only to the fact that many IT jobs go unfilled but also to the lack of diversity within the IT workforce (Barker & Aspry, 2006; Borg, 2002; McClelland, 2001). This lack of diversity is of most concern as it might help maintain the status quo and contribute to the needs and interests of different segments of the population being overlooked. Having a deeper understanding of technology may help motivate youth of diverse backgrounds to pursue technology-oriented careers and be successful at them (Barron, 2004; Margolis & Fisher, 2003).

Finally, a third argument given by researchers is that learning is multimodal and hence technology can be an effective tool for learning (see, e.g., Burn & Parker, 2003; Jewitt, 2003). Yet it is not enough to bring technology into the classroom, the way in which it is used matters. Different kinds of uses afford different kinds of learning. When used in meaningful and profound ways, technology can facilitate deep learning (diSessa, 2000; Papert, 1993). As schools incorporate technology into education, it is in the best interest of all students to learn to engage with it in complex ways. For all of these reasons and more it becomes clear that developing technological fluency is a desirable endeavor.

Technological Fluency

A fundamental premise behind the concept of technological fluency is the fact that technology is pervasive and constantly and rapidly changing. Hence possessing skills associated with specific applications is not sufficient any more. Instead individuals need to understand technology broadly so that they are able "to apply it productively at work and in their everyday lives, to recognize when information technology would assist or impede the achievement of a goal, and to continually adapt to the changes in and advancement of information technology" (NRC, 1999, p. 15). In other words, individuals need to develop technological fluency.

As framed by the NRC, technological fluency involves three distinct but interrelated dimensions: intellectual capabilities, conceptual knowledge, and an appropriate skill set (see

Figure 1). Intellectual capabilities are higher order thinking skills formulated in the context of information technology. Conceptual knowledge refers to the basic ideas and concepts underpinning information technology. An appropriate skill set includes those technological skills needed to use today's computer applications. Finally, the NRC pointed out that developing technological fluency is not an end state but rather a lifelong endeavor that will typically involve particular applications in a variety of domains.

Intellectual Capabilities	Technology Concepts	Technology Skills
Engage in sustained reasoning	Computers	Set up a computer
Manage complexity	Information systems	Connect a computer to a network
Test a solution	Networks	Use a word processor
Manage problems in faulty solutions	Digital representation of information	Use the Internet to find information and resources
Think about technology abstractly	Algorithmic thinking and programming	Use basic operating system functions
Collaborate	Modeling and abstraction	Use a computer to communicate
Communicate to other audiences	Information organization	Use a graphics package
Expect the unexpected	Universality	Use a spreadsheet
Anticipate changing technologies	Limitations of technology	Use a database system to set up and access information
Organize and navigate information structures and evaluate information	Societal impact of technology	Use instructional materials to learn how to use new applications or features

Figure 1. Technological Fluency Components (NRC, 1999, p. 4)

Technological Fluency and the Digital Divide

Over the past 15 years notions of technology access have steadily shifted to include not only physical access to technology but also types of use and the socio-economic and cultural factors surrounding the use of technology. The main argument behind this shift has been that access to what could be considered complex and meaningful technological activities is not equally distributed to all individuals for a variety of socio-economic and cultural factors (for a review, see Warschauer & Matuchniak, 2010). A greater focus on socio-economic and cultural factors surrounding the use of technology is in fact very much relevant to individuals' development of technological fluency. In particular, some researchers have argued that developing technological fluency is not only about knowing how to use technological tools but also about constructing things of significance with those tools, and hence that technological fluency is best developed by engaging in complex and meaningful activities (Barron, 2004; Barron, Walter, Kennedy Martin, & Schatz, 2010; Resnick, Rusk, & Cook, 1998). Paying attention to the different types of factors, not just physical, that could limit access to these types of activities then becomes central to any efforts directed at helping individuals develop technological fluency.

Becoming Technologically Fluent

Looking at socio-cultural factors related to identity could prove particularly productive. Although not always explicit in the conversations about the nature of technological fluency and the types of technological activities that promote it, developing technological fluency is intricately related to identity. For example, in their report, the NRC stated that developing technological fluency is a process during which an individual is able to adapt to inevitable change as information technology evolves and to use his/her current knowledge and skills to acquire new knowledge and skills. Certainly such a process of adaptation and learning implies having the ability to confront unknown technological situations and persevere in the face of difficulties. Yet individuals will only do so if they believe they will be able to produce the desired outcome and find value in doing so (Eccles, 2009), in other words, if they have an identity as someone who is technologically fluent. Hence, the process of developing technological fluency involves not only developing the intellectual capabilities and technology concepts and skills included in the NRC's intellectual framework but also developing an identity as someone who engages in activities that promote technological fluency, that is, engages in complex and meaningful technological activities. Therefore, when thinking about individuals and their technological fluency it is more fruitful to think about individuals not as developing technological fluency but rather as becoming technologically fluent. Becoming technologically fluent involves having a deep understanding of information technology as well as developing an identity as someone who engages with technology in meaningful and complex ways.

This conception of becoming technologically fluent is similar to David Shaffer's concept of epistemic frames. David Shaffer (2006) proposed that in order for students to be able to use their experiences outside of the original context of learning they need to develop an epistemic frame. Epistemic frames include not only declarative and procedural knowledge but also "a form of knowing with that comprise [sic], for a particular community, knowing where to begin looking and asking questions, knowing what constitutes appropriate evidence to consider or information to assess, knowing how to go about gathering that evidence, and knowing when to draw a conclusion and/or move on to a different issue" (p. 228). Furthermore, epistemic frames include "self-identification as a person who engages in such forms of thinking and ways of acting" (p. 228). In a sense then becoming technologically fluent is akin to developing the epistemic frame of technological fluency.

Girls and Technological Fluency

Despite the advances women have made in obtaining college degrees, they are still underrepresented in computing fields (Cohon & Aspray, 2006; Freeman, 2004; Peter, Horn, & Carroll, 2005). One of the factors believed to play a role in this underrepresentation is computing experience (Barron, 2004; Margolis & Fisher, 2003; Varma, 2009). In fact, past research has found meaningful differences in the types of technological activities boys and girls engage in and therefore the type of experience they acquire. For example, Roberts, Foehr, and Rideout (2005) and Ito, et. al (2008) found that girls engage less often than boys in digital gaming, an activity considered highly technical (see also Warschauer & Matuchniak, 2010). The identification of more complex technological activities, such as digital gaming, as the domain of males, has been considered in part as a contributing factor to girls opting out (Cassell & Jenkins, 1998; Goldstein, 1994; Ito et al., 2008). Identity is influenced by self-perceptions of ability, competence, and efficacy. However, it is also structured according to "socially constructed markers of difference" (Compton-Lilly, 2006, p. 60) such as gender, race, ethnicity, and social class. These categories, among others based on difference, encompass behaviors, values, and norms that have been previously codified as appropriate for their members (Mahiri & Godley, 1998). Hence, focusing on the development of both technological knowledge and skills and an identity as someone who is able– and for whom it is appropriate– to engage with technology in meaningful and complex ways could be fruitful when looking to provide girls with opportunities to acquire relevant computing experience. In other words, helping girls become technologically fluent could help address their underrepresentation in computing fields.

Programming and Technological Fluency

Although computer programming is traditionally considered a male-oriented field, it could provide a good opportunity for girls to become technological fluency. Designing and creating a computer program is a technological activity that may allow for the development of many of the skills, concepts, and capabilities included in the intellectual framework of technologically fluency. In addition, programming knowledge is itself a component of technological fluency. Moreover, programming knowledge does not need to be acquired using a conventional programming language. The importance of programming knowledge lies in understanding computational concepts such as conditional instructions, repetition constructs, functional decomposition, and functional abstraction.

Similarly, designing and creating a computer program is an activity that allows for the observation of immediate results and privileges the process of solving a problem over trying to find the right solution. Hence, by engaging in a programming activity, a girl can come to feel technologically competent by understanding not only how technology functions but also that competence in relation to technology is developed over time. Moreover, a meaningful personal experience with programming may give girls the opportunity to question the stereotype that it is only for boys. In this way taking part in a programming activity could play a positive role in a girl's development of an identity as someone who is technologically fluent. The process of identity formation involves the internalization of behaviors, values, and norms that each person maintains as appropriate for members of a group to which he/she belongs as well as the outcomes of his/her exploration of different activities and which speak to his/her ability, competence, and efficacy (Côté & Levine, 2002).

Learning to Program

Some researchers have noted that learning to program is hard (Guzdial, 2004); hence several research efforts have investigated approaches to make it more accessible. Among these efforts some have chosen to focus on the development of programming environments while others have paid particular attention to the learning environment within which students might develop programming knowledge and skills.

Programming Environments for Novices

The main questions driving the design of programming environments for novices are "What makes programming hard?" and "How can the programming environment provide relevant scaffolding?" According to Guzdial most of these environments fall within one of three main "families" of programming environment: the LOGO family, the rule-based family, and the traditional programming language family.

The Logo family. Logo is a functional programming language. Within functional programming a program could be seen as a sequence of function evaluations. These evaluations cause an action but no side effects. Helping students learn to program was not the main objective behind the development of Logo. Instead, Logo was designed, in the tradition of constructivist learning, as a medium for students to develop higher-order thinking skills as they constructed computer programs. Almost all of the programming environments for novices in the Logo family have been developed and/or researched in relation to what students may be able to learn (beyond programming knowledge) by designing and writing computer programs (e.g., diSessa, 2001; Kafai, 1995; Louca, 2004; Yoshimasa, Takada, & Sakai, 2005). However, research on Logo and its descendants, LogoWriter, StarLogo, and MooseCrossing, has made a considerable contribution to a better understanding of what makes programming hard and inspired the creation of other programming environments for novices.

Squeak Etoys and Boxer are two novice programming environments that capitalized on the research on Logo. The designers and creators also subscribe to the idea that deep learning could be supported through the creation of computer programs. In addition to keeping the syntax of the language simple and sparse like Logo's however, these environments implemented additional features to help novices cope with the challenges of learning to program in an object-oriented style. Programming in an object-oriented style allows students to explore more complex domains (e.g., an ecosystem). Within this style a computer program consists of a collection of objects that interact with each other. The individual creating the program defines what these objects are, how they act, and how they are affected by their interactions with other objects. Both Squeak Etoys and Boxer provide on-screen graphical representations of the objects, behaviors, and side-effects from interactions (see Figures 2 and 3). In addition, Squeak Etoys' interface follows a drag-and-drop style where instructions are selected from menus and dropped on the screen instead of having to be typed in (see Figure 4). Finally, in an effort to make the creation of programs more attractive to youth, Squeak Etoys supports the use of multimedia such as music and pictures in the construction of a program.

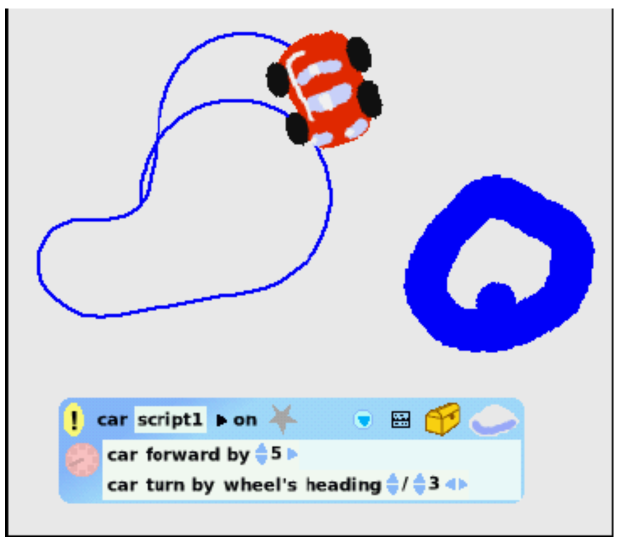

Figure 2. Squeak Etoys; car controlled by blue "steering wheel" (Kay, 2005, p. 2)

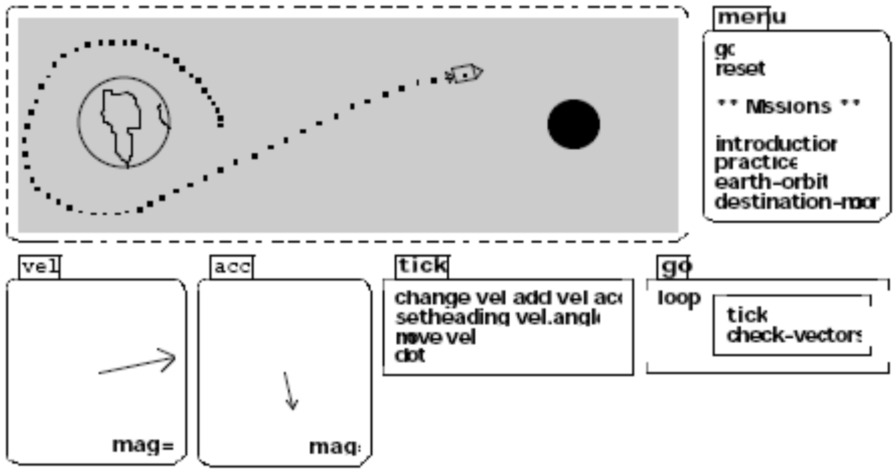

Figure 3. Boxer; space ship controlled by velocity/acceleration vectors (diSessa, n.d., p. 14)

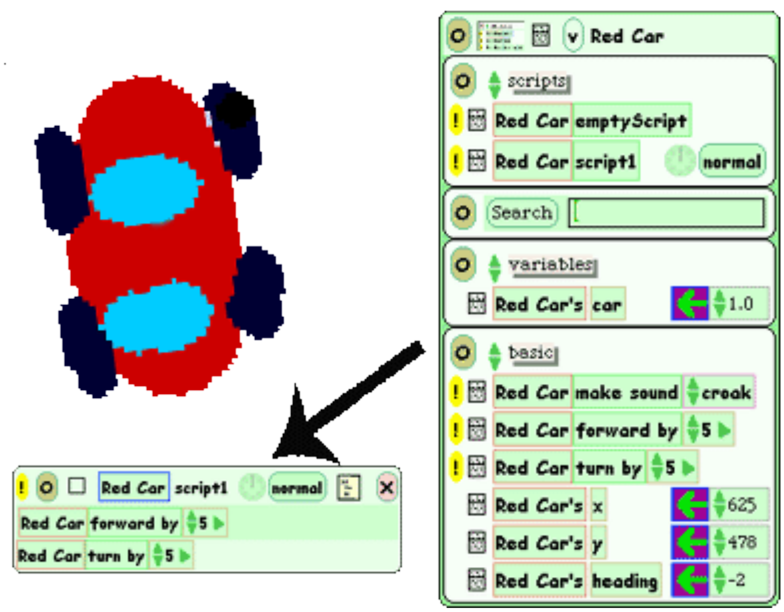

Figure 4. Squeak Etoys (www.squeakland.org/school/drive_a_car/html/Drivecar12.html) behaviors of objects can be made into a script by dragging them out from the "basic" menu associated with that object and dropping them on the desktop.

The rule-based family. Stagecast Creator, AgentSheets, and ToonTalk are popular examples of novice programming environments in the rule-based family. Within this paradigm the emphasis is on the logical relations between objects relevant to a given problem, rather than on procedural steps necessary to solve it. Hence, through facts and rules, a program describes states of the world as opposed to telling the computer how to operate upon the world. In other words, the individual creating the program describes through rules what he/she wants done under certain circumstances and leaves it to the computer to do it for him/her. In all of the three novice programming environments (Stagecast Creator, AgentSheets, and ToonTalk) the programming is mostly done in a purely graphical mode allowing the user to define the rules through images (see Figure 5). Both AgentSheets and Stagecast Creator are more often used for building simulations and games than for learning programming. In contrast, ToonTalk was designed and created to help children learn computational concepts by replacing programming abstractions with concrete familiar objects (Kahn, 1999). In addition, ToonTalk has also been used as a tool to help children learn mathematical concepts (e.g., Jewitt, 2003).

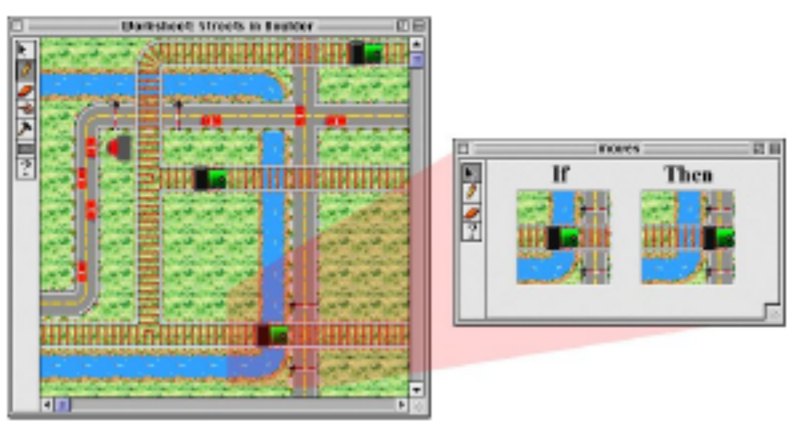

Figure 5. AgentSheets; simulation of train (Guzdial, 2006, p. 142)

The traditional programming language family. The basic design approach behind the programming environments in both the Logo and the rule-based families has been to take formal programming languages and paradigms and modify them in order to make programming easier for novices. Hence Logo's syntax and programming style are similar to Lisp, one of the oldest programming languages. Stagecast Simulation, AgentSheets and ToonTalk carry Prolog, a popular rule-based programming language, into a purely graphical language. Contrary to this approach, the programming environments in the traditional programming language family focus on the programming environment itself. Hence these environments are structured editors for traditional programming languages, such as Pascal, with much of the scaffolding aimed at relieving syntax complexity. For example, a user could choose a "for loop" structure from a menu to be inserted into his/her program. The construct would then be inserted with placeholders identifying where additional pieces need to be specified (see Figure 6). Examples of programming environments in this family are Genie and GPCeditor and its descendants Emile and ModelIt!. A different approach is to provide software visualization tools. Software visualization tools provide an interactive animation of program execution. Bradman is an example of a program visualization tool designed to provide a conceptual model of C program execution for novice programmers (Smith & Webb, 2000). Needless to say, these environments are probably most relevant to students studying computer science as a potential profession.

```
For $control-variable$ :— $start-value$ $direction$ $end-value$ Do
    Begin
        $statement$
    End
```

Figure 6. Genie; “for loop” with placeholders to be completed (Guzdial, 2006, p. 146)

Beyond Programming Paradigms

Most of the research about novice programming environments has focused on the affordances and constraints of the environments themselves (e.g., Canfield Smith & Cypher, 1999; Fernaeus & Tholander, 2003; Sheehan, 2004). Following a related line of investigation some researchers have decided to focus instead on the users of these environments. The main questions driving their research are “How can we provide a meaningful context for students to engage in programming?” and “How can we motivate students, especially women and other underrepresented groups, to engage in programming activities?”

Currently the main answer to these questions is to provide a context within which users can become personally connected to their programs. Some researchers interested in this type of question have developed programming environments that emphasize the role of the user as creator, narrative as a context, and guided exploration. For example, Alice (http://www.alice.org/), a freely available programming environment allows users to learn fundamental programming concepts in the context of creating an animation for telling a story, producing a video to share on the web, or playing an interactive game. Similarly, Virtual Family (Duplantis, MacGregor, Klawe, & Ng, 2002) presents users with a completely functioning game. The scenario is a family, and "playing" the game involves choosing from a variety of actions for a chosen character. Each game comes with all of the necessary tools for a user to extend the family through programming by adding new backgrounds, creating a new character, writing new actions, and designing a new story line. A final example, Rapunsel (http://rapunsel.org/) allows users to use programming to teach their characters how to dance and compete against other characters by challenging them in dance competitions.

In addition, other researchers have chosen to use existing programming languages such as Logo and Java and concentrate instead on the design of the learning environment (see e.g., Edwards, 2002; Nightingale, Halkett, Hammond, Mason, & Wilson, 1997) or curriculum (see, e.g., Countryman, Feldman, Kekelis & Spertus, 2002; Margolis, Holme, Estrella, Goode, Nao, & Stumme, 2003) so that it supports students', and specially women's and other underrepresented groups', learning style.

Programming Outside of School

Several if not most of the novice programming environments mentioned above have been used at one time or another in classroom settings. However, they have usually been used as tools to help in the learning of content matter than for learning to program. Learning to program in school is done instead by using traditional programming languages such as Basic, Pascal, C++, and Java. Until recently, there was the general belief that programming knowledge was only relevant to students considering computer science as a potential profession. The reasoning has been that students should acquire programming knowledge and skills at school relevant to their future educational and professional careers.

Recently, however, researchers have started arguing that understanding programming concepts and learning to program are necessary for the development of technological fluency, a desirable outcome for all students due to the ubiquitous nature of technology and its rapid and constant evolution (NRC, 1999). The emphasis is on helping all students acquire programming knowledge, not just those who might pursue a career in computer science. With this in mind, and building on knowledge from previous efforts to introduce novices to programming, some researchers have started focusing on helping youth learn to program out of school. One of these efforts resulted in the creation of Scratch.

Scratch is a novice programming environment; descended from Logo and inspired by Squeak Etoys. Hence its syntax is similar to Logo's and its interface follows Squeak Etoys drag-and-drop style. However, Scratch also provides syntax scaffolding similar to some of the novice environments in the traditional programming language family. For example, a user creating a program in Scratch would do it by snapping together graphical blocks much like LEGO bricks or puzzle pieces. These blocks represent the different commands a user can choose from a variety of menus. Their colors make it easy for users to remember what kind of command they represent (e.g., purple for movement, orange for conditionals, green for arithmetic expressions). Their shapes help users avoid syntax errors since different blocks have different shapes and hence fit together only in syntactically correct ways (see Figure 7). Additionally, Scratch, like some of the other environments that emphasize the role of the user, highlights the user as a creator and allows for guided exploration by supporting the use of multimedia and providing access (through a website) to a well-developed network of Scratch users.

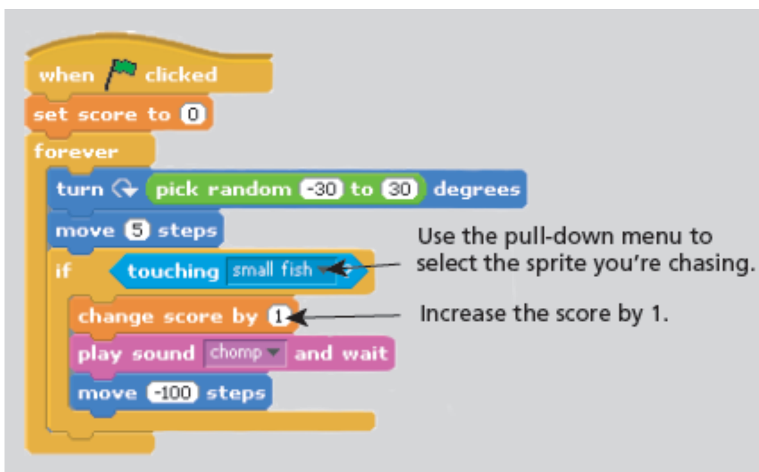

Figure 7. Scratch; scoreboard script (Lifelong Kindergarten Group – MIT Media Lab, Scratch card: Keep Score, http://scratch.mit.edu/cards)

Chapter III

Research and Pedagogical Approach

As it was previously mentioned, the design, implementation, and investigation of the learning environment at the center of this study was informed by research in four areas of inquiry: the learning sciences, computer science education research, identity development, and women and technology. This chapter provides a description of the ways in which findings from each field informed the present study as well as a description of the learning environment's pedagogical approach.

Theoretical Framework

The Learning Sciences

The learning sciences is a research paradigm spanning many disciplinary approaches to the study of learning (e.g., constructivism, cognitive science, socio-cultural studies). Contributing researchers are mainly concerned with what is going on in a learning environment and how it is contributing to improving student performance. Their main objective is the discovery of principles that can inform the design of effective learning environments. Often their research includes new educational technologies. Findings from this research informed the pedagogical framework employed in the design of the learning context. In particular, the design strived to incorporate characteristics of learning environments that have been found to promote better learning, such as building from concrete to abstract knowledge, scaffolding, externalization and articulation, and reflection (Sawyer, 2006).

In addition, the research approach of the learning sciences is “design based in that it is theoretically framed, empirical research of learning and teaching based on particular designs for instruction” (Sandoval & Bell, 2004, p. 199). One could say that studies within this paradigm are always a work in progress. As dozens of variables interact in real world learning, continuous refinement and multiple iterations are required if true understanding is to be achieved. Hence “design based research involves more than simply reporting outcomes” (Barab, 2006, p. 154). It provides insights about processes, noting how the intended design failed and how it changed. A design-based research approach allowed the design of the learning environment to be informed by both theory and empirical data and provided the opportunity for the design to be adjusted as necessary during the implementation stage of the study.

Computer Science Education Research

Similar to the learning sciences, computer science education research is informed by many established fields of scholarship (e.g., engineering, education, psychology). However, computer science education research only investigates questions specifically related to the learning of computer science (Fincher & Petre, 2004). Research in the areas of student understanding, teaching methods, assessment, educational technology, and recruitment and retention of students informed the instructional goals and provided the rationale behind the design of the specific learning activities. Specifically relevant were findings related to misconceptions and attitudes that interfere with learning to program, differences between novices and experts, and pair programming. Some of the computational concepts investigated were procedures, loops, and threads. These concepts among others are recommended by the ACM Model Curriculum for K-12 Computer Science (ACM, 2006) as computational concepts that students should understand. This model curriculum influences the computer science curriculum in many US states.

Identity Development

Wigfield and Wagner (2005) state that identity is inclusive of self-concept and self-esteem. (p. 228). Although there is no definite agreement as to the distinctiveness of these two constructs, in their review of the literature, Butler and Gasson (2005) state that self-concept is mostly regarded as an over-arching view of self while self-esteem relates to the evaluative aspect (i.e., one's judgment of worth or value as a person). Since the main focus of the study was discovering the participants' thoughts about themselves, the focus of investigation was on the self-concept aspect of identity.

Broadly defined, self-concept derives from evaluations of performance in different areas, based on experiences, and influenced by attributions for the individual's own behavior (Marsh &

Hattie, 1996; Novick, Cauce, & Grove, 1996; Wigfield & Wagner, 2005). Furthermore, researchers believe that the construct of self-concept is multidimensional and hierarchical; several domain specific self-concepts lead to a global self-concept (Bracken & Lamprecht, 2003). There are a variety of models of self-concept (and hence a variety of measures), however all of them include a social, an academic, and a physical dimension. Some researchers are working on developing multidimensional, hierarchical models of self-concept that are specific to one of these three dimensions. Other researchers have opted for proposing new dimensions (e.g. performing arts).

Competence is an integral part of the self-concept and identity formation (Dweck & Molden, 2006; Wigfield & Wagner, 2005). In the process of developing his/her identity, a youth will try on several roles and use perceptions of competence as a measure of fit. Furthermore, perceptions of competence inform the development of possible selves, an important aspect of the development of identity. Possible selves help organize and direct youths' behaviors in the process of forming a certain identity. For example, Novick, Cauce, and Grove (1996) mentioned that perceptions of competence substantially influence both career planning and preparation for careers. However, perceptions of competence are influenced by attributions. The successful outcome of an event can be attributed to personal capabilities (e.g. effort, ability) or situational factors (e.g. luck) affecting competence self-judgments. "In particular, research has found that perceptions of personal competence increase when people ascribe achievements to their own capabilities rather than to situational factors" (Novick, Cauce, & Grove, 1996, p. 218).

In addition to attributions, gender schemas (i.e., stereotypes) influence perceptions of competence. Stereotypes are knowledge structures that contain information related to attributes and organized into domains (e.g., appearance, occupation). In particular gender stereotypes are an important source of messages about what to attain and what to avoid and children often use this information when evaluating competence. For example, "when a male and a female are both described as being in the same job, children will rate the one who fits as the gender typing of the position (e.g., a female nurse) as more competent than the other person" (Eisenber, Martin, & Fabes, 1996, p. 365). Currently, engagements with technology are not part of any of the existing models of self-concept. Hence the study was informed by the literature on competence self-concept and academic self-concept. Findings from this research and research on gender identity and stereotypes guided the investigation of identity.

Achievement goals. Motivation plays an important role in the development of identity. Developing an identity as someone who is capable of engaging with technology in meaningful and complex ways requires that youth actually engage in the types of activities that could lead to that outcome. Furthermore, it requires that they are motivated to persist in the face of difficulty. The motivational framework employed in the design of the workshop was informed by research in achievement goals. Achievement goal researchers have mainly focused on two contrasting types of goals that they have labeled “mastery” and “performance” goals. Adopting mastery goals has been shown to promote an adaptive pattern of achievement behavior characterized by challenge seeking and high, effective persistence in the face of obstacles (Elliot & Dweck, 1988). Moreover, there is evidence to suggest that students show positive motivational and cognitive patterns when they perceive their classroom/school as emphasizing mastery-oriented goals (Meece, Anderman, & Anderman., 2006; Urdan, 1997).

Studies have shown that classroom goal structures might influence the type of achievement goals that students adopt. Specifically, students are more likely to adopt mastery-oriented goals when they perceive their classroom environment as emphasizing effort and understanding. Additionally, there is evidence to suggest that students’ perceptions of classroom goal structure exert a direct effect on outcome measures such as avoidance behaviors and self-efficacy ratings (Meece et al, 2006). Therefore, the design of the pedagogical framework strived to incorporate characteristics of learning environments that have been found to promote a focus on the improvement of competence through effort, such as varied tasks, reasonable challenge, short-term and self-referenced goals, and opportunities to develop responsibility and independence (Ames, 1992).

Women and Technology

The research on women and technology is vast and relevant issues are addressed by a wide array of disciplines. In particular, the present study was informed by research on girls' engagements with technology. A specific focus on teaching girls programming could not be adopted since at the time the design of the present study was taking place little research had been published in this area. Therefore research from this broader field informed the design of the learning environment in regard to characteristics that would make it appealing to girls. Specifically, the workshop was offered in a girls-only setting. Given that computing is regarded as a male domain and girls tend to underestimate their technological abilities (AAUW, 2000; Margolis & Fisher, 2003), a single-sex setting was believed to be the most conducive environment. For example, both Edwards (2002) and Countryman et al. (2002) highlighted the positive impact that a girls-only setting had on the participants. In another study, Stepulvage (2001) found that girls tend to take on passive roles when working alongside boys on the computer. In addition, emphasis was placed on the participants collaborating since past research has shown that girls enjoy working in groups and their performance is enhanced when working in collaborative settings (Volman & van Eck, 1990).

Another characteristic included in the design of the learning environment was a focus on design and creativity. This kind of learning environment is in accordance with the programming style to which, some researchers argue, many women are drawn (Turkle, 1995). This programming style sometimes referred to as "soft" is characterized by playing with the elements of a program, tinkering with the outcome, and developing a personal connection with one's object of study, in this case the computer program. Finally, the design called for the inclusion of appropriate and relevant female role models. An important component of identity is the concept of possible selves. These selves develop in part from messages adolescents receive about what to attain and what to avoid (Wigfield & Wagner, 2005). Media images are important conveyors of such messages. In relation to programming "media images more frequently depict computer programmers and developers as males, and women as users" (Barker & Aspray, 2006, p. 38). It was believed that being introduced to relevant female role models (i.e., women who do programming) could help the participants regard being a programmer as a possible self. "Seeing someone socially similar to oneself in a role makes it more likely you could see yourself in that kind of role" (Cohoon & Aspray, 2006, p. 156).

Pedagogical Framework

Programming Environment

During the workshop participants worked with Scratch, a novice programming environment designed specifically to introduce programming to youth at after-school centers. Its development was guided by its creators' experience on what software tools have succeeded at the

Computer Clubhouse (http://www.computerclubhouse.org/), an after-school center. Its features were chosen specifically to address problems commonly found by youth being introduced to programming (Maloney, Burd, Kafai, Rusk, Silverman, & Resnick, 2004).

At the core of Scratch is a graphical programming language that lets users control the actions and interactions among different media such as graphics, photos, music, and sound by snapping together graphical blocks, much like LEGO bricks or puzzle pieces. Scratch's interface is divided into three sections (see Figure 8). The section on the left contains all of the instructions, represented by graphical blocks, available for use. The middle section is where the user constructs programs by combining different instructions/blocks. Instructions/blocks are moved between these two areas in a drag-and-drop style. The section on the right is where the user can observe what happens when he/she runs a program.

In addition to the free software environment, the creators of Scratch provide what are called "Scratch cards". These cards are intended to provide a quick way to learn Scratch code. The front of the card shows an action a user might want to implement (e.g. changing the color of an object); the back shows how to do it (see Figures 14 and 33 for an example). Several copies of the cards were available for the participants to use as needed during the workshop. Finally, a Scratch website (http://scratch.mit.edu/) allows users to try out other people's projects, reuse and adapt other people’s images and scripts, and post their own projects. However, participants were not introduced to the website.

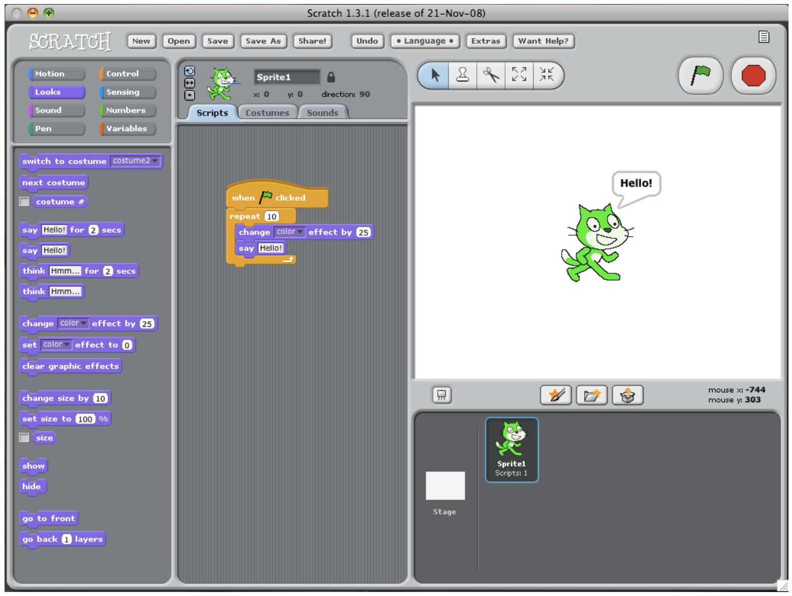

Figure 8. Scratch’s interface

Scratch was chosen as the programming environment for the workshop based on its learning affordances. For example, Scratch scaffolds novices’ programming activities through its graphical language, its blocks fit together only in ways that make syntactic sense, the color of each block makes it easy to remember what kind of command the block represents (e.g., motion, looks, sounds, etc.), and the shape of each block guides the user as to the block’s particular function. The Scratch cards provide additional scaffolded instruction. Furthermore, Scratch has a highly interactive environment that allows the observation of immediate results. As a user builds scripts, he/she is able to observe the script that he/she had built and its outcome next to each other; this provides a concrete representation of his/her developing understanding and allows him/her to reflect on it. Finally, Scratch emphasizes design and creativity by allowing its users to create many different types of projects (e.g., stories, games, animations, simulations) and use its scripting area as a physical desktop where a user can leave extra blocks or stacks of blocks lying around without affecting the outcome of a project or create multiple scripts to try at different times or as parallel threads.

Workshop Activities: Introductory Sessions

Previous to the implementation of the workshop, the researcher sketched several activities that would introduce the participants to programming and the programming environment. These activities were shared with several individuals knowledgeable about Computer Science and programming and its teaching and learning and were also piloted at a different after school center. Based on the input from those with whom the activities were shared and the pilot study, some of the activities were modified accordingly. Below is a description of the activities as they were implemented during this study in chronological order. The rationale for the activity sequencing was to scaffold the participants as they learned progressively the skills and knowledge needed to create projects on their own. Each activity was implemented during one workshop session.

Activity: Introduction. Participants were informed that they would be creating computer programs and asked to provide examples of computer programs they knew. Digital games, animated movies, and animations were highlighted as kinds of computer programs they could be able to create through programming. Subsequently, participants were divided into groups of three or four participants and asked to come up with instructions they could give someone on how to make a peanut butter and jelly sandwich. After a period of 15 to 20 minutes, each group was asked to share their instructions with the whole group and a whole group conversation, led by the instructor, took place where degree of specificity of instructions and familiarity with task were discussed. Finally, participants were introduced to the interface of the programming environment they would be using to create their projects (i.e., Scratch), and shown what the functions of some of the buttons were (e.g., save project, open project, run script, etc).

In addition to introducing the participants to the programming environment, the purpose of this activity was to help them connect what they would be doing to real-life examples they might have encountered before. Based on the researchers' previous experience at the CTC as a volunteer it was concluded that for the most part youth who attend the CTC have access and utilize a variety of computer programs yet very few would be able to explain how these programs work. Making an explicit connection between computer programs they have used before and what they will be doing could help the participants increase their understanding of computer software.

Activity: Understanding Instructions. At the beginning of the session participants were asked to form groups of two to three participants and presented with a list of some of the blocks available in Scratch. Participants were given 15 to 20 minutes to discuss within their small group what they thought the functions of the blocks were. Since some of the blocks are better understood in context this was done with a subset of the blocks in the 'motion', 'looks', and 'sounds' menus. Afterwards, participants were asked to test the blocks and note if their predictions were correct. Finally, each group was asked to share their predictions and the results of their tests with the whole group.

The purpose of this activity was to introduce the participants to the programming language and clarify beforehand any misconceptions that may emerge due to linguistic transfer. Mismatches between the meaning of a term in English and its meaning in programming are a common source of programming misconceptions for novices (Clancy, 2004). The fact that a programming environment was designed exclusively for novices does not guarantee that such mismatches are not possible. Addressing students' misconceptions is important since these usually make learning difficult.

Activity: Understanding Scripts. The instructor began the session by providing a demonstration of the different ways in which the Scratch blocks can be put together. The participants were asked to suggest combinations and each combination was tried out. This was done with three of the instructions in Scratch. Next, participants were encouraged to make combinations on their own. After an adequate period of time, the participants were asked to share one of their combinations with the group. Finally, participants were given a short story (5 statements) and asked to create a script that represented the story; they were asked to do this in pairs.

In addition to introducing the participants to the basic functioning of Scratch, the purpose of this activity was to introduce the participants to the concept of procedures (i.e., short programs to execute specific goals) and encourage them to think about process instead of product. Although by itself this activity may not seem very relevant, it is a building step towards expert-like behavior. Expert programmers usually construct separate subroutines to perform distinct programming functions (Kurland, Clement, Mawby, & Pea, 1987).

Activity: Same Destination, Alternate Routes. At the beginning of the session participants were given a simple story (5 statements) and asked to create one or more scripts that implemented the story. They were asked to do this in pairs. After a period of approximately 30 minutes the instructor asked for a group to volunteer to share their program with the group and explain how they used the different instructions to get it to work. A group discussion followed. The main objective of this activity was for the participants to become more familiar with Scratch, but most importantly for them to see that one outcome can be created using different combinations of instructions and that in programming there is not right or wrong answer.

Workshop Activities: Individual Project Sessions

The main activity the participants engaged in during the workshop was an individual project that consisted of creating a collage of animated objects that included things and activities the participants identified with; it resembled a profile page they might have built on an online social network (see figure 38). This activity was designed based on the participants' reactions to the introductory sessions and it main purpose was to create a personally meaningful context for the participants to continue acquiring new knowledge and skills while drawing on experiences with technology from their daily lives (Blumenfeld, Kempler, & Krajcik, 2006). In addition, the activity allowed for the provision of varied tasks, reasonable challenge, short-term goals, and opportunities to develop responsibility and independence. All of these are characteristics that support the adoption of mastery goals. Finally, by allowing the participants to choose what to include in their collages and work on them over several sessions the activity put an emphasis on design and creativity and provided opportunities for the participants to develop independence and responsibility. Instruction during this time was provided on demand, either individually when requested, and therefore tailored to the needs of a specific participant, or in the form of mini lessons when the instructor deemed that all participants would benefit from it. In addition, the instructor herself built a collage of her own and it was available for the participants to explore (see Figure 9).

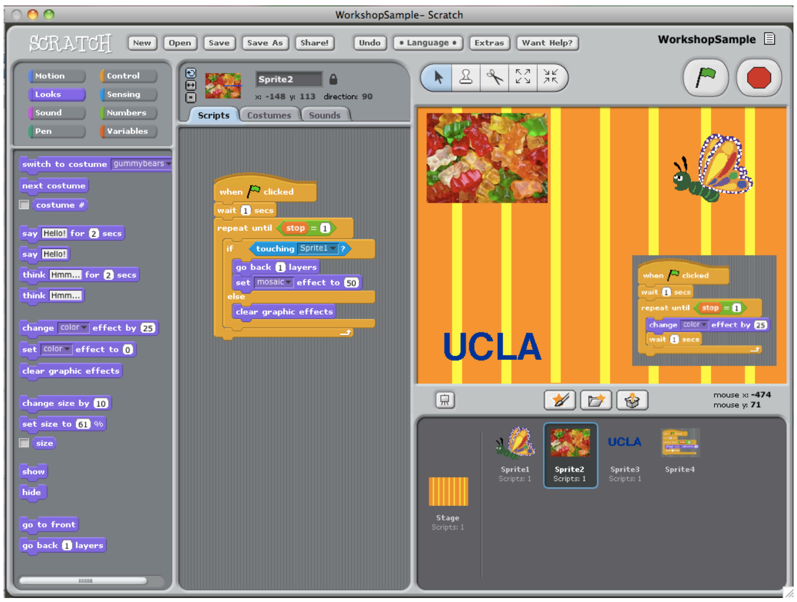

Figure 9. Sample project created by the instructor

Collaboration

While an emphasis on collaboration was observed to make the learning environment more attractive to the participants, talking to each other and helping each other out also provided opportunities for them to engage in articulation and reflection. The introductory sessions deliberately fostered collaboration by requiring participants to work in groups. For the individual project, it had first been intended for participants to choose a partner with whom they could share thoughts and feelings and offer suggestions on how to address a problem and/or encouragement. Werner, Hanks, and McDowell (2004) found that paired students enjoyed working on programming assignments more than non-paired students and they produced better programs than those who worked alone. Additionally, paired students reported having higher confidence in their program solutions than those students who worked independently; this was especially true for the female students. However, this was not specifically implemented because all but three of the participants were already attending the workshop in pairs, i.e., each participant had one good friend attending as well. In addition, participants were not open to idea of sharing a computer, especially since during all but one of the sessions there were enough computers for every participant to work individually. Instead, participants were encouraged to consult with each other, not just their friend(s), while engaged in the construction of their projects.

Role Models and Mentoring

During the design phase of the workshop, it had been decided that high school/college female students interested in Computer Science could be invited to act as experts during one or more of the workshop's sessions. Unfortunately, this was not possible due to lack of volunteers and logistical issues such as transportation and conflicting schedules. However, the instructor as planned did try to act as a role model/mentor through her behavior. For example, sharing information about herself and her experiences studying Computer Science and later on working in the software industry, encouraging the girls to try out more complex things than what they have done so far and not give up easily, reframing conversations that included self-labeling as geek or nerd, etc. In addition, the participants were invited to visit the headquarters of MySpace. During the field trip they had the opportunity to meet with several female software engineers of different races/ethnicities (including one bilingual Latina), ask them questions about their jobs, and observe their working environment.

Research Questions

Since the publication of the NRC report in 1999 arguing for individuals' need to develop technologically fluency, many researchers have supported the argument for a variety of reasons. Fewer, however, have investigated how to achieve this goal in an equitable way (e.g., Barron, 2004; Campe et al., 2005; Koch, 2006). Moreover, the concept of identity seems to be mostly absent from these efforts. The present study looked to contribute to this area by exploring the interrelationships between minority youths' (i.e., young Latinas) development of technological fluency (as conceptualized by the NRC) and an identity as someone who is able and for whom it is appropriate to engage in complex technological activities. In addition, this study looked to contribute to a knowledge base about the design of learning environments that provide opportunities youth to become technologically fluent.

The study addressed three research questions:

1. - What were the characteristics of the learning environment that supported the participants' development of technological fluency? What were the participants' perceptions of what helped them learn?

2. - What were the characteristics of the learning environment that supported the participants' development of an identity as someone who is able - and for whom it is appropriate - to engage with technology in complex ways? What were the participants' perceptions of what might have contributed to this development?

3. - What were the interrelationships between the participants' development of technological fluency and their identity as someone who is able - and for whom it is appropriate - to engage with technology in complex ways?

Chapter IV

Methods

At the heart of this research study was the design and implementation of a learning environment consisting of a programming workshop for girls offered at a community technology center (CTC). The workshop had a focus on design and creativity, following a model of scaffolded instruction and collaborative learning. The programming project the participants worked on, building a "profile page", was based on a technological activity preferred by girls, visiting online social networks (Rideout, Foehr, & Roberts, 2010). This chapter describes how the study was conducted, including the implementation of the workshop and the collection of the data. The analysis of the data is described in subsequent chapters as it pertains to each of the research questions.

Research Site

The foundation that houses the site where this research study took place has been carrying out community organizing in central Los Angeles since the mid-1980s. The neighborhood in which it organizes is one of the poorest with more than 40% of the people living below the poverty line. Its community center provides a wide array of programs that include a health clinic, a homework assistance program, employment training, and a technology center. The center is open from 9 AM to 7 PM all year round except holidays. The youth can attend the center between 3 to 7 PM. When they first arrive they are free to eat and socialize until 4 PM. From 4 to 5 PM they are required to either attend the Homework lab or receive individual tutoring. From 5 to 7 PM they are required to attend one of the workshops offered, ranging from technology, to leadership skills, to physical activities. The youth are required to leave the center at 7 PM.

At the time the study took place the technology center was equipped with 28 Internet-networked iMacs, black-and-white and color laser printers, scanners, and state-of-the art projection equipment. Professional multimedia and business productivity software was installed on all computers, and many of the computers were capable of high-end digital editing. The center also had a multimedia studio equipped with two G4 Macintosh computers with 23" flat screen monitors and a professional scanner and drawing slate. Members at the center could check out digital video equipment for in-house use as well as for outside projects if staff will accompany them. A variety of computer classes and workshops were available to the members to help them learn industry-standard software applications. In addition, youth members could attend workshops in business productivity and multimedia applications after school or during their vacation periods.

Participants

Participants in the study were 14 bilingual Latinas between the ages of 11- and 14-years old. An additional participant had joined the workshop and study when it first commenced but stop attending after four weeks since she was out of the city for a long period of time. All participants lived in the community where the CTC is located and frequented it after school. All reported using a computer everyday for two to three hours, and were familiar with popular computer and Internet applications such as MySpace, Google, and MS Word. Only one of the participants had prior programming experience; she had attended a class about HTML, the predominant language used to create web pages. All of the participants joined the workshop and agreed to participant in the research study voluntarily.

The workshop's instructor, a bilingual Latina who was also the researcher, majored in Computer Science in college and has prior experience as a software engineer. She had been volunteering at the research site for approximately a year and participated in both the homework assistance program and in some of the computer workshops. This allowed her to become familiar with the site and get to know the people who work at and/or attend the site. For example, it was during this time that she developed a relationship with four of the workshop's participants. After the programming workshop ended, she volunteered for an additional year during which she tutor individual youth and led computer workshops for boys and girls.

In addition, two research assistants participated during the implementation of the workshop. Both were female undergraduate students at UCLA, Latina, and bilingual. Neither had attended the CTC prior to the implementation of the workshop. Their participation included conducting interviews prior to the beginning of the workshop and taking field notes during one of the workshop's session each week. Occasionally, they would assist participants with their work during the workshop if asked. In addition, they would sometimes assist participants with their homework during homework time. Neither of them continued their participation at the CTC after the workshop ended.

Technology

During the workshop participants were introduced to and used Scratch, the programming environment chosen during the design phase of the study. They also used Photo Booth to obtain images that they could then add to their projects. Photo Booth is a software application for Apple computers that allows users to take photos (image effects can subsequently be applied to them) and videos. In addition, participants used the Internet to locate images and music that they could then use in their projects. In particular, participants used their MySpace profiles as a source for pictures, images, and music. MySpace (www.myspace.com) is an online social network website, highly popular with the participants during the time the workshop took place (see Figure 38).

Procedures

Recruitment of Participants

Approximately two weeks before the workshop began an announcement was made to inform all female youth members of the community center of a new workshop being offered. During the announcement the researcher gave specifics about the workshop (e.g., date and time), and showed projects that other youth have built using Scratch. Interested female youth were invited to sign up for and attend an information session the following week. During the information session the researcher explained the research project and distributed consent and assent forms to those who expressed an interest in participating in the study. However, it was made clear that those interested in attending the workshop could still do so even if they did not wanted to participate in the research study. All 15 girls who signed up for the workshop agreed to participate in the study. One participant stopped attending the workshop after the first four weeks. Since the workshop was a girls-only activity, a similar workshop was offered concurrently to interested boys with a male staff member of the center leading it. In addition, the researcher led a third workshop for girls and boys afterwards.

Workshop Sessions

The workshop took place two days a week for eight weeks; each session lasted approximately one hour. Attendance to the workshop was voluntary. In the event that a participant did not show up for a session, the researcher tried to encourage her to come if she was at the center. Refreshments such as juice, cookies, and fruit were offered during each of the workshop sessions.

During the first three weeks of the workshop the participants engaged in the four activities designed to give them a basic introduction to programming and Scratch. This occurred during sessions 1, 2, 3, and 5. Due to extremely low attendance during session 4, participants were allowed to engage in activities of their choice instead. A group discussion was conducted during session 6. This session took place in a room different from the computer lab and pizza and soft drink were provided. During this session participants talked about their experiences and opinions of the workshop so far. Both the researcher and the two research assistants attended this session and took turns guiding the conversation by asking the participants questions related to their experiences in the workshop and with technology in general. In addition, the possibility of holding a contest at the end of the workshop was discussed but discarded by the participants as a group. Based on participants' input during the group session, where they expressed that the workshop felt "too much like school", the researcher decided to change the format of the workshop to one where there would be no direct instruction. Instead, the participants worked on their individual projects and the instructor provided help as needed. A typical session would start with the instructor coming into the computer lab and setting her laptop at the front of the room where it was connected to a projector. The instructor would then proceed to open her own project and project it on a screen at the front of the room for all participants to see. Several minutes later participants would start coming into the computer lab and locating an empty computer. After most of the participants were sitting at a computer a sign-in sheet, snacks, and the participants' flash drives were passed around. This was followed by the instructor making any necessary announcements (e.g., remind participants to submit their permission slips for the field trip to MySpace headquarters). After each participant obtained her flash drive she would then plug it into the computer, open her project, and proceeded to work on it until it was time to leave. Occasionally, participants were observed spending some of the time interacting with friends on MySpace instead of working on their projects. At the end of each session, participants saved a copy of their projects to their flash drive and turned it in to the instructor as they left the computer lab. During the last session, a pizza party was held and each participant received a certificate of completion.

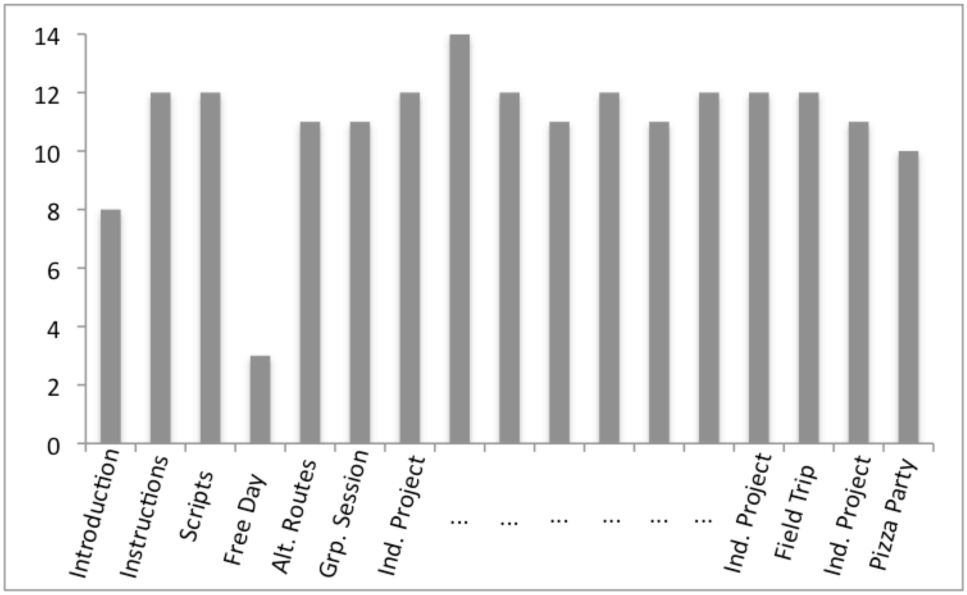

Figure 10. Sequence of workshop sessions as they took place and number of participants who attended each session
(Note: the field trip took place during week 7, on Friday)

Data Collection

Interviews

Participants were asked to take part in an individual interview before the workshop started and again after it ended. The main objectives in interviewing the participants were: (1) assess their experience with technology before the workshop, (2) assess their self-concept in relation to their use of computers (including programming) both before and after the workshop, and (3) obtain their opinions about their experience in the workshop after it ended. Both before and after the workshop, interviews lasted between 30 and 40 minutes and were audio taped. In addition, notes were taken during the interview as well and used to expand the tape transcription and clarify misunderstandings. The researcher and both research assistants interviewed five participants each before the workshop; after the workshop only the researcher conducted interviews, 14 total.

Interview protocol A. This interview protocol was used during participants' interviews before the workshop and included a series of questions in regard to their current technological experience. Participants' responses to the questions in this protocol provided baseline information in regard to their previous experiences with technology, including similarities and differences among them. See Appendix A.

Interview protocol B. This interview protocol was used during participants' interviews both before and after the workshop and was designed to assess their self-concept in relation to their use of computers (including programming) and future educational and career plans. Bracken's (1992) Multidimensional Self Concept Scale (MSCS) was used as a model for the questions that measured competence self-concept and perceptions of ability. The MSCS is one of the few scales that measure competence self- concept in addition to academic self-concept. In addition, the questions used to measure the endorsement of gender stereotypes were modeled after a measure developed by Schmade, Johns, & Barquissau (2004) to assess stereotype endorsement. Finally, additional questions attempted to measure future educational and career goals, including reasons for attending the workshop. Participants' responses to the questions in this protocol provided data in regard to the efficacy of the workshop in helping participants develop an identity as someone who is able– and for whom it is appropriate– to engage with technology in meaningful and complex ways. See Appendix B.

Interview protocol C. This interview protocol was used during participants' interviews at the end of the workshop and included questions in regard to what aspects of the workshop worked, which ones could be improved, and which ones should be taken out or changed. Participants' responses to the questions in this protocol provided a measure, from their point of view, as to the overall efficacy of the designed workshop in helping them develop technological knowledge and skills and an identity as someone who is able– and for whom it is appropriate to engage with technology in meaningful and complex ways. See Appendix C. Before the interview participants were read the following script:

> *"Hi! I would like to ask your opinion about the workshop you just finished. Your opinion is very important to me because it will help me make the workshop better. It will also help me learn more about helping youth like you learn about technology and feel confident to use it. So, please do not be afraid to mention whatever you did not like or whatever you think needs to change."*

Group Session

After the first four sessions of the workshop, participants were asked to participate in a group session. The main objective of this group session was to obtain participants' opinions about their experience in the workshop so far, and based on them determine if changes to the workshop's design were necessary. In addition, the session included conversations about participants' experiences using computers in a mixed environment, mainly the computer lab at the CTC, and gender and technology more generally. It had not been previously planned for the session to include conversations about these last two topics, however they emerged during the conversation of their experiences in the workshop and participants were interested in pursuing them. The researcher and the two research assistants attended the session and recorded field notes immediately afterwards.

Projects.

At the end of every session, participants were asked to save an electronic copy of their projects on a flash drive that was provided at the beginning of the workshop by the researcher. On average, participants saved seven different versions of their projects. The different versions of participants' project were used to capture their development of technological fluency throughout the workshop, albeit in a limited manner since not all changes participants made during a session were saved.

Field Notes

At the end of every session, the instructor and one research assistant recorded field notes. The field notes included a description of the learning activity or activities engaged in by the participants during a particular session, as well as personal observations of what transpired during the actual activity. These observations included among other things, activity participation patterns, task involvement, participants' talk (e.g., words they choose to describe themselves and their creations/programs), and roles participants took (e.g., giving suggestions about project topics or how to resolve a programming issue). Attendance information was also recorded in the field notes since attendance was voluntary. Whenever a participant had missed a session, for example, the researcher tried to find out the reason for her absence so that it could be recorded and considered in the analysis. Data from the field notes were used to gain an understanding of the characteristics of the learning environment that contributed to participants' development of technological fluency and an identity as someone who is able– and for whom it is appropriate to engage with technology in meaningful and complex ways.

Analytical Memos

In addition, analytic memos were written at the end of each week based on available field notes for a week. These memos include a summary of what had transpired during the workshop sessions and served as a source for possible coding categories. They also included the researcher's thoughts on possible connections of the data to previous memos and current relevant research. In addition, the researcher had planed to include brief profiles of the participants based on the interview data collected before the workshop commenced and data from the week's field notes. However, given that participants were very similar in their prior experiences with technology and field notes included limited information specific to each participant, the researcher decided against it.

Chapter V

Participants' Development of Technological Fluency

This chapter presents participants' development of technological fluency. Specifically, it describes their development in regards to each of its three dimensions: technological skills, technological concepts, and intellectual capabilities. Evidence of participants' development was provided by the different versions of the project they built, by their engagement in the workshop as recorded in the field notes, and by their own accounts of their experiences with technology and in the workshop during the interview before and after the workshop. The first three sections of the chapter briefly describe one of the three dimensions of technological fluency and how the data was analyzed in regards to it, the corresponding results are then presented. The following section presents participants' own opinions in regards to their development of technological fluency as expressed during the interview after the workshop. The last section offers some concluding remarks.

Technological Skills

Technological skills refer to "the ability to use particular (and contemporary) hardware or software resources" to accomplish a task (NRC, 1999, p. 18). The examination of the data in regards to this dimension began by selecting those skills included in the NRC framework for technological fluency that participants could have had an opportunity to develop given the subject and nature of the workshop and project. Three of the ten skills were selected: (1) use the Internet to find information and resources, (2) use a graphics package, and (3) use instructional materials. The analysis then proceeded to examine the data for presence/absence of these skills. A skill was marked as present if a participant had indicated during the interview after the workshop that she had used it or there was evidence in the field notes or her project that she had used it during the workshop. The results of the analysis for each of the three selected skills are presented next.

Use the Internet to Find Information and Resources

This skill pertains to the ability to find information on the Internet based on "an understanding of one's needs and how they relate to what is available and what can be found readily" (NRC, 1999, p.38). Analysis of the data showed that most participants used the Internet as a source for images, about half used it as a source for pictures of themselves and their family and friends, and about one third used it as a source for music

Figure 11. Alexandra's project
Alexandra used the Internet to obtain an image of one of her favorite cartoons and several pictures of herself.

The analysis also showed that participants not only used web browsers and search engines to locate desired information, in this case content for their projects, but also their MySpace profiles, as the following vignette exemplifies:

> *"Adriana wanted to add a song to her project and asked the instructor for help. The instructor explained to her that she needed to have an mp3 file. Adriana seemed puzzled by her response and asked what was an mp3 file. The instructor explained to her that it was a type of sound file. Adriana replied that she did not have that type of file and went back to working on her project. Sometime later Adriana called the instructor over and asked her for help again. This time she wanted to add to her project a song that she had recorded from her MySpace profile using Scratch's recording capabilities" (FN, 10/21/08).*

Although all participants indicated, prior to the beginning of the workshop, knowing how to use the Internet to do research, find images, or listen to music, participating in the workshop gave them the opportunity to increase their experience using the Internet to find information and resources.

Use a Graphics Package

This skill is described as "the ability to use the current generation of presentation software and graphics packages" (NRC, 1999, p. 38). Analysis of the data showed that by the end of the workshop all participants had learned to use the Scratch paint tool, which is similar to other contemporary paint applications (e.g., Paintbrush and Paint).

Figure 12. Gloria's project
Gloria chose an image of a bedroom included in Scratch as her background. She then used the Scratch paint tool to modify the colors and draw a picture of a girl that represented her.

The analysis also showed that about half of the participants had learned to use Photo Booth– a software application for taking photo and video clips– to get pictures and modify them before using them in their projects. For example, Martha used Photo Booth to take severa pictures and add effects to them, which she then used as backgrounds in her project (see Figure 13).

Figure 13. Pictures taken and modified by Martha using Photo Booth

Prior to the beginning of the workshop only one participant indicated that she knew how to use Photo Booth, and Scratch was a new application for all participants. Hence, participating in the workshop gave all participants the opportunity to develop their competence in regards to using graphic packages.

Use Instructional Materials.

This skill refers to the ability to use help files and printed manuals to understand and use a new application (NRC, 1999, p. 39). Analysis of the data showed that about one third of the participants used the Scratch cards to learn how to build scripts. When asked, prior to the beginning of the workshop, how they had learned to use computers and computer applications, all of the participants mentioned taking a class at school or learning from a family member or friend. Hence participating in the workshop provided at least these six participants with the opportunity to acquire or expand this skill. For example, Rebecca used one of the Scratch cards as a guide to build a script that made one of her sprites move (see Figure 14).

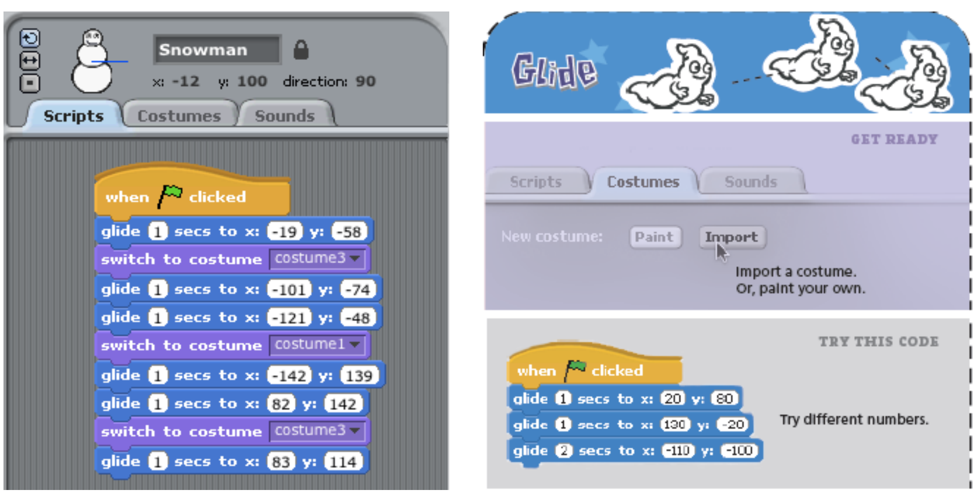

Figure 14. Scratch card used by Rebecca as guide to build script that made a sprite move

Overall, the data indicated that all participants developed two of the skills, using the Internet to find information and resources and using a graphics package, and about one third developed the third one as well, using instructional materials (See Figure 15). It is possible, however, that more participants developed the third skill but this was not captured by the data.

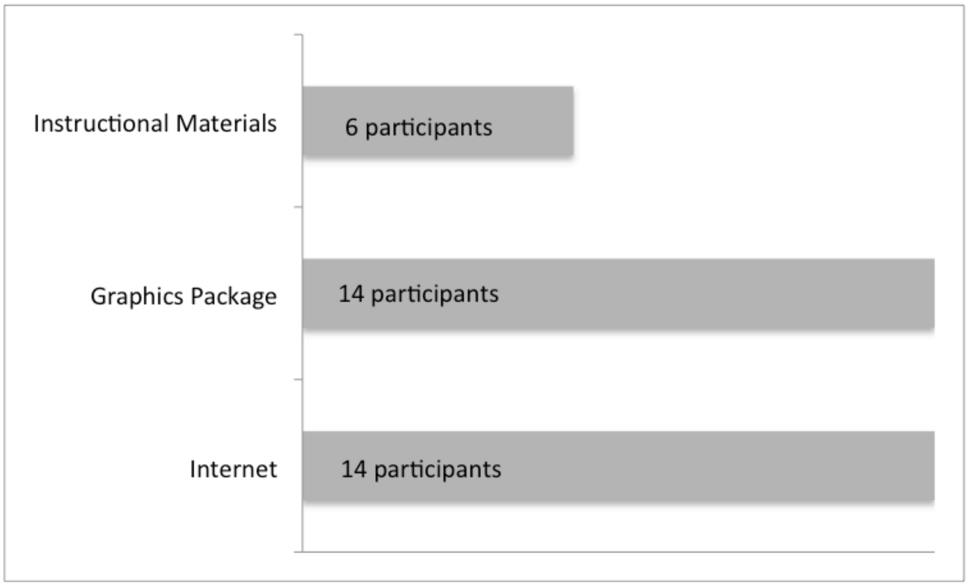

Figure 15. Number of participants who developed each of the technological skills

Technological Concepts: Programming Concept and Constructs

The NRC's framework for technological fluency included ten concepts. However only the concept of programming was selected for investigation, as this was the main subject of the workshop. Programming is the construction of a sequence of instructions (i.e., a program) for executing a task by an agent other than the programmer. The action entails decomposing the task into a sequence of steps and specifying them, sufficiently precisely, so the interpreting agent can execute the intended task. The examination of the data in regards to programming consisted of analyzing it for evidence that participants had engaged in activities that would help them understand what is programming and any related constructs.

The NRC stated that there are four constructs in particular that are important to programming: conditional instructions, repetition, functional decomposition and functional abstraction. This examination –informed by the personal knowledge and experience of the researcher as well as pertinent literature (e.g., ACM Model Curriculum for K-12 Computer Science, 2006)– identified four activities that provided participants with the opportunity to understand the concept of programming and, in particular, two of its constructs (i.e., repetition and functional decomposition). Participants' engagement with these two constructs occurred while engaging in one or more types of the activities identified during the analysis and described below.

In addition, the data was examined for types of commands used. Using different types of commands provided participants with experiences with different types of tasks and more varied opportunities to understand what is programming. The analysis identified four types of commands, out of eight included in Scratch, used by participants: "Looks", "Sound", "Motion", and "Control". Subsequently, the data was analyzed for participants' engagement in these activities and use of the commands.

Programming Activities

Activity 1: Script, sequence of commands not significant. The most basic of the activities participants engaged in, was building a script without taking into consideration the need to put commands together in a particular order. Analysis of the data showed that rarely was this activity done using more than one type of commands, usually of the type “Looks”, hence this activity frequently provided participants with the opportunity to engage with the concept of repetition. Figure 16 shows two examples of this type of scripts, one built by Natalia and the other by Adriana. Although the two main commands in each of these scripts are in opposite order, once executed the outcome was similar. Analysis of the data showed that all participants engaged in this activity, and all both three built scripts that incorporated the concept of repetition.

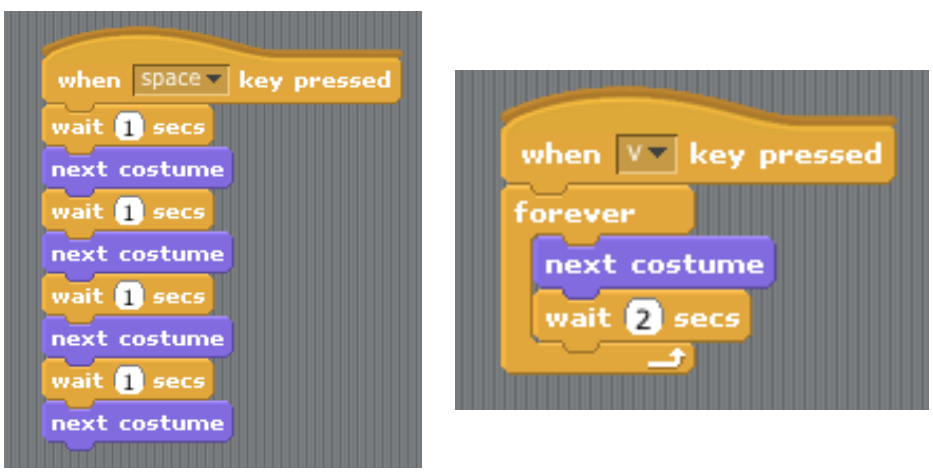

Figure 16. Sample scripts that repeat the same action; sequence of commands not significant

Activity 2: Script, sequence of commands significant. A more complex activity was building a script that took into consideration putting commands together in a particular order. Figure 17 shows two examples of this type of scripts, one built by Alma and the other by Rebecca. In both cases, the participants needed to be aware of the sequence in which they wanted actions to occur and arrange the commands accordingly. Analysis of the data showed that ten participants engaged in this activity, on some occasions they used more than one type of commands (e.g., Alma's script in Figure 17, left pane), on others they used commands of type "Motion" only, which to a certain degree, similarly to programming activity 1, allowed them to engage with the concept of repetition (e.g., Rebecca's script in Figure 17, right pane; the "glide" command is used twice).

Figure 17. Sample scripts where sequence of commands is significant

Activity 3: Additional scripts. A third activity was building additional scripts for a particular sprite (object). This activity added complexity to participants' understanding of programming by providing an opportunity to further think about the importance of order of execution, as they had to consider when should each script execute. It also provided the opportunity to engage with the concept of functional decomposition (i.e., creating specific scripts to execute specific tasks). Figure 18 shows two scripts built by Katia for the same sprite. The first script causes the sprite to change color continuously and starts executing when the space key is pressed. The second one causes a song to play and starts executing when the green flag button is clicked. Analysis of the data showed that seven participants engaged in this activity, frequently when adding a song to their projects, although none built more than two scripts per sprite.

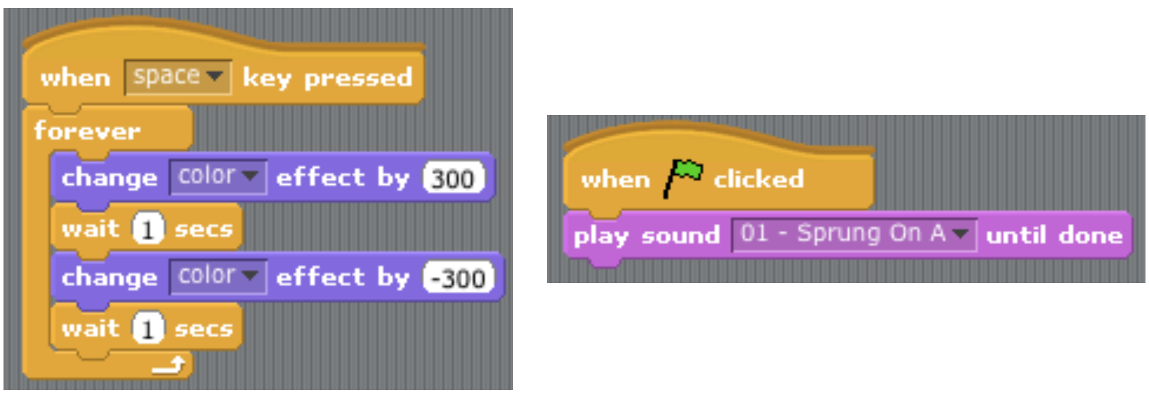

Figure 18. Two scripts built by Katia, for the same sprite

Activity 4: Introduction. Finally, the fourth activity was adding an introduction to their projects. This activity added complexity to participants' understanding of programming by requiring for them to consider the different sprites (objects) in their projects as a collection. At a basic level a program is a sequence of commands, however, at a higher level a program is also a system. Understanding when and how its' different elements interact is necessary in order to obtain the desired outcome. Hence, just as a participant had to think about the order of steps in a script while engaging in programming activity 2 and the order in which scripts for a certain sprite were executed while engaging in programming activity 3, she had to think about when and for how long each sprite would execute as part of the overall project. Furthermore, this activity provided an opportunity for participants to further engage with the concept of functional decomposition as they considered the role that each sprite played as an element of the overall project. See Figure 19 for an example of a script built by Luna where she delineated the sprite's function and execution time. Analysis of the data showed that six participants engaged in this activity.

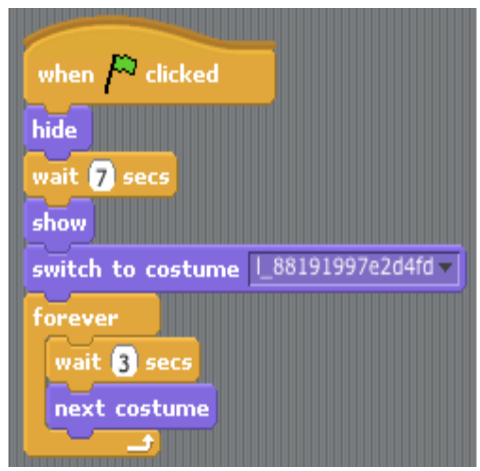

Figure 19. One of Luna's scripts
The first three commands told the sprite to wait 7 seconds until the introduction of the project had executed before executing the next commands. The fourth command told the sprite which "costume" to start with. The last three commands told the sprite to change costumes indefinitely every three seconds.

Overall, the data showed that all of the participants engaged in the construction of scripts by engaging in activity 1 and/or activity 2, and some created multiple scripts for a sprite and/or added an introduction to their projects. Furthermore, the analysis showed that as an activity increased in complexity, fewer participants engaged in it. See Figure 20.

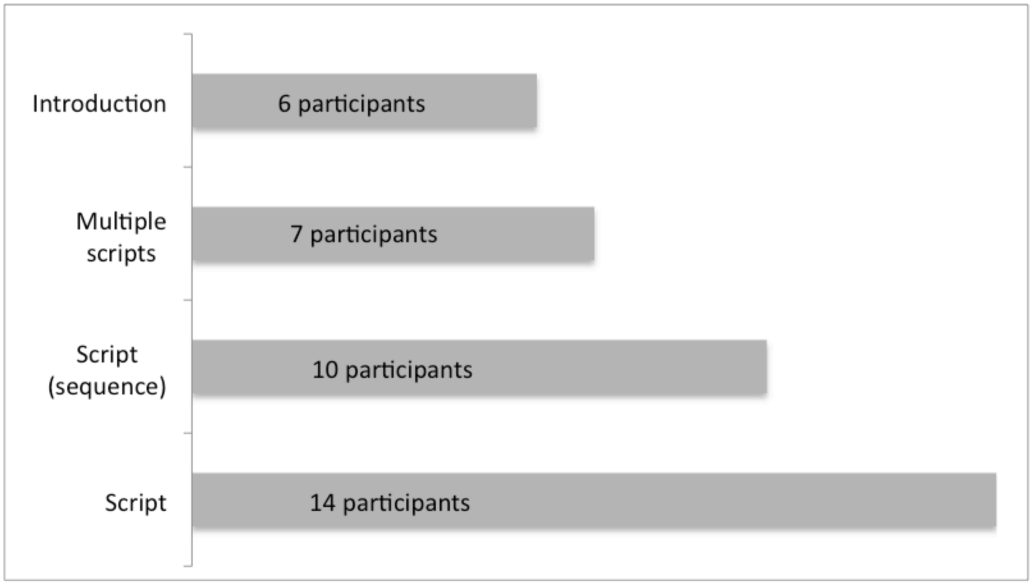

Figure 20. Number of participants who engaged in each of the programming activities

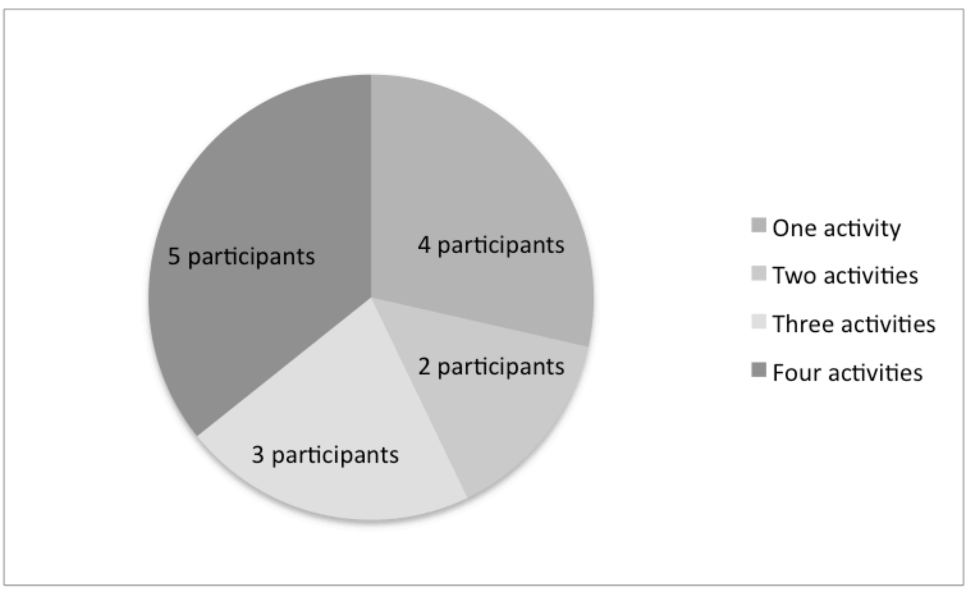

Figure 21. Number of participants who engaged in one, two, three, or four types of activities

Programming Commands

Type 1: "Looks" and "Sound". These commands were considered the least complex ones since they required that only surface features of a sprite (object) be considered. See Figure 19 for an example of these types of commands. The analysis showed that these types of commands were the most frequently used with all participants using commands of the type "Looks" and two thirds using commands of the type "Sound".

Type 2: "Motion". These commands were considered more complex than commands of the types "Looks" and "Sound" since they required that a sprite be regarded as a mobile object and frequently involved paying attention to two of its properties (i.e., its x and y coordinates). See Figure 17, right panel, for an example. The analysis showed that commands of this type were used by two thirds of the participants as well.

Type 3: "Control". In addition to the "Control" command that specifies when should a script run and the one that makes the execution of a script pause for a specified number of seconds –both of which were used frequently by all participants– the other "Control" commands used by the participants were the ones that implement the concept of repetition (i.e., loops), and hence were considered the most complex ones. See Figure 18 for an example. The analysis showed that these commands were used by half of the participants.

Overall, the data showed that commands of the type “Looks” were used by all of the participants, commands of the type “Sound” and “Motion” were used by about two thirds of the participants, and commands of the type “Control” (i.e., loop) were used by half of the participants. In addition, similarly to participants’ engagement in the different programming activities, the data showed that as a type of command increased in complexity, fewer participants engaged with it. See Figure 22. The data also showed that two thirds of the participants engaged with at least three of commands. See Figure 24.

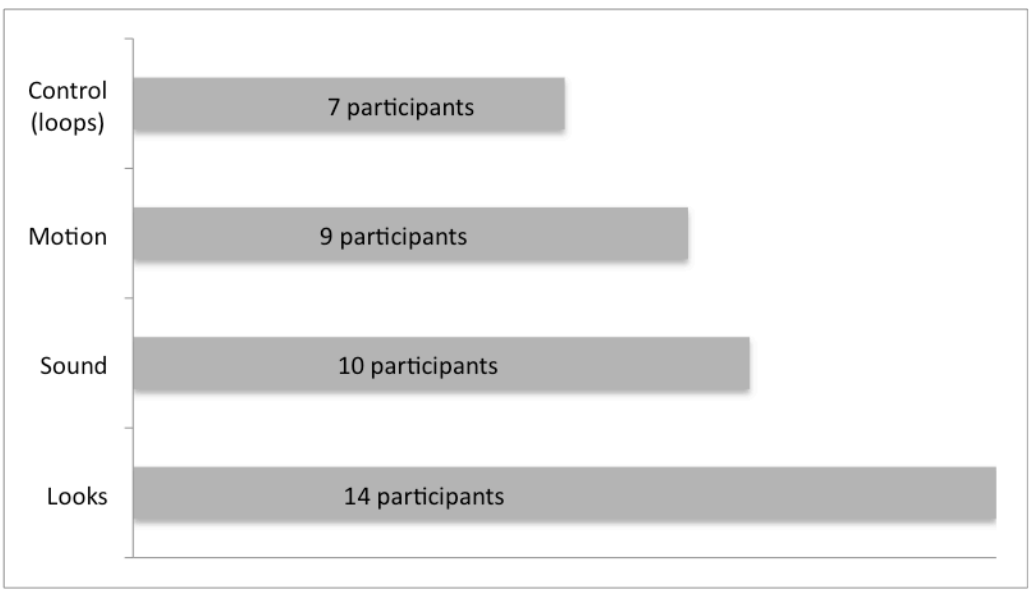

Figure 22. Number of participants who used each type of command

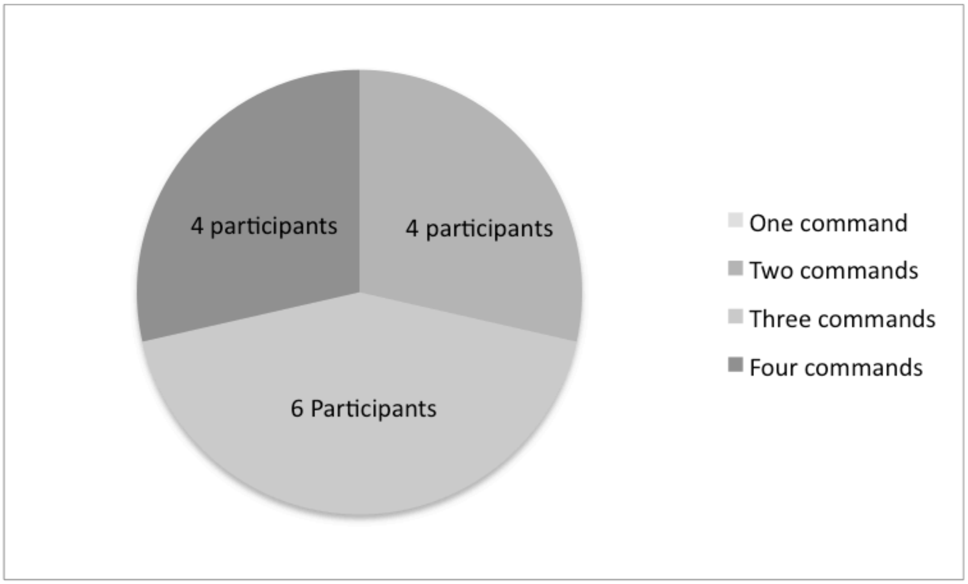

Figure 23. Number of participants who engaged with two, three, or four types of commands (Note: no participant used only one type of command)

Intellectual Capabilities

Intellectual capabilities empower people as they manipulate technology to achieve a goal, including the handling of unintended and unexpected problems when they arise; hence these capabilities are independent of specific hardware or software applications (NRC, 1999). Often, creating a computer program involves many if not all of the capabilities included in the NRC framework for technological fluency. For this reason, the data was first coded for evidence of participants engaging with any of the ten capabilities. This analysis indicated that there were three capabilities that were most engaged in by the participants: (1) engage in sustained reasoning, (2) manage complexity, and (3) manage problems in faulty solutions. The analysis then consisted of looking for evidence that showed a participant had engaged with any of these three capabilities during the workshop.

Table 1. Intellectual capabilities participants engaged with more often, and criteria used to determine engagement during the workshop

Intellectual Capability	Description	Criteria
Engage in sustained reasoning	Carry out an integrated effort to implement a solution that covers days or weeks (p. 21).	Participant worked on project during three or more sessions.
Manage complexity	Identify and integrate the different components of a solution, including unexpected happenings (p. 21).	Participant worked on including several sprites (with scripts) in her project.
Manage problems in faulty solutions	Detect and correct problems during the implementation of a solution as necessary (p. 22).	Participant worked on making her scripts execute as desired.

Analysis of the data showed that all participants engaged in sustained reasoning and the management of complexity as they worked on their projects. Specifically, all of the participants worked on their projects over at least 5 sessions (average: 6.4 one hour sessions), during which time all added different components (i.e., sprites) to their projects and built scripts for some of them. For example, Cristina's first version of her project included five different sprites, two of them with scripts (see Figure 24, left panel); the second version of her project included 13 different sprites, 8 of them with scripts (see Figure 24, right panel).

Figure 24. Cristina's first and second version of her project

In addition, the data showed that almost all participants encountered and solved issues during the construction of some of their scripts. Sometimes, participants engaged in the detection and correction of problems during the implementation of one of the components, as the following vignette illustrates:

> *"Alma would get frustrated because she was trying so hard to figure out a way to record a song and add it to her project, but it was not working out the way she planned. However, after several tries, during which she talked to the computer and shook it once or twice, she managed to accomplish her task" (FN, 10/21/08).*

Other times, unexpected results rose as the final solution was tried out (i.e., the project as a whole was made to play), as can be seen in the vignette below:

> *"Kathy came to ask Paulina how it was going. Paulina told her, 'I think I'm done!' Kathy asked if she could look at it and Paulina showed it to her. As the project was executing, Kathy was telling Paulina that it was really good and it seemed that she had spent time on making all the sprites in her project work together since Kathy had last seen it. In the middle of the animation, however, something went wrong. Paulina said she needed help and started calling for the instructor to come to her computer. The instructor did not seem to hear her however. So Paulina said, 'She isn't listening to me!' and then turned around and tried to figure out how to fix it herself" (FN, 11/06/08).*

Overall, the data indicated that all of the participants developed two of the capabilities and about two third developed all three capabilities. See Figure 25. Once again, it is possible, however, that the remaining participants developed the third capability as well but this was not captured by the data. In addition, as can be seen in the two vignettes presented above, the data showed that participants often made use of these capabilities concurrently.

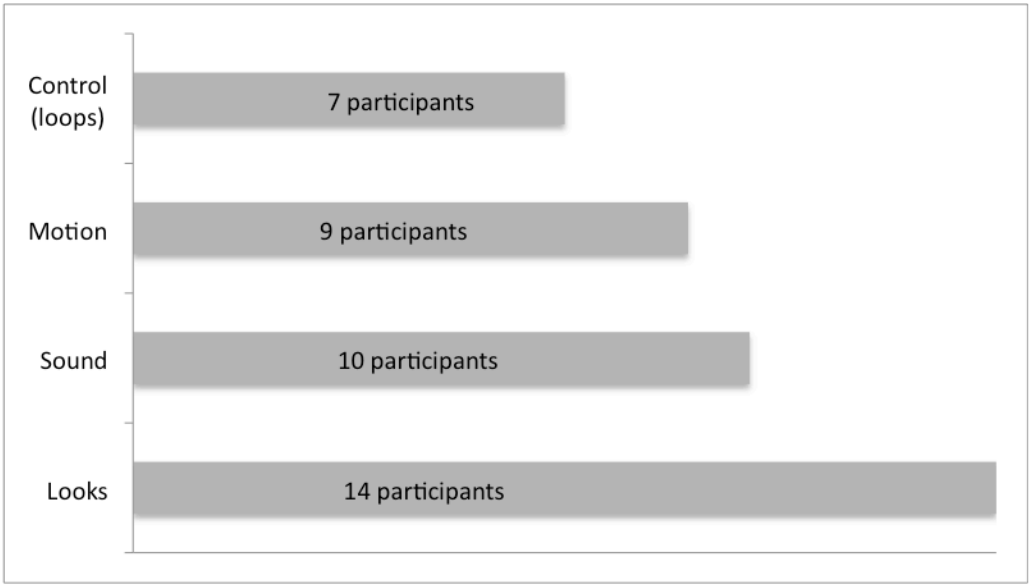

Figure 25. Number of participants who engaged with each of the Intellectual Capabilities

Conclusion

By the end of the workshop all of the participants have had the opportunity to develop their technological fluency. In particular, all of the participants learned more about using the Internet to find information and using graphic packages, all built scripts using at least two different types of commands, and all engaged in sustained reasoning and the management of complexity as they did so. Furthermore, all thought that coming to the workshop had given them the opportunity to learn a new program or programs and hence become better computer users. In addition, about half of the participants explicitly expressed a basic understanding of what programming is during the interview at the end of the workshop. The next chapter presents the results of the analysis in regards to the design characteristics of the learning environment that could have played a role in the participants' development of technological fluency, specifically, their role in participants' engagement in the different programming activities and use of the different commands.

Chapter VI

Participants' Development of Technological Fluency and the Learning Environment

This chapter presents the analysis of the characteristics of the learning environment that supported participants' development of technological fluency. Six characteristics were included in the analysis: voluntary attendance, girls-only environment, emphasis on design and creativity, building from concrete to abstract knowledge, opportunities for articulation and reflection, and scaffolding. Informed by past research, these characteristics were selected during the design phase of the study as the ones to be investigated. An additional characteristic, prior knowledge, was not included in the analysis since none of the participants, except one, had engaged in programming before. Each characteristic was examined individually. Given that the main focus of the workshop was on programming, the main focus of the analysis was on the characteristics as they related to the participants' development of programming knowledge and skills.

Methods

As it was described in chapter five, the analysis of participants' development of technological fluency identified four programming activities participants could have engaged in while building their projects. Further analyses identified three groups based on the number of activities participants engaged in; it was assumed that the more activities a participant engaged in, the more complex her experience in the workshop would be, this in turn would lead to increased development of programming knowledge and skills. The first group included participants who had engaged in only one type of activity, building a script without taking into consideration the order of commands; this group was deemed the lower development group and included four participants. The second group included participants who had engaged in two to three types of activities. Two of the activities were building a script without consideration for order of commands and building a script with consideration for order of commands; the third activity was either building additional scripts for a sprite or adding an introduction to the project. This group was deemed the medium development group and included five participants. The third group included participants who had engaged in all four types of activities; this group was deemed the higher development group and included five participants. See Appendix D.

A participant's engagement in the activities was determined using data from each of the sessions she attended. In other words, once evidence was found in the field notes or her project that a participant had engaged in an activity this was noted. Moreover, given that participants had a limited amount of time during which to engage in the creation of their projects, and the limited nature of the data, no distinction was made in regards to participants engaging more or less frequently in an activity. The three development groups were subsequently compared in the analysis of each characteristic of the learning environment. The data included in the analysis consisted of the participants' projects (all versions available), field notes and attendance records of each workshop session, transcripts of the interviews conducted with the participants before and after the workshop, and field notes from the focus group conducted after the introductory sessions but before the project sessions.

In addition, two alternate analyses were conducted to account for differences in attendance among participants. First, an analysis was conducted using data only from the first six sessions each participant attended (all participants attended at least six project sessions) and her placement in a development group was determined using these data (see Appendix D). The second alternate analysis was conducted using data only from those participants who attended more than six sessions (i.e., eight to nine sessions). This analysis included ten participants (see Appendix D). Results from the two alternate analyses supported those from the main analysis and are not presented here. A possible explanation as to why results from the alternate analyses were similar to those of the main analysis is that most participants engaged in any of the activities for the first time within the first six sessions they attended (see Figure 26). This in turn, caused the groups used in each analysis to be almost identical. For example, four out of the five participants in the higher development group in the main analysis were also part of this group in both alternate analyses; similarly with participants in the other two groups (see Appendix D).

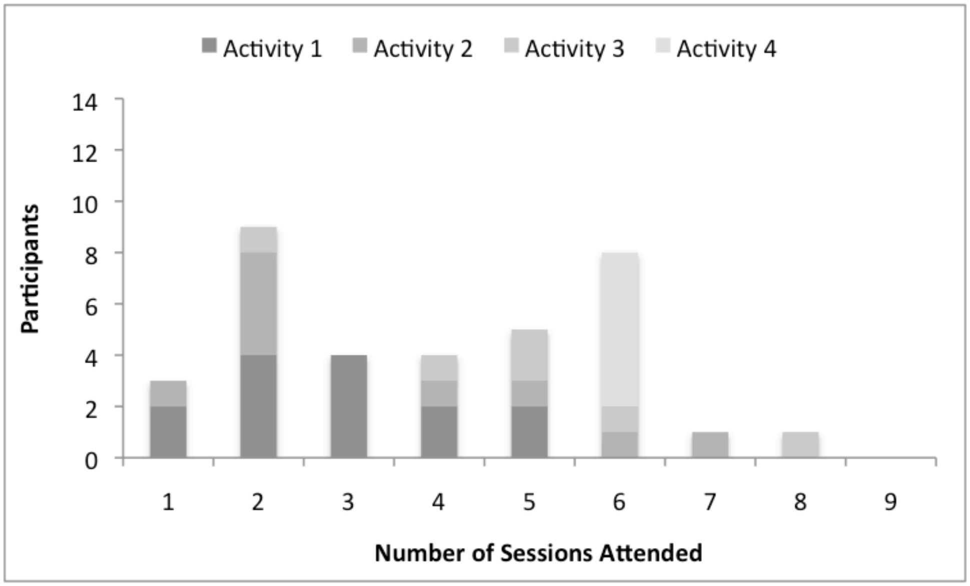

Figure 26. Number of participants who engaged in each of the programming activities for the first time during a particular session they attended

Findings

Voluntary Attendance

One of the characteristics of the CTC selected as the site for this study is that attendance to workshops is voluntary. Although being able to make a choice in regards to attending the workshop could have had a positive impact on participants' development by giving them a sense of agency (Blumenfeld, Kempler, & Krajcik, 2006), a negative consequence could have been that participants would choose not to attend sessions and hence miss opportunities to develop their programming knowledge and skills. Hence, an analysis was conducted using the number of introduction and project sessions each participant missed to investigate the possible role that missing sessions could have had in participants' development of programming knowledge and skills. In addition, attendance rate for both the introductory and project sessions was calculated, i.e., the percentage of participants who attended each session on average. Finally, the analysis was also informed by data from field notes and participants' interviews in regard to reasons a participant might have had for missing a session.

Sessions were highly attended. Participants chose to attend most of the time: 77% and 85% attendance rate for introductory and project sessions, respectively. Furthermore, whenever a participant did not attend the workshop, it was due to factors besides choice (see Figure 27).

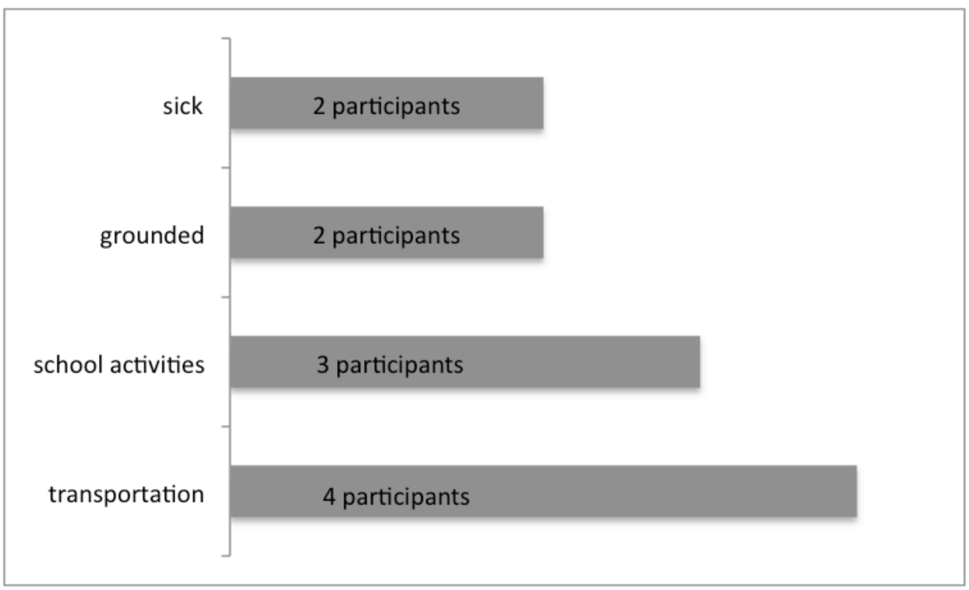

Figure 27. Number of participants who mentioned each external factor as a reason for not being able to attend the workshop occasionally

Attendance not a determining factor. The analysis of participants' development of technological fluency suggested that missing sessions– be it introductory or project sessions– played a slight negative role. In particular, participants in the higher development group missed no more than two sessions and none missed more than one introductory or project session. Participants in the middle development group missed between one and five sessions, and four out of the five participants missed more than one introductory or project sessions. Participants in the lower development group missed between one and seven sessions, and three out of the four participants missed three or more project sessions. However, as can be seen in Figure 28 below, there were exceptions in the middle and lower development groups (i.e., Rebecca, Thalia, and Natalia) indicating that attending or missing sessions was not a determining factor in participants' development of technological fluency. It is important to note that the sessions participants missed were distributed throughout the duration of the workshop.

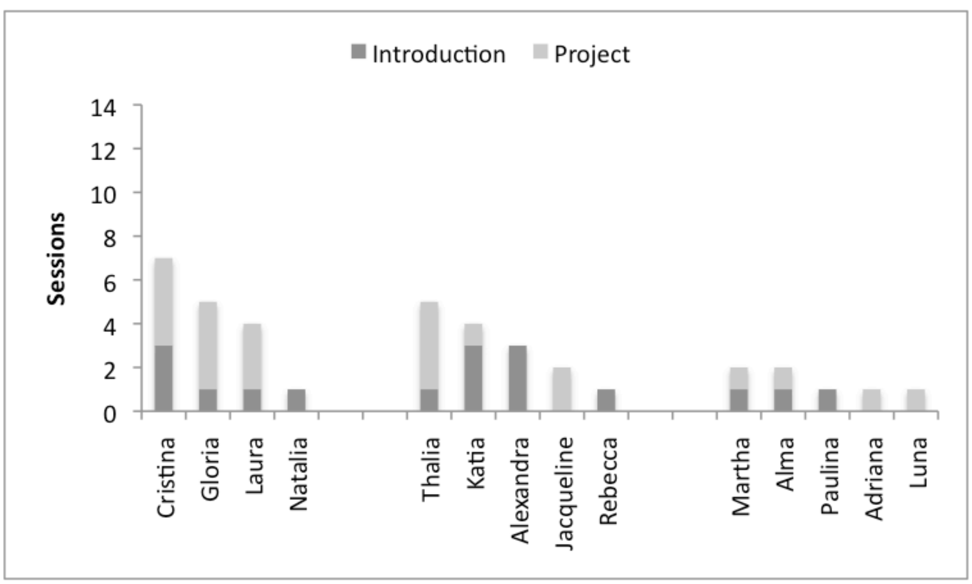

Figure 28. Number of introductory (max = 4) and project sessions (max = 10) each participant missed, by development group
(Note: lower development group, far left; higher development group, far right).

Girls-only Environment

As it was previously mentioned, a single sex setting was chosen for the workshop since past research has suggested that girls tend to underestimate their technological abilities and take on passive roles when working with computers in mixed environments (AAUW, 2000; Margolis & Fisher, 2003; Stepulvage, 2001). To explore the role that a girls-only environment might have played on participants' development, the analysis looked at what the participants had to say when interviewed before and after the workshop in regards to this characteristic.

Negative relationship of relevance to development. Although a girls-only environment was an appealing characteristic for several participants both before and after the workshop, its relevancy was negatively related to participants' development of technological fluency. For example, fewer participants in the higher development group than in the medium and lower development groups had indicated before the workshop that it being a girls-only activity was particularly appealing. After the workshop, only one participant in both the medium and higher development groups indicated this while all participants in the lower development group did (see Figure 29).

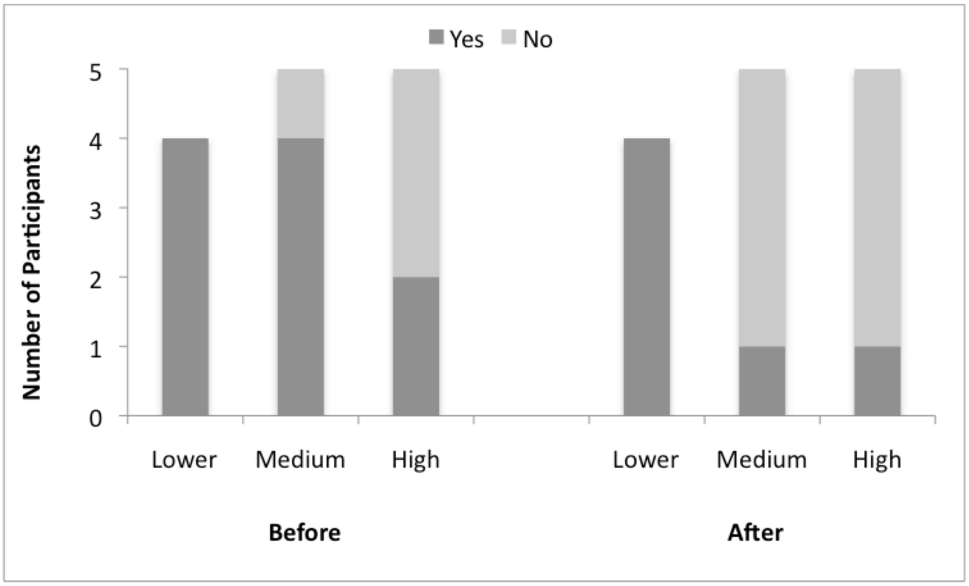

Figure 29. Number of participants who liked or not liked the workshop being a girls-only activity, before and after the workshop, by development group

Emphasis on Design and Creativity

It was intended for the project to emphasize design and creativity. Hence, there was not a specified set of elements that their projects must contain or a specified sequence in regards to what activities needed to be completed first. Moreover, throughout the workshop participants were allowed to choose what to spend their time on during the sessions they attended. These features were implemented in an effort to provide motivation and an activity in accordance with a "soft" mastery style, a programming style to which, some researchers argue, many women are drawn (Turkle, 1995). In particular, this style is characterized as being highly interactive: the final project emerging through a process during which its elements are added, deleted, arranged and rearranged in a constantly iterative process.

In order to see if an emphasis on design and creativity played a role in participants' development, the analysis looked at participants' engagement with their projects; in particular, how many sessions were spent on programming, how many scripts were built and/or deleted, and how many of those were original scripts. A script was considered original if it was not a copy of any other script and did not accomplish a task already accomplished by another script. In addition, the analysis looked at what participants had to say about their projects during the interview at the end of the workshop.

Pre-determined design and free exploration. All participants followed a structured approach to the construction of their projects that included three phases: working on the background first, working on adding elements to the project next, and finally, if desired and time permitted, adding a title screen. However, not all followed a particular design when constructing their projects. In particular, after the workshop about half of the participants indicated that they did not rely on any kind of model when building their projects, rather, as they worked, they used what they "liked" as a source of inspiration. The rest of the participants mentioned that they did rely on an outside source for inspiration and a way to come up with ideas for their projects. The sources mentioned were the instructor's sample project, other participants' projects, and websites they liked. This was apparent in their projects as well. For example, Laura's project exhibited a design that was observed on several other participants' projects (see Figure 30, left panel);

Jacqueline’s project followed a design similar to a website (see Figure 30, middle panel); Alma’s project displayed a design unique to her project.(see Figure 30, right panel).

Figure 30. Different project designs

More iterations, more development. Although no differences among development groups were found in regards to the projects’ design, participants did differed on the number of sessions they spent on the programming aspect of their projects and the number and types of scripts they included. By the end of the workshop all fourteen participants had engaged in programming; however, some spent more sessions on programming than others did. In particular, participants in the higher and medium development groups spent more sessions on programming than did participants in the lower development group, and participants in the higher development group spent more sessions programming than did participants in the medium development group. Similar results were found in regards to participants adding scripts and creating more original scripts. In addition, three participants in the higher development group deleted a considerable number of scripts (i.e., about half as many scripts as they added); none of the participants in the medium and only one participant in the lower development group did.

Table 5. Number of programming sessions, original scripts, and scripts added and deleted by each participant, by development group

Group	Participant	Programming	Original	Add	Delete
Higher	Adriana	6	5	31	1
	Martha	7	6	20	8
	Alma	6	10	16	9
	Paulina	8	7	11	6
	Luna	6	5	10	0
Medium	Rebecca	5	3	8	1
	Thalia	4	2	8	0
	Alexandra	5	3	8	0
	Jacqueline	4	3	7	1
	Katia	5	4	6	1
Lower	Laura	3	2	7	0
	Cristina	2	2	5	1
	Natalia	3	3	4	3
	Gloria	1	2	2	0

Building from Concrete to Abstract Knowledge.

One of the workshop's main objectives was to introduce participants to the concept of programming, and it was believed that working on their projects and in particular building scripts would help them develop an understanding of what programming is. One of the tenets of the learning sciences is that "learning starts with more concrete information and gradually becomes more abstract" (Sawyer, 2006, p. 12). To explore the role that building scripts played in participants' understanding of programming, the analysis looked at what transpired while they were engaged in this activity, as well as their responses during the interview at the end of the workshop in regards to what they had learned.

Positive relationship between building scripts and understanding of programming. More participants in the higher development group, who also added the higher number of scripts, indicated an emerging understanding of what programming is in their responses than those in the medium and lower development groups. In addition, more participants in the medium development group than in the lower development group added more scripts and indicated an emerging understanding of what programming is in their responses, see Tables 5 and 6.

Table 6. Number of participants in each group, whose responses indicated an emerging understanding of programming, including their responses, by development group

Group	Participants' Responses
Higher 4 Participants	Adriana: I learned how to tell the computer what to do, more about how to control it. Alma: I learned how to tell the characters in Scratch what to do. Luna: I learned to tell the computer what to do, that I need to do every little step. Paulina: I learned how to use the computer to make our own program
Medium 3 Participants	Jacqueline: I learned what commands to use to make a "picture album". Katia: I learned how to use Scratch, put this [command] in order to do that. Rebecca: I learned how to use Scratch, tell the characters what to do.
Lower 1 Participant	Laura: I learned that computers do not always do what we tell them to do.

Role of the programming environment. Scratch was chosen as the programming environment for the workshop because of its graphical language and highly interactive environment. It was believed that these characteristics would allow participants to observe a concrete representation of the process involved in creating a script in particular and the abstract notion of what programming is in general. An examination of participants' interactions with the programming environment showed that on many occasions having the ability to observe the script that they had built and its outcome next to it facilitated participants' emerging understanding of programming and their role in it. For example, during one of the sessions, Rebecca had built a script for one of her sprites to change locations using one of the Scratch cards but it was not working. After the instructor suggested the sprite was already at the location indicated in the script, Rebecca exclaimed: “Oh, so I have to tell it where I want it to go!” (FN, 10/23/08). This experience provided Rebecca with a concrete example of the connection between her goals, the blocks as a means to communicate it, and her role in this process. Paulina had a similar experience:

> *“Paulina did not understand why the sprite had turned green. The instructor asked her if she had told the sprite to do this. At first, Paulina said that she had not. However, when she looked at the script she realized that she had in fact done this by using the “change <color> effect by <#>” block. As Paulina tinkered with the parameter of the block and observed what happened to the sprite in the stage area, she came to comprehend where the bug in her script was located” (FN, 10/21/08).*

For both Rebecca and Paulina, their realization of this connection and the role they played was aided by the fact that they could see the script and its output next to each other, observe how their choices reflected on the output, and understand they were the ones telling the sprite what to do; they were the ones programming the sprite. The following vignette shows Alma going through a similar process, aided by her ability to see the results of her choices every step of the way:

Alma had painted the background purple and there was a ghost. While the instructor was looking at her project, Alma commented that she wanted the background to change colors repeatedly and added, "I think I need to look in the 'Looks' menu". Alma did this, found the block she was looking for and added it to her script. As she ran the script and the background started changing colors, she seemed pleased with the outcome. The instructor then suggested she could make the ghost fly and Alma replied, "Yeah, but I need to find the glide block first." Alma clicked on the 'Motion' menu and found the "glide <secs> secs to x: y:" block, added it to her script inside a "forever" block, adjusted the x and y coordinates and made the script run. She repeated this process two more times. When she made the script run one last time she saw the outcome and exclaimed, "This is so cool" (FN, 10/23/08).

In addition to aiding participants' understanding of the nature of programming, Scratch supported their understanding of programming concepts through its graphical language. In particular, this was observed in regards to the concept of repetition/looping, which can be implemented in Scratch through the use of the "forever" and "repeat" blocks. The shape of these two blocks is a C and the block(s) to be repeated are inserted inside. This provided participants with a concrete representation of the concept of a loop and aided their understanding of it. For example, on one occasion Adriana was trying to build a script that caused the looks of a sprite to change continuously:

> *Adriana clicked on the "wait <secs> secs" block and asked, "Here? Do I put it here?" She was trying to put it above the "forever" block. The instructor said, "If you put it there it will only happen once". She said, "Oh! Then I should put it here [inside the forever block]" (FN, 10/23/08).*

Moreover, the fact that participants could leave extra blocks or stacks of blocks lying around the scripting area without affecting the outcome of a project supported their understanding by allowing for multiple concrete representations of the concept. For example, examination of Alexandra's project showed that at some point she had a concrete representation of both a naïve and a more sophisticated implementation of repetition/looping. Initially she included a sprite and wrote a script to make it change color three times (see Figure 31, right panel). At a later session, she learned about the "Repeat" block and used it to build a loop that would make the sprite change color ten times; she built this loop immediately below the script that she had previously built (see Figure 31, middle panel). Two seesions later, Alexandra replaced the stack of blocks that made the sprite change color three times with the loop that made it change color ten times (see Figure 31, right panel).

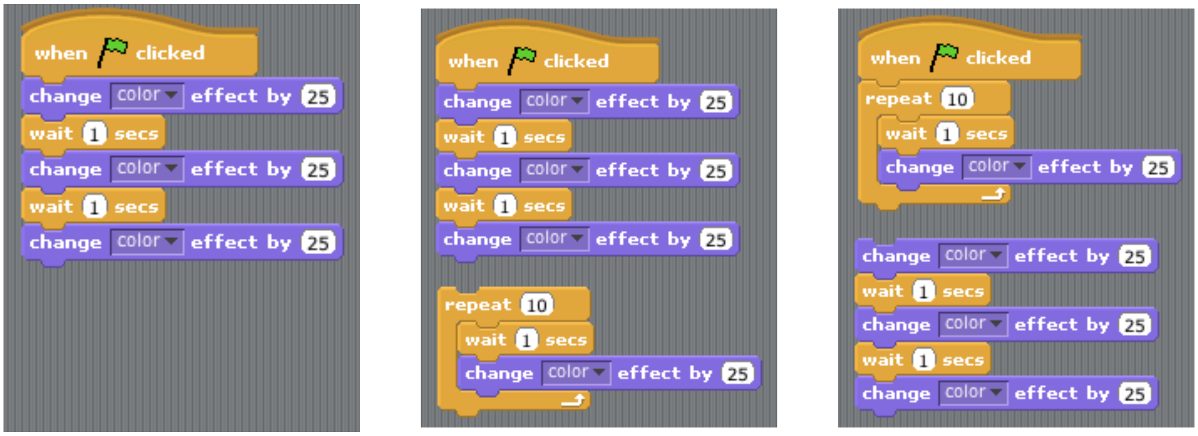

Figure 31. Three version of one of Alexandra's scripts

Laura's project showed evidence that she had undergone a similar process. When asked about it, she explained, "this script [the one composed of the same block repeated several times] and this other one [a script with a loop] do the same thing, but it's easier this way [pointing to the script with a loop] because I do not have to repeat the block many times, just change the number in the repeat block" (FN, 11/04/08).

Opportunities for Articulation and Reflection

Participants were encouraged throughout the workshop to interact with the instructor and other participants as a mechanism to precipitate their engagement in articulation and reflection. Past research from the learning sciences has established that providing opportunities for articulation and reflection can enhance students' understanding (Sawyer, 2006). To explore the role that having such opportunities played in participants' development of programming knowledge and skills, the analysis looked at what transpired during interactions between participants and between the participant and the instructor. In addition the analysis noted if a participant tried something on her own before asking for help as this could have provided a concrete opportunity for her to engage in articulation and reflection.

Interacting provided opportunities for articulation and reflection. A common subject of participants' interactions was translating an idea of what they wanted for a sprite to do into a script, and in particular what commands to use. Often participants had already some experience building scripts and using some of the commands but had difficulties conceptualizing a new idea and coming up with commands to use. For example, on one occasion, Jacqueline had asked the instructor for help making a "picture album":

Prompted by the instructor Jacqueline explained, "I want to make the pictures change." The instructor asked her which menu would she use if she wanted to make something look different. After hearing this, Jacqueline clicked on the "Looks" menu and exclaimed, "Oh, yeah, I can use the next costume block" (FN, 10/28/08).

Katia had a similar experience where she had to explain to the instructor what she meant by making her sprite "twilight" (i.e., sprite's colors keep changing fast), and after being asked which block she thought she could use went on to build a script using the 'change <effect> effect by <#>' block. At the time this interaction was recorded, Katia's project already included a script that made use of this particular block. Hence, interacting with the instructor often provided participants opportunities, such as in Jacqueline and Katia's case, to work out an idea and reflect on their current knowledge and experience so that they could then build the new script. Here is one more example:

> *The instructor had asked Martha to play her project. Martha complained about having to manually move all the sprites to their original positions. The instructor suggested she could build a script that caused her sprites to move to their original positions and asked her what blocks she would use. Martha thought for a moment and replied that she could use the glide or the go to blocks and then proceeded to build the script (FN, 10/21/08).*

In addition, interacting with another participant provided opportunities for them to articulate and reflect on their understanding of commands and building scripts. For example, this was observed often with the "picture album" script since this became a popular script and one that participants showed each other how to build:

> *Jacqueline was complaining to the instructor about how the script that she had built for her "picture album" only showed each picture once. She wanted for this to happen more than once. Adriana, who had come to say hi to Jacqueline, agreed to help her. Jacqueline started showing Adriana her script and telling her what she was doing with it. Adriana told Jacqueline that she needed to repeat the*

"change costume" block, clicked on the "Control" menu, dragged a "repeat" block and attached it to the script and then inserted the "next costume" block. Jacqueline ran the script and when Adriana saw the pictures changing really fast, said "oh, yeah" and stopped the script. She then inserted a "wait" block inside the loop. Jacqueline ran the script again and it worked (FN, 10/28/08).

As this vignette shows, showing Jacqueline how to build the script gave Adriana the opportunity to articulate and externalize her understanding about how to build a script for a sprite to change costumes several times and what the different commands in the script did. After she observed the script that she had built execute, she realized she had forgotten an important element and fixed it. In addition, Jacqueline had the opportunity to reflect on her own understanding by explaining to Adriana what she wanted to do and had done, and comparing the script she put together to the one Adriana built.

Not a lot of trying. Most participants tried to solve a problem or figure out how to achieve a goal seldom before asking for help. In fact, only about half tried to do something on their own once or twice before asking for help. This was unfortunate since building a script before asking for input or help often facilitated participants' engagement in reflection during an interaction, mainly by providing a concrete articulation of their understanding on which to reflect upon. This was the case, during one of the sessions for Adriana:

Adriana told the instructor that she wanted to make some of the letters in her project change colors. She asked the instructor if she could take a look at her project and see how the instructor had done it. The instructor walked to the front of the room where her laptop was and Adriana followed her. The instructor brought up her project on the screen and then she clicked on the sprite that Adriana was talking about so that the script would become visible. In her project the instructor had use a "forever" block with a "change <color> effect by <25>" block. Adriana saw the script and said, "That is how you did it. I thought you had several costumes. Ok, thanks." The instructor asked her what she meant and she replied that she had tried it with several costumes, a different color each, but the effect was not the same (FN, 11/04/2008).

In this vignette the instructor's code and Adriana's previous attempt served as resources for her to articulate her understanding of the task she was trying to implement and reflect on her own performance. Afterwards, Adriana was able to build a script that achieved the effect she was looking for. Luna had a similar experience that provided an opportunity for her to reflect and increase her understanding of the "looping" commands:

"Luna called the instructor over and showed her one of her scripts. The script that she had built included a "forever" block. When the instructor noticed that the

"forever" block included a second, and in her opinion unnecessary, "forever" block, she asked Luna about it. At first Luna asked if she should have used a "repeat" block instead of the same block twice. The instructor told her that "repeat" and "forever" were "kind of similar" and after a few seconds Luna went, "Oh!" and proceeded to take out one of the blocks out" (10/14/08).

Positive relationship of articulation and reflection to development. All except one of the participants was observed interacting with the instructor and/or other participants, although some more often than others. More importantly, however, some participants engaged in interactions that included articulation and/or reflection more often than others and a positive relationship between this and participants' development of technological fluency was observed. In particular, participants in the higher and medium development groups engaged in articulation and/or reflection more often than participants in the lower development groups and similarly between those in the higher and medium development groups. In addition, it was observed that most participants engaged in articulation more often than they did in reflection probably due to their novice status.

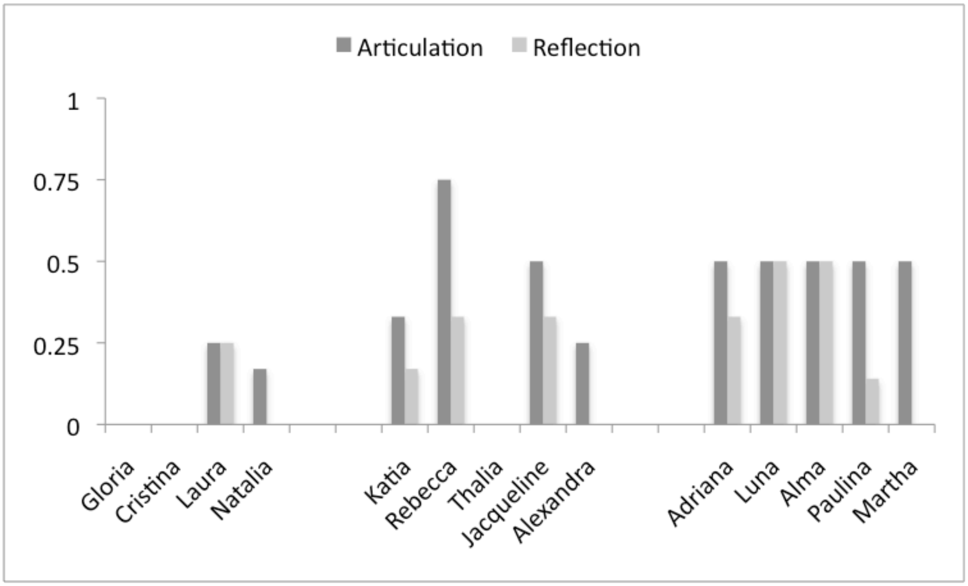

Figure 32. Ratio of number of interactions during which a participant engaged in articulation or reflection to total number of interactions she took part in, by development group

Scaffolding

Scaffolding "is the help given to a learner that is tailored to that learner's needs in achieving his or her goals of the moment". For example, providing prompts and hints that help learners figure something out on their own. In order to see if receiving scaffolding played a role in the participants' development of technological fluency the analysis looked at what transpired during those interactions during which a participant was receiving help by the instructor or another participant.

Varied types and frequency of scaffolding. Throughout the workshop scaffolding was provided on an as-needed basis. This is, a request for help from a participant initiated most of these interactions. In particular three types of scaffolding were identified, each occurring at a different frequency during the workshop (see Table 7).

Table 7. Scaffolding strategies and frequency of occurrence

Strategy	Description	Interactions: Scaffolding
Modeling	Demonstration of particular skill (by Instructor/Peer/Scratch).	55%
Suggesting	Provide hints or suggestions to help student move forward.	25%
Instructing	Tell the student what to do or explain how something must be done.	20%

Modeling was the most frequent type of scaffolding. Often the instructor modeling how to build a particular script provided this type of scaffolding:

> *Thalia asked the instructor for help adding the letters of her name to her project. She wanted to make them move. The instructor first showed Thalia how to add a new sprite for the first letter in her name and then showed her how to use the glide and go blocks to make it move; where she could look at the x and y coordinates of the sprite so she could use them with the blocks. Thalia then spent the rest of the session working on adding the rest of the letters in her name. (FN, 10/28/2008).*

During this interaction the instructor modeled for Thalia how to add a sprite for one of the letters in her name and build a script to make it move. Thalia then had the opportunity to engage in this activity for the rest of the letters. Other times it was a participant who modeled for another participant how to build a certain script, as was the case when Rebecca helped Alexandra build a “picture album” script:

> *Alexandra wanted to make a “picture album” and asked Rebecca to show her how to make a sprite change costumes. Rebecca went to Alexandra’s computer. At Alexandra's computer Rebecca proceeded to build the "picture alvum" script while telling Alexandra that she needed the "switch to <costume> costume block several times” and the "wait <secs> secs" block so “the pictures don't go really fast”. Afterwards, Alexandra tried and build one for another sprite (FN, 10/21/2008).*

In addition to modeling of more expert behavior, scaffolding through modeling can also be embedded in a learning tool, such as with the Scratch cards. For example, Paulina used one of the cards to add a drum to her project during one of the sessions (see Figure 33).

Figure 33. Paulina's project, including the drum sprite and the scratch card she used as a model to create it

The second most frequent type of scaffolding was suggesting. Similarly to modeling this type of scaffolding was provided by the instructor when a participant had a question about building a new script such as when Paulina asked the instructor for help making the "slide show" and the instructor suggested she thought about how to make the sprite change costumes or when Luna asked the instructor for help making one of her sprites change color and the instructor suggested she could use the "color effect" block but let her figure out how it worked (FN, 10/14/08). However, scaffolding through suggesting also occurred when a participant had already attempted to build a script but was having difficulties making it work:

Alma asked the instructor to help her because she had put together a script that included a loop but it was not working. The instructor could see that Alma was getting frustrated. The instructor took a look at Alma's script and suggested that *maybe it was not working because she had the "change <color> effect by <25>" block twice inside the loop (FN, 10/23/08).*

Finally, scaffolding was also provided through instructing. Both the instructor and participants provided this type of scaffolding, however the context of the interactions differed. For the most part, the instructor used this type of scaffolding when helping participants with tasks other than building scripts such as using the programming environment or adding sprites to projects:

Gloria asked the instructor for help because, she said, she had "added this image and moved it over there but" when she did this the pictures disappeared. The instructor explained to her that what she had right now was like having herself with two different outfits but she guessed what Gloria wanted was to have her with one outfit and her sister with one outfit. Gloria opened her eyes big and asked "so, I need to add a new sprite?" (FN, 10/23/2008)

When participants engaged in this type of scaffolding it was related to them building scripts and consisted of telling each other which blocks to use. For example, during one of the sessions Paulina was observed telling Jacqueline about using the "hide" block to hide her sprites during her project's introduction. Similarly, Rebecca was observed talking to Katia about how she could use the "change costume <costume>" block to make her background change pictures.

Frequency of each type. All participants frequently received scaffolding through modeling. However, differences were observed in regards to participants receiving scaffolding through suggesting and instructing. Specifically, more participants in the lower and medium development groups than in the higher development group received scaffolding through instructing, while more participants in the medium and higher development groups than in the lower development group received scaffolding through suggesting (see Table 8).

Table 8. Types of scaffolding each participant received, by development group

Group	Participants	Modeling	Suggesting	Instructing
Higher	Alma	X	X	
	Paulina	X	X	X
	Martha	X	X	
	Adriana	X	X	X
	Luna	X	X	
Medium	Rebecca	X	X	X
	Jacqueline	X	X	X
	Katia	X	X	X
	Alexandra	X	X	X
	Thalia	X		
Lower	Gloria	X		X
	Laura	X		X
	Natalia	X		X
	Cristina			

Conclusion

Analyses of the characteristics of the learning environment included in the design in order to support participants' cognitive engagement (i.e., building from concrete to abstract knowledge, scaffolding, and opportunities for articulation and reflection) showed that they in fact played a meaningful role in their development of technological fluency. On the other hand, it was not very clear what the relationship was between those characteristics included in an effort to make the activity more appealing to girls (i.e., girls-only environment and emphasis on design and creativity) and their development of technological fluency. It may be that these two characteristics played an indirect role and that the method employed to measure their role was not the most adequate one to identify this relationship. These characteristics were once again examined in relation to participants' identity and their motivation to participate in the workshop and engage in programming. The results of these analyses are presented in a subsequent chapter.

Chapter VII

Participants Identity and Technological Fluency

This chapter presents the findings of the analysis pertaining to participants' identity as users of computers. Specifically, it describes the measure it was used and the results of the examination of the answers given by participants before and after the workshop. In addition, it introduces participants' scores based on their answers to the measure; each participant received two scores, one based on her answers before the workshop and one based on her answers after the workshop. Moreover, the chapter presents the results of the analysis into possible contributing factors to any changes between participants' scores before and after the workshop. Finally, although the analysis found no meaningful differences in regards to participants' scores and their answers to the interview questions pertaining to girls and computers, gender schemas play an important role in identity development and hence participants' answers in regard to this topic are presented in a separate section.

Methods

Measure

The measure used to appraise participants' identity as users of computers consisted of eight questions, each of equal weight in relation to the overall score. It is important to point out that some of the categories used to score participants' answers emerged from the researchers initial analysis of the data (i.e., all participants responses to each question). These categories were subsequently shared with and validated by three additional individuals with relevant educational research experience. Below is a description of each question and the categories used to score participants' answers.

The first question asked participants to describe how good they were at using computers. This was an open-ended question but analysis of the responses produced five categories and participants' answers were scored on a scale of 1 to 5 as follows: 1 – *Not good*, 2 – *Kind of good*, 3 – *Good*, 4 – *Between good and very good*, 5 – *Very good*.

The second and third questions inquired about participants thoughts in regards to using and learning about computers. Participants were given a choice of answers on a scale of 1 to 4, however they were not compelled to choose one of these options and analysis of the data showed that an additional option was needed to accommodate some answers, these were subsequently scored on a scale of 1 to 5 as follows: 1 – *Really hard*, 2 – *Hard*, 3 – *Not easy but not hard* (added option), 4 – *Easy*, 5 – *Really easy*.

The fourth, fifth, and sixth questions asked participants if they considered themselves a "computer person", "as good using computers as they could be", and if they would like to work with computers in the future. All three were yes/no questions (although they allowed for elaboration) but analysis of the answers showed that a category in between was needed to accommodate some answers. To remain consisted with the previous questions, answers were scored on a scale of 1 to 5 as follows: 1 – *No*, 3 – *Maybe*, 5 – *Yes*.

The seventh question asked participants to describe what they would do when they encountered computer trouble. Like the first question this was an open-ended question but analysis of the responses produced three categories, and similarly to the three previous questions participants' answers were scored on a scale of 1 to 5 as follows: 1 – *Ask for help*, 3 – *Sometimes ask for help, sometimes figure it out on my own*, 5 – *Figure it out on my own*.

The eight and last question inquired about participants' thoughts in regards to computers being "more of a boy thing than a girl thing". Similarly to the fourth, fifth, and sixth questions, this was a yes/no question but allowed for elaboration. Since all participants provided the same answer both before and after the workshop (i.e., they did not believe so), it was decided to not include this question when looking at participants' identity, hence participants' answers to this question were not scored.

Participants' Scores

Participants received a score before and after the workshop based on their responses to the measure previously described. The minimum score a participant could have received was seven points and the maximum was 35 points. Both before and after the workshop, all participants received scores between 16 and 31 points (except for one participant who received a score of 12 points after the workshop). However, participants' scores were slightly more distributed between these two scores after the workshop than before the workshop (see Figure 33).

Each participant's score before the workshop was subsequently compared to her score after the workshop to determine change. A change in score was considered meaningful if the difference between the scores was equal to or above the groups' change average (i.e., three points). Group average was used as determinant because analysis of the distribution of the participants' scores did not yielded any naturally occurring groups (as can be observed in Figure 34). No change was observed between their score before the workshop and their score after the workshop for half of the participants, a positive change was observed for four participants, and a negative change was observed for three participants.

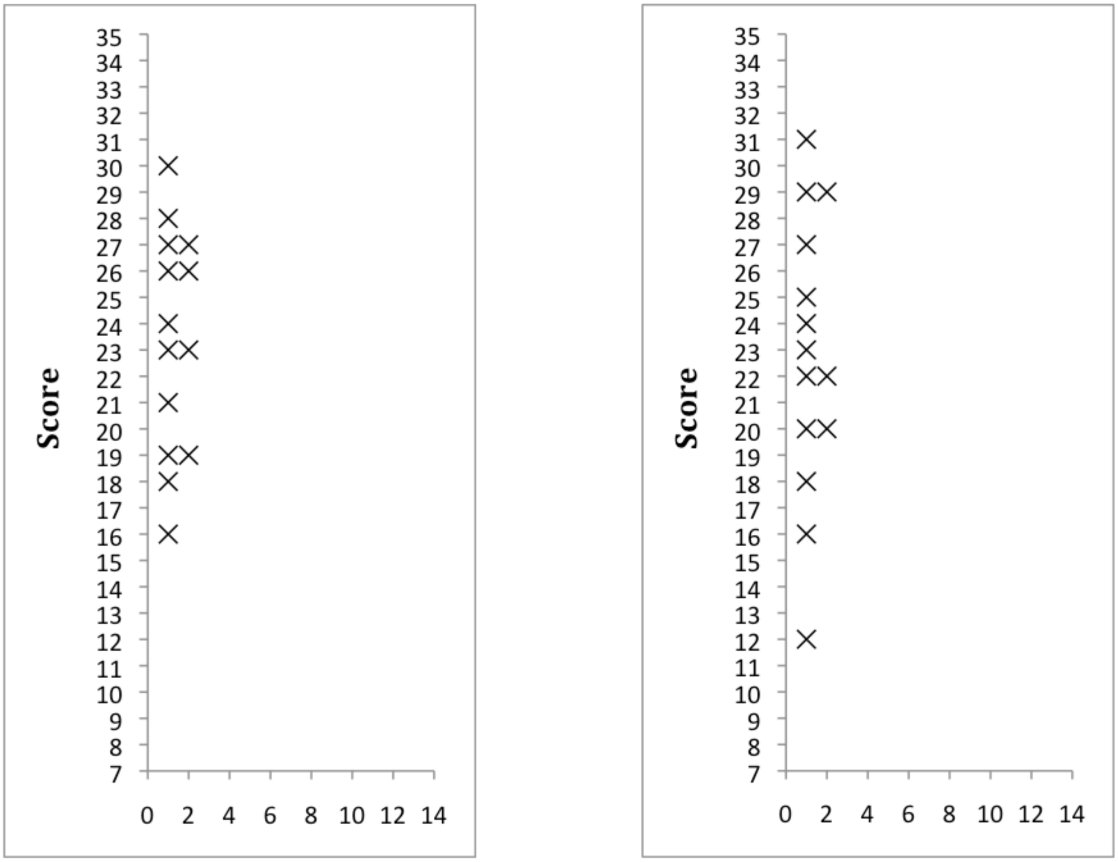

Figure 34. Distribution of self-concept scores before and after the workshop

Individual Characteristics

To explore any possible differences among participants based on background characteristics believed to contribute to identity development such as age, previous experience, and task value (Bong & Skaalvik, 2003; Eccles, 2009; Wigfield & Wagner, 2005) an analysis was conducted that included data on participants' access to computers and the Internet, knowledge of computer applications, preferred computer activities and types of website, digital games played, and classes previously taken. The analysis also looked at the data as it related to participants' thoughts about computers and their reasons for participating in the workshop, as well as sources of information such as friends and family members. Finally, the analysis explored participants' pre score as a possible contributing factor.

Slight Difference in Video Game Play

No differences were found in regards to age or task value and only a slight difference was found was in regards to participants' experience playing digital games. Specifically, all four of the participants who showed a positive change and two of the seven participants who showed no change mentioned playing on a regular basis three or more different types of games, including at least 2 different types of video games. In contrast, of the reminder participants, four (2 who showed no change and 2 who showed negative change) mentioned playing Internet games and one type of video games, one (who showed no change) mentioned playing only Internet games, and three (2 who showed no change and 1 who showed negative change) mentioned not playing digital games at all.

Possible Role of Pre Score

In order to explore the possible role of pre score, it was first determined if a participant's pre score was above or below the group's average (i.e. 23). Again, group average was used as determinant because analysis of the distribution of the participants' scores did not yielded any naturally occurring groups. Half of the participants were considered to be above the group average and half were considered to be at/below average in order to create groups with similar number of participants. Afterwards the analysis suggested that a participant's pre score being above or at/below the group's average could have played a role in participants' scores showing a change. Specifically, all except one participant with a score above average showed no change or a negative change in their self-concept score after the workshop. All participants with a score at/below average showed no change or a positive change in their self-concept score after the workshop.

Table 9. Number of participants who scored above and below average before the workshop and showed a positive, negative, or no change in their self-concept score after the workshop

Score (before workshop)	Participants	Change Positive	Change Negative	Change No
Above Average	7	1	3	3
Below Average	7	3	0	4

Individual Questions

In order to better understand participants' differences in scores before and after the workshop, participants' answers to each question before and after the workshop were analyzed; the findings are presented below. Participants' answers to some of the other questions included in the interviews were used to inform these findings as well.

Less Competent but Able to Learn

Although all of the participants said that attending the workshop helped them become better at using computers since it gave them the opportunity to learn how to use a new program, fewer participants indicated that using a computer was “Easy” or “Really Easy” after the workshop than before the workshop. Similarly, fewer participants indicated that they were at least “Good” if not “Between good and very good” or “Very good”, at using computers after the workshop than before the workshop. See Figure 35.

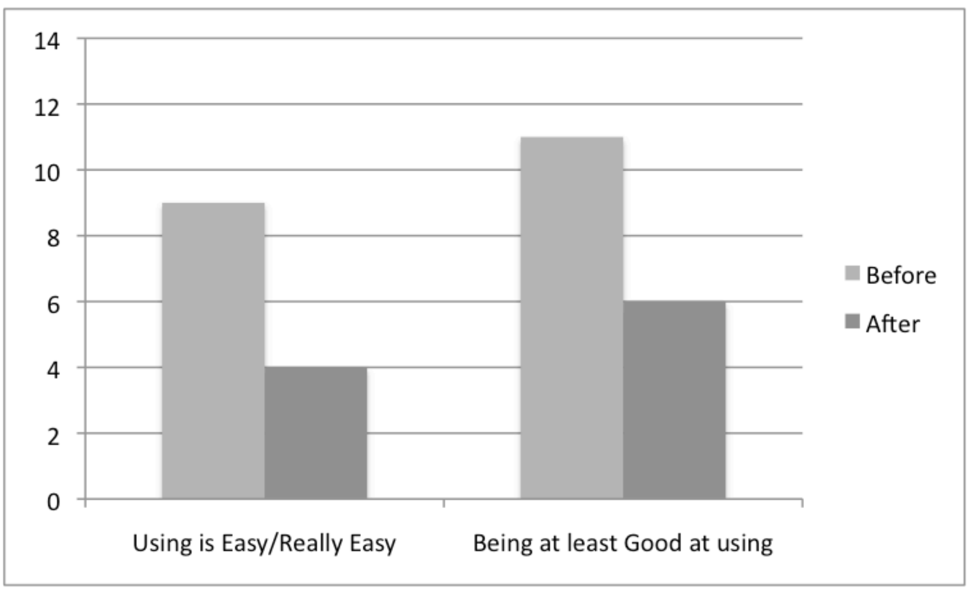

Figure 35. Number of participants who indicated that using computers was “Easy” or “Really Easy”, and number who indicated that they were at least “Good” at using computers, before and after the workshop

In addition, fewer participants indicated that they were "A computer person" after the workshop than before the workshop, and more indicated that they were as good as they could be after the workshop than before the workshop. See Figure 36.

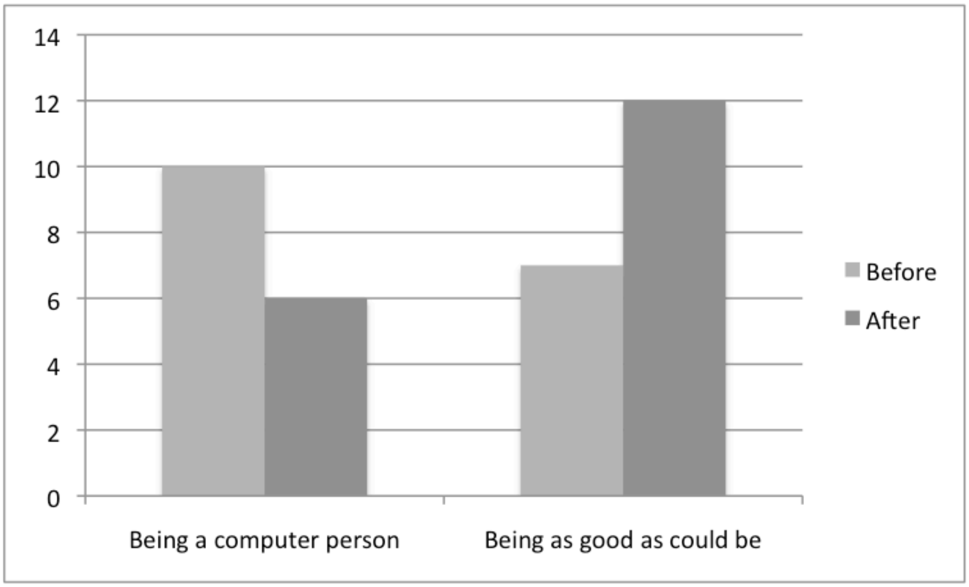

Figure 36. Number of participants who indicated that they considered themselves a computer person and as good as they could be using computers, before and after the workshop

This apparently negative change in participants' answers, however, seemed to be more a result of being exposed to a new computer activity and understanding that, as Katia said, "there are lots to learn", than their performance during the workshop and consequently their ability in regards to computers. For example, most of the participants who elaborated on their answers, talked about "not knowing lots of programs" or "not knowing everything" as determining factors. Rarely did they talk about their competence (or lack of) as a contributing factor. Furthermore, all but one of the participants indicated that at learning how to do new things on the computer was at most “Not hard but not easy” both before and after the workshop. In addition, half of the participants indicated both before and after the workshop that they would try and figure things out, at least some of the time, when using the computer and encountering problems. See Figure 37.

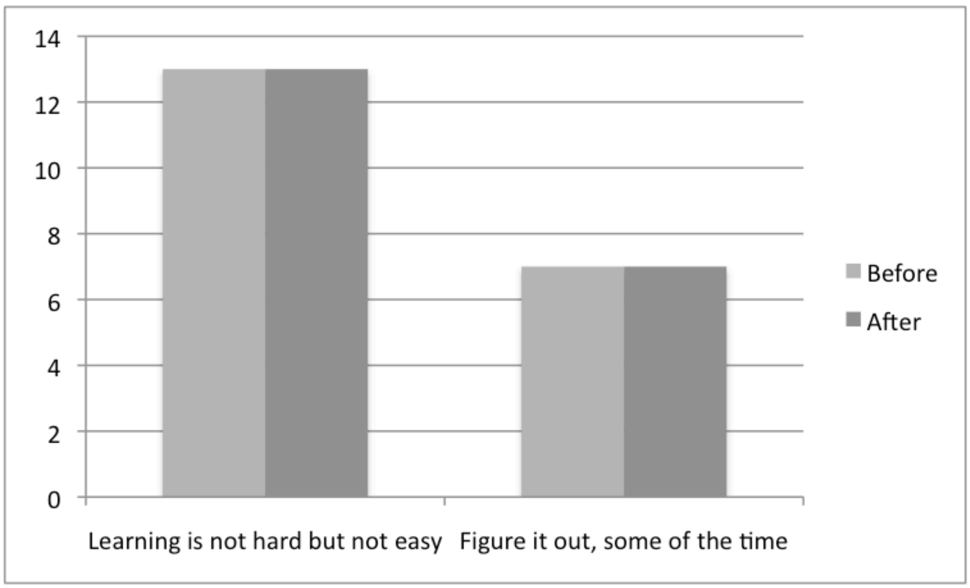

Figure 37. Number of participants who indicated that learning how to do things on the computer is at most “not hard but not easy”, and that they would figure things out if they had problems when using the computer, before and after the workshop

Together, these findings seem to indicating that even though participants might not have seen themselves as competent in regard to using computers after the workshop as they did before, they still believed they had the ability to learn and become better. In fact, most of the participants replied that their project was “cool”, “good”, and even “awesome” when asked what they thought about it after the workshop. And although one third replied that their project was only “ok”, none of them attributed it to a lack of competence. Rather, they said this was due to their “beginner” state as Alma put it, or because they “did not work hard enough” as Rebecca suggested, or they had “spent too much time talking” as Alexandra explained.

Using versus Creating

While about two thirds of the participants indicated that they would consider working with computers as part of their job, only about half said so after the workshop.

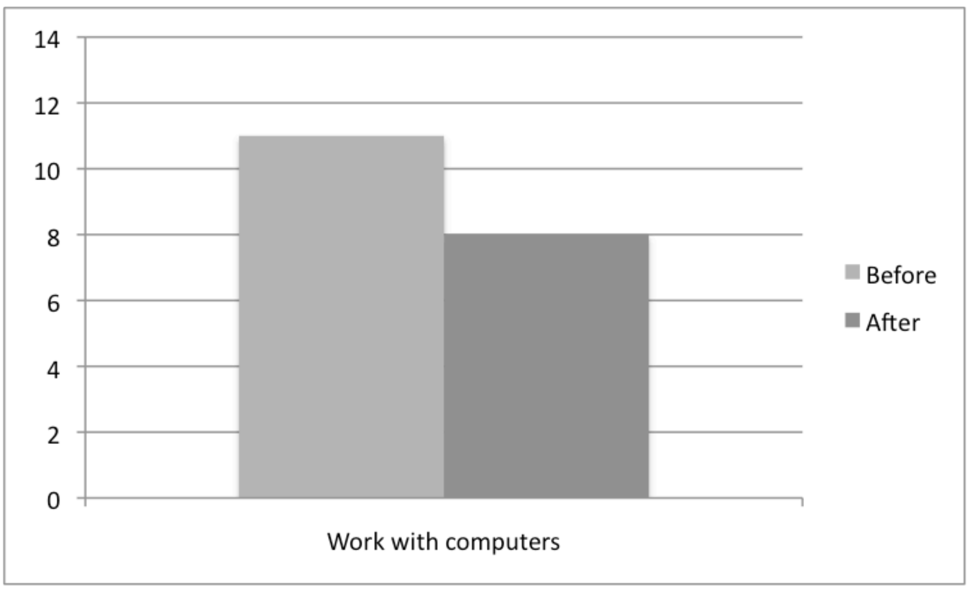

Figure 38. Number of participants who indicated that they would like to work with computers (as a job), before and after the workshop

This difference however may be based more on participants putting greater emphasis on the use of programs than on the creation of a product. For example, all of the participants mentioned someone who “knows how to use a lot of programs” or “type fast” when asked to describe someone who knows how to use computers really well before the workshop. None of them talked about someone who creates technology or a technological product. Moreover, their answers in regard to a possible desire to work with computers, regardless of what it was– yes, maybe, or no– indicated a view of themselves as users of computers and not creators of technology. For example, Paulina said she would like to be a lawyer and could use the computer for typing; Jacqueline replied, when asked before the workshop that she would not be using computers since she was going to be a nurse, however, after the workshop she said she would be using them since she wanted to be a criminalist (á la CSI). Alexandra thought, both before and after the workshop, that she wouldn't be using computers in her job since she wanted to do something related to either psychology or art. Hence the number of participants indicating that they would consider working with computers both before and after the workshop might be a reflection of how many of them thought that there were computer programs that they could use given the profession they might have been thinking about choosing at the time of the interview.

This greater emphasis on the use of programs as opposed to the creation of technology is not unexpected however, considering the participants' lack of access to role models who are creators of technology or opportunities to engage with computers as creators. For example, about two thirds mentioned the computer lab manager at the afterschool center when asked before the workshop if they knew anyone who worked with computers– his most often mentioned duty being "he helps kids with homework [(e.g., doing searches and using a word processor)] on the computer". And as it was mentioned before, only one of the participants had previously taken a class or workshop that involved engaging with computers in a more complex way than learning how to use a computers operating system or a word processor. On the other hand, these findings suggest that although an effort was made to introduce the participants to relevant role models of women crating technology (i.e., the instructor and female engineers at MySpace), a more concerted effort might have been required during the workshop to make participants see themselves as creators and not only users of technology.

Gender

Participants were asked several questions before the workshop related to girls and computers. All were yes/no questions but allowed for elaboration. Analysis of their responses indicated that all participants thought that girls in general should know about computers, although one participant, Alma, added that "only if they want". Furthermore, all participants thought that they, as girls, should know about computers; helping others use computers and being able to use computers for school and work in the future, were the main reasons they gave for why they needed to know.

On the other hand, only three participants– Katia, Adriana, and Cristina– reported thinking that other people thought that girls in general should know about computers; eight participants reported not knowing; the remaining three– Paulina, Natalia, and Laura, reported thinking that some people did but some thought girls were not capable. The majority did report however thinking that their family and/or friends thought that they as girls should know about computers. Only Rebecca and Gloria reported having no knowledge of this.

In addition, participants were asked, both before and after the workshop, if they thought computers were more of a boy thing than a girl thing. All participants reported that they did not think so both times. However, their reasons behind their answers each time differed. Before the workshop all of the participants talked about everyone using computers and/or both boys and girls doing things on the computer as to why they did not think that computers were more of a boy thing than a girl thing. After the workshop, the majority talked about girls being as capable as boys. For example, Adriana and Natalia talked about some boys needing help just like some girls, and some girls being smarter than some boys. Furthermore, some of the participants added that boys might know more only because they use them more frequently or have been using them for a longer period of time. Other participants further explained that girls and boys used them for different things, not better or worst, just different. However, Luna and Gloria talked about boys liking computers more than girls and being more connected to them.

Finally, at the end of the workshop participants were asked two questions that had to do with the workshop being geared towards girls specifically. In particular, participants were asked if they thought the following goals where achieved: help girls believe they are able to use computers and learn new computer things easily, and help girls believe that it is ok for them, as girls, to be interested in computers. Almost all of the participants answered that they thought these two goals were achieved (Martha thought the first goal was "sort of" achieved since "some stuff was not easy"); unfortunately, very few elaborated on the reasoning behind their answers. Of the five participants who elaborated on their answer to the first goal, four offered their own experience as proof, sharing that they now knew more about computers, and Katia observed that "eventually [they] asked [the instructor] less for help". Of the five participants who elaborated on their answer to the second goal, three talked about a change in beliefs. For example, Alma said, "Yes, because computers are fun and not only something [boy] nerds do"; and Martha replied, "Yes, because I saw that it is ok to try new things." Two participants, Natalia and Cristina, offered their own experiences as proof.

Conclusion

This chapter described the measure that was used to ascertain participant's identity as users of computers as well as their scores before and after the workshop. As it was mentioned comparison of these scores showed only a small change in participants' self-concept and only for about half of the participants. However, this was expected given that identity develops over an extended period of time and is informed by many different activities (Eccles, 2009). In addition, the design of the measure could also have played a role since it asked participants about their use of computers in general and the workshop was for the most part about one specific activity, i.e., programming. In addition, the chapter included a comparison of participants' answers before and after the workshop to each of the measures' questions as well as their thoughts at the time the study took place in regard to girls and computers. Although the latter was done in a limited manner given the limited data available. The next chapter presents the results of the analysis in regards to the design characteristics of the learning environment that could have played a role in the participants' development of an identity as someone who is able– and for whom it is appropriate– to engage with technology in meaningful and complex ways.

Chapter VIII

The Learning Environment and Participants’ Development of Identity

This chapter presents the analysis of the characteristics of the learning environment that were believed to foster participants’ development of an identity as some who is able– and for whom it is appropriate– to engage with computers in complex ways. In particular, the analysis included several characteristics suggested by past research as relevant to students’ perceptions of competence and identity development, and contributing to their adoption of adaptive achievement behaviors. The characteristics, which were previously selected for investigation during the design phase of the study and examined individually during the analysis, were the following: voluntary attendance, reasonable and meaningful challenge, varied tasks and short term goals, interactions with an emphasis on effort, and opportunities to develop responsibility and independence. In addition, the analysis included a fifth characteristic, exposure to appropriate and relevant role models, given that gender schemas play an important role in perceptions of competence and identity development. Since the main focus of the study was on identity in relation to complex computer activities, the main focus of the analysis was on the characteristics as they related to participants’ development of programming knowledge and skills.

Methods

As it was described in the previous chapter, participants were asked a series of questions related to their identity as users of computers both before the workshop started and after it ended. Both times they received a score based on their responses and these scores were subsequently compared to determine change. Participants were then placed into one of three groups: (1) positive change, (2) no change, or (3) negative change. The no change group was further divided based on participants' score before the workshop. This process produced four groups with similar number of participants. See Appendix E. In addition, a secondary analysis was conducted that looked at the characteristics of the learning environment in regards to the frequency of participants' engagement in the programming aspect of their projects. See Appendix E. This additional analysis was conducted to explore the proposal, previously stated, that the characteristics of the learning environment would play a role on participants' motivation to engage with their projects and in particular on the construction of scripts.

Both analyses included participants' projects (all versions available), their experiences as recorded in the field notes, transcripts of the interviews conducted with each participant before and after the workshop, and field notes from the focus group conducted after the introductory sessions but before the project sessions. Since the analysis into participants' overall development of programming knowledge did not show meaningful differences based on their attendance and participants' self-concept was measured at the beginning and end of the workshop the analyses were carried out only once and included all 14 participants. The findings for both analyses are presented together in the next section, grouped by the characteristics of the learning environment examined.

Findings

Voluntary Attendance

Similarly to the analysis into the characteristics of the learning environment and participants development of technological fluency, missing sessions was not found to have a meaningful role in participants' showing a change or not in their identity. For example, at least two participants in each group missed two or more sessions, at least two participants in each group missed an introductory session, and at least one participant in each group missed two or more project sessions (see Figure 39).

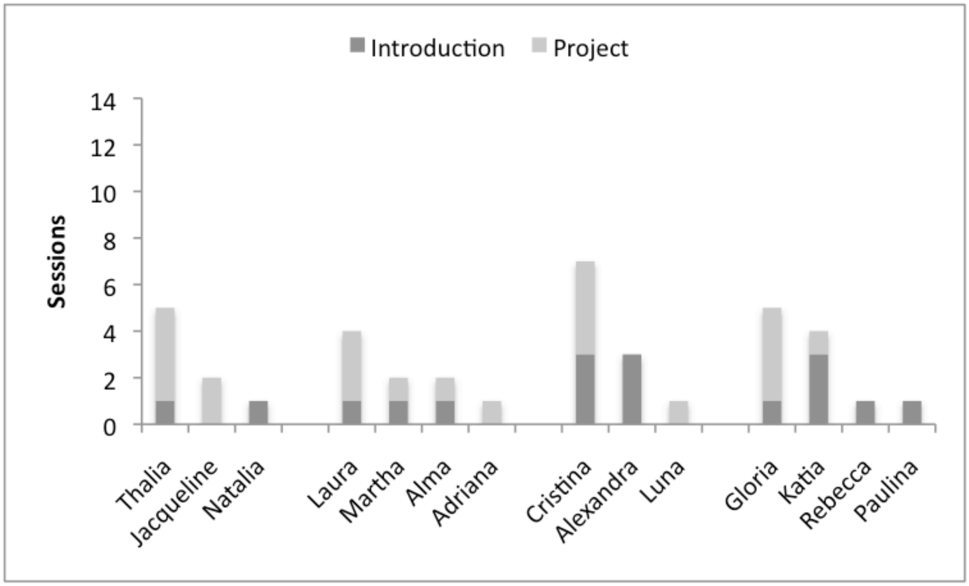

Figure 39. Number of introductory (max = 4) and project sessions (max = 10) each participant missed, by identity group
(Note: negative change group, far left; positive change group, far right).

Meaningful and Reasonable Challenge

Students acquire information about their competency from their experiences engaging in an activity. When they feel personally connected to the activity, it provides an intrinsic reason to understand, their experiences become more meaningful and the information gathered more relevant. In addition, the degree of challenge an activity provides also plays a role. For example, an activity that is too easy would not offer students opportunities to develop understanding or improve skills, rendering the activity and the information students might gather from it less meaningful. On the other hand, an activity that is too hard might decrease expectations for success and this could have a negative impact on students' motivation to engage in it and their perceived competence.

Authentic and personally relevant. Participants' projects came to be regarded as similar to a profile page for MySpace, a popular social networking website frequented by almost all of the participants. Participants often referred to their projects as "my profile" and many of them used their MySpace profiles as sources for pictures and music. In one unique case, a participant's engagement with her project provided an opportunity for a better understanding of her experience building her MySpace profile as well:

> *Jacqueline logged onto her MySpace account and tried to get an image but was having difficulties and asked the instructor for help. The instructor tried with no success, but then Jacqueline said, "Wait!" and scrolled down "see the code?!" Jacqueline had originally obtained the image from a website that gave instructions to copy a piece of html code and put it on the MySpace page. After the instructor examined the code, she realized that the image was being rendered from an external website, so she told Jacqueline that what she needed to do was open a new browser and use the address on the "img=src" field to get to the image* (FN, 10/21/08).

Although Jacqueline did not have a clear understanding of how the image and the code in her MySpace profile were related, by pointing out "the code" she indicated an emerging understanding of making something happen through programming. By the end of her interaction with the instructor, Jacqueline had come to understand the relationship between the code and the image, and several sessions later she was observed going through the process by herself in order to obtain another image and explaining what she was doing to one of the research assistants.

In addition, similar to a profile for MySpace, which serves as a medium to present oneself to the world, participants' projects served as a representation of them. For example, when asked, at the end of the workshop, where they had looked for inspiration for their projects, about half of the participants replied that they had included "stuff" they liked; they had made it about them.

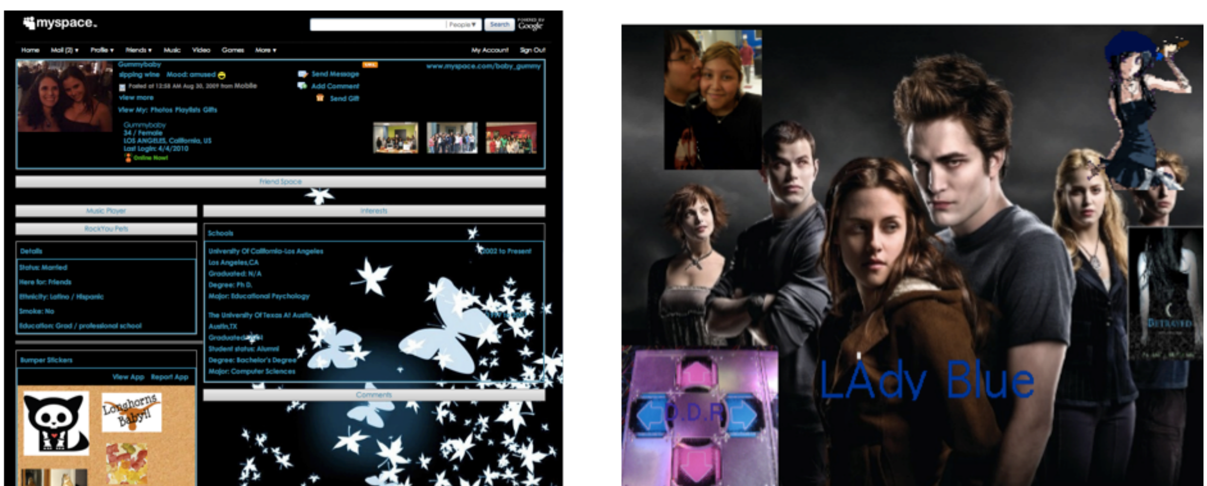

Figure 40. A profile in MySpace.com and one of the versions of Luna's project (left and right panel, respectively)

Although no differences were found in relation to a change in identity among participants who explicitly talked about the personal aspect of the project and their enjoyment of this and those who did not, the data showed that there was a small difference in relation to participants' engagement. Specifically, all of the participants who talked about this during and/or after the workshop (about two thirds), engaged in the programming aspect of their projects during more of the sessions they attended (50% or more vs. 43% or less).

Differentially challenging. Based on participants' responses when asked at the end of the workshop what were the hardest and easiest aspects of working on their projects, the majority of the participants indicated that they had found the programming aspect of their projects challenging. Specifically, about two thirds of the participants talked about their experiences building scripts as the hardest aspect of working on their projects. For example, Adriana, Rebecca, and Martha, all shared that making a sprite move was the hardest task they had engaged in. However, as suggested by the percentage of sessions each of the eleven participants attended and chose to engage in programming, they seemed to have found the building of scripts more or less reasonably challenging. In particular, five of the participants chose to work on the programming aspect of their projects during 66% or more of the sessions they attended, three chose to work between 50% and 55% of the sessions, and three chose to work no more than 43% of the sessions.

It was hard to assess how challenging the remaining three participants found engaging in programming given that they did not talk about it as the hardest or the easiest aspect of working on their projects and engaged in the construction of scripts between 30% and 67% of the sessions they attended. Interestingly, it was these three participants the ones that showed a negative change in self-concept. All of the participants mentioned tasks not related to programming (e.g., finding a background they liked) as the easiest aspect of working on their projects.

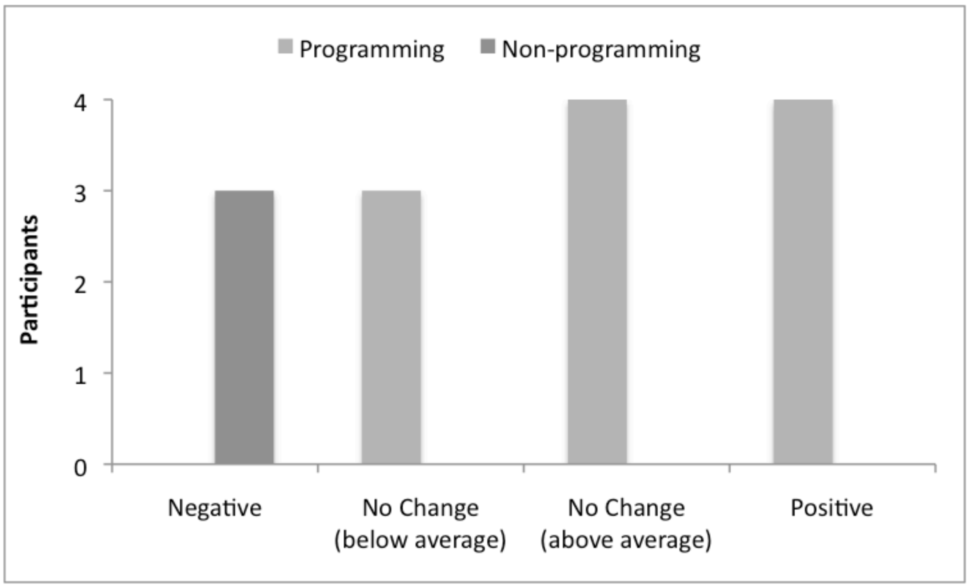

Figure 41. Number of participants who showed negative, positive, or no change and mentioned or not mentioned programming as the hardest part of working on their projects

Varied Tasks and Short-term Goals

In addition to offering students meaningful and reasonable challenge, a specific method to help them feel that they can successfully engage in an activity with reasonable effort is by providing tasks with specific, short-term goals (Ames, 1992). Moreover, having a variety of these tasks provides an assortment of opportunities from which students can obtain competence related information.

Variety of tasks. Based on participants' creation of original scripts and the number of programming activities they engaged in (see Chapter V) there was a positive association between variety of tasks and participants' engagement. Specifically, participants who created more original scripts and engaged in more programming activities, tended to engage in programming during more of the sessions they attended, see Figure 42.

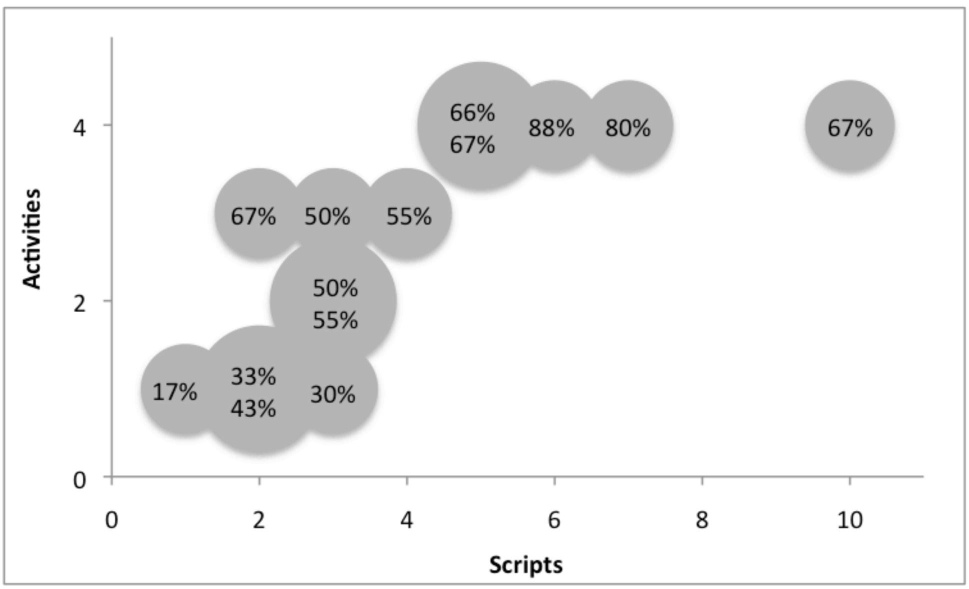

Figure 42: Percentage of sessions a participant attended and engaged in programming in relation to number of scripts she created and number of programming activities she engaged in (Note: each percentage corresponds to one participant)

The relationship between variety of tasks and participants' identity was not very clear however. For example, the data suggested a positive association between the number of programming activities a participant engaged in and a change in her self-concept; that is, while more of the participants who showed a positive change in identity engaged in three to four programming activities, more of the participants who showed a negative change engaged in only one to two programming activities. Yet, a similar relation was not observed in regards to number of original scripts participants created, see Figures 43 and 44.

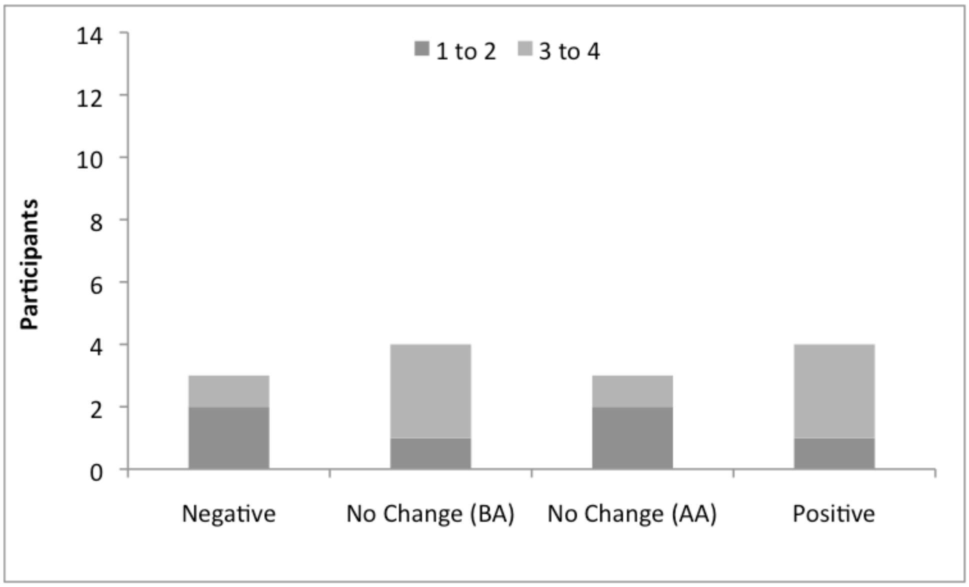

Figure 43. Number of participants who engaged in one to two or three to four programming activities and showed negative, positive, or no change in identity

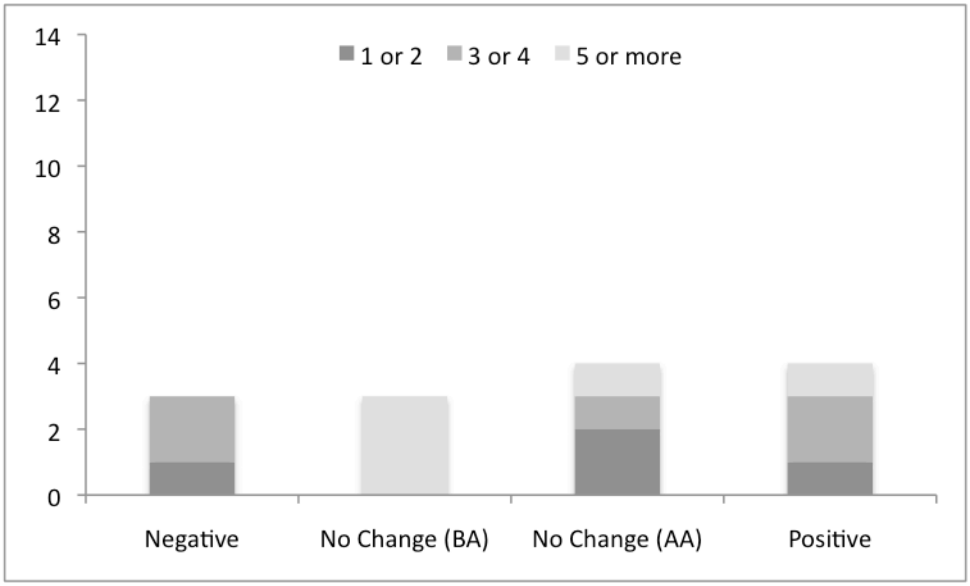

Figure 44: Number of participants who built between one and 10 original scripts and showed negative, positive, or no change in identity

Challenging but attainable tasks. Participants often decided on a task for a sprite from the first time they added it, and for the most part each script they built for it performed the same task in the first version of the project it had been added and all subsequent versions. However, as it can be expected since this was their first time using Scratch and building scripts, these were not always finished during the first session they were created. For example, during one of the sessions she attended, Luna added a sprite and started building a script, which she finished during a later session (see Figure 45).

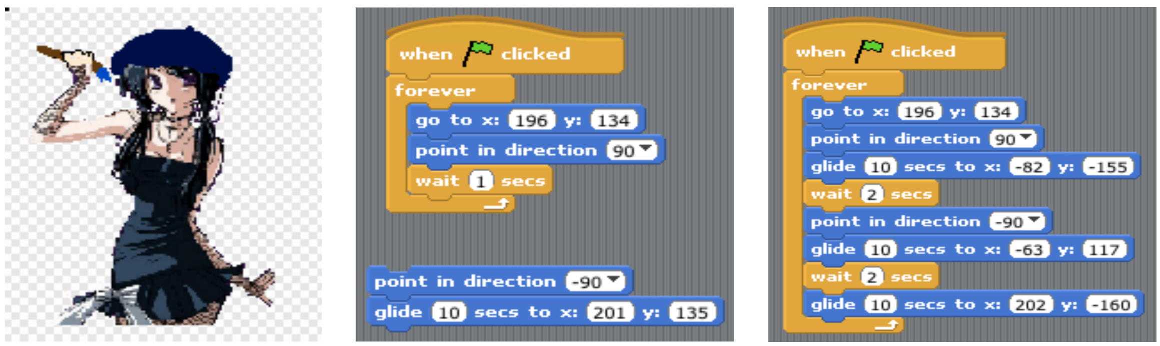

Figure 45. One of Luna's sprites (left panel); the script she built for it as she worked on it (middle panel); the script she built for it in its final state (right panel)

In addition, on a few occasions, participants experimented before settling on a scripts' final function. For example, Alma included a sprite in her project that performed three different tasks on three consecutive versions of her project (see Figure 46). In either case, participants, on average, worked on most scripts during two to three sessions. Hence, adding sprites provided participants with the challenge of deciding the tasks it should execute and building the scripts, yet they were able to achieve their object in a reasonable number of sessions. No meaningful differences were found on the number of sessions participants worked on their scripts and their engagement or identity.

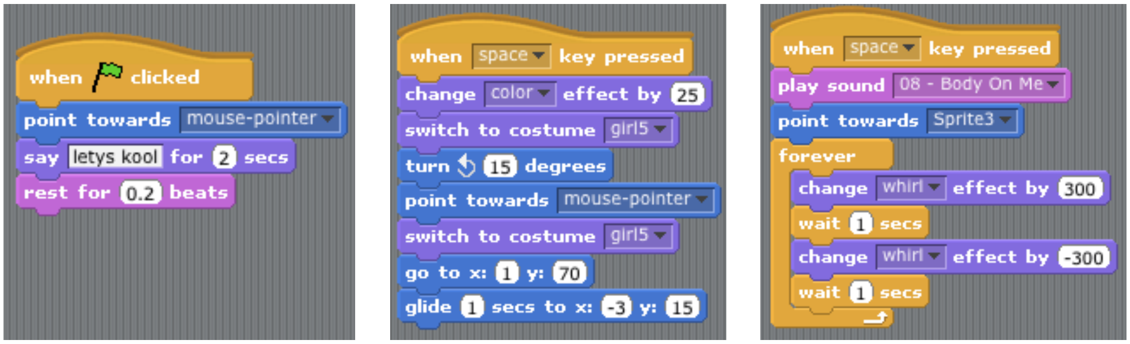

Figure 46. Three different scripts built by Alma for the same sprite

Emphasis on Effort

Past research has shown that the adoption of adaptive achievement behaviors, such as believing that competence is malleable and can be improved through effort, relates positively to students' sense of competence and motivation to engage in an activity. The adoption of such behaviors can be encouraged when students perceive the learning environment as valuing effort over performance. More specifically, when quality of effort as opposed to quantity of work becomes a more salient evaluative factor (Ames, 1992).

An emphasis on effort was communicated to all participants by explicitly encouraging them during the introduction of the activity to explore different designs for their projects and telling them that there was not a right or wrong way to work on their projects. However, analysis of the data showed that an emphasis on effort over performance or vice versa could also have been made salient during interactions that occurred between a participant and the instructor (or another participant, occasionally) and that were related to participants receiving verbal judgments and/or help. In particular, three different types of situations emerged during the analysis of the data.

Effort spent vs. project's appearance. One way effort was made salient was when the instructor or a research assistant commented on the work a participant had put into building her project. For example, when Paulina showed the instructor her project, pointing out the sprite and script she had added with the help of a Scratch card, the instructor replied that Paulina was doing a great job with her project and building scripts, and encouraged her to keep working on it (FN, 10/21/08). There were other occasions however, when the focus of an interaction was on how a participant's project looked, as the following vignette illustrates, where the main theme is how few sprites Alexandra had added to her project and not the work she had done building scripts for them.

> *When Alexandra came back, the instructor followed her to her computer. All she had was a background, her name in the middle of the screen, some polka dots, and a party hat on her name. The instructor asked her if she was going to add anything more and she said, "I don't think so. This is me." The instructor tried to give her some ideas, telling her that she should add some pictures or sounds but Alexandra didn't seem very enthusiastic about it* (10/16/08).

Process vs. commands. When participants asked for help, the instructor often tried to direct their attention towards the action they were trying to implement through a script. For example, when Rebecca was having difficulties making one of her sprites move, the instructor suggested she thought about the current position of the sprite and the position to where Rebecca wanted it to go (FN, 10/23/08). This was in contrast to the instructor's commenting on the participants' choice and usage of commands, as was the case when Alma asked the instructor to help her because she had put together a script that included a loop but it was not working and the instructor suggested she not use the same command twice in a row (FN, 10/23/08)

Participants helping each other. Finally, most of the interactions between participants when helping each other made performance more salient than effort. This was because a participant usually helped another by telling her which commands to use. Hence the emphasis of the interaction often was on knowing (or not) the commands as opposed to the process of transforming an idea into a script.

Overall. Participants who had a higher ratio of interactions they might have experienced as emphasizing effort to sessions attended also engaged in programming during more of the sessions they attended. Once again, however, the relationship between ratio of interactions to sessions attended and participants' identity was not very clear. The only difference observed was between participants who showed a negative change in self-concept and those who showed a positive or no change, with the former having a lower ratio of interactions they might have experienced as emphasizing effort to sessions attended. See Figures 47 and 48.

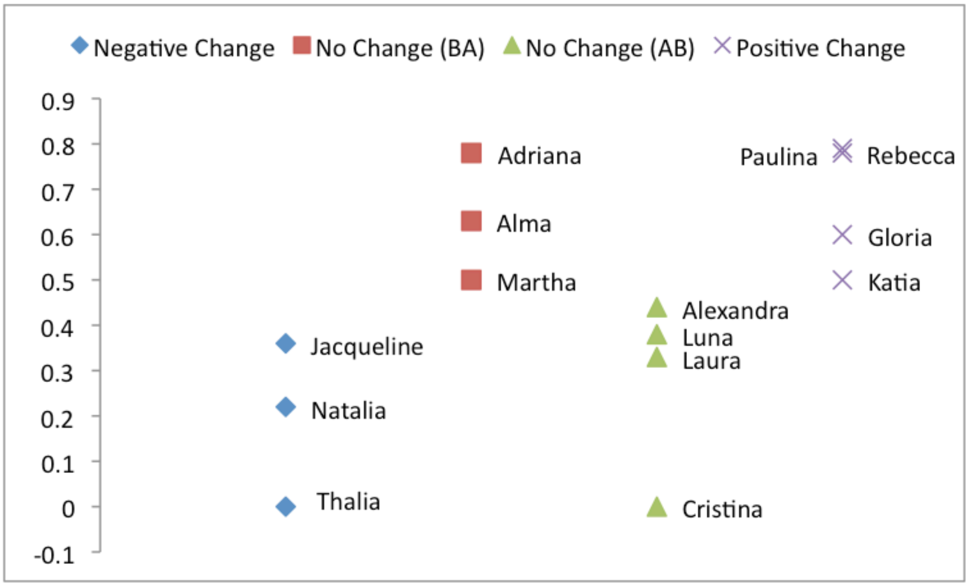

Figure 47. Ratio of interactions participants could have had experienced as emphasizing effort to total number of sessions they attended, by change in self-concept

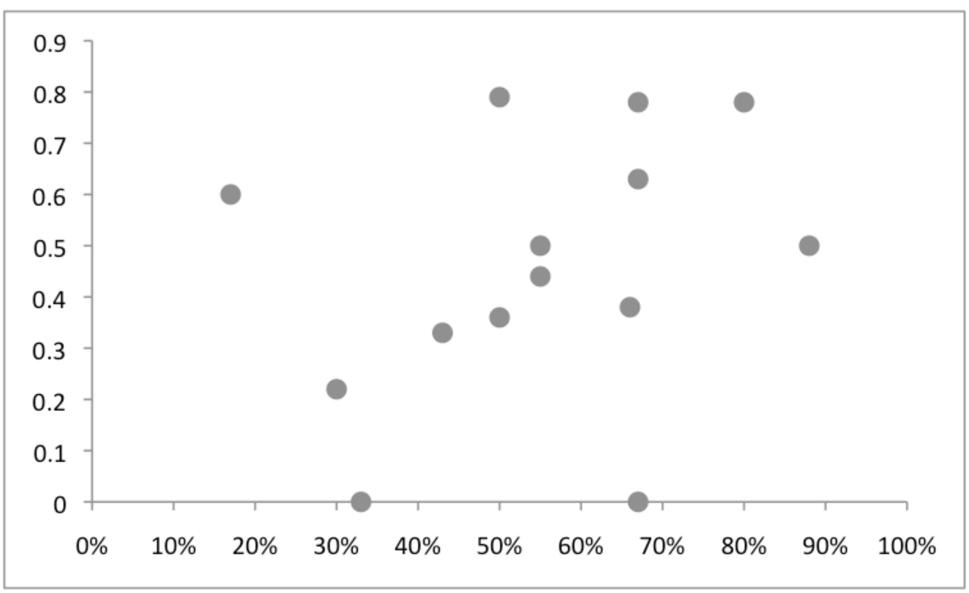

Figure 48. Ratio of interactions participants could have had experienced as emphasizing effort to percentage of sessions they engaged in programming

Opportunities to Develop Responsibility and Independence

In addition to perceiving the learning environment as emphasizing effort over performance, having opportunities to play a role in directing their own activity also plays a role in students' perceived competence and motivation (Ames, 1992). As they make decisions about topics, selection and planning of activities, or artifact development, for example, students develop responsibility and independence regarding their learning and this relates positively to their sense of competence, interest, and willingness to approach challenges (Ames, 1992). In addition, helping peers provides additional opportunities to make decisions and engage in independent thinking and further develop their sense of competence.

Own source, others' resource. The workshop offered participants several opportunities to make choices and direct their own activity. For example, each participant decided what her project should look like and the different tasks the sprites in her project were to perform and hence, the scripts to build. In addition, participants had ample opportunities to help other participants, as they were continuously encouraged to turn to each other for assistance. Based on participants answers after the workshop as to what were their sources for inspiration, participants who referenced themselves and what they liked, tended to engage in programming more often. Moreover, it was the same participants who reported referencing themselves as source of inspiration the ones that were observed helping peers more often. No meaningful differences were observed in relation to participants' identity however.

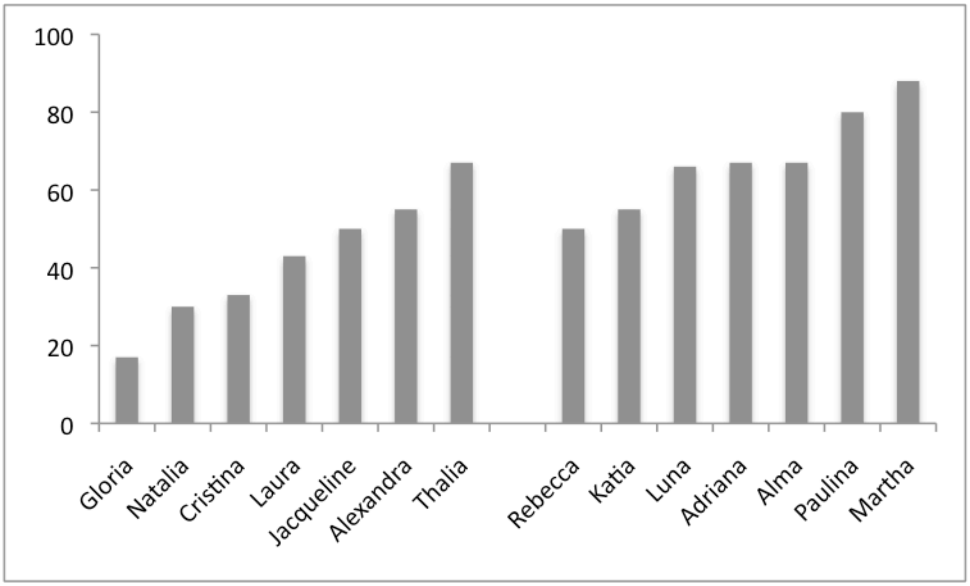

Figure 49. Percentage of sessions each participant attended and engaged in programming, grouped by source of inspiration and having helped other participants

Exposure to Role Models

In addition to the previous five characteristics discussed so far, the analyses examined participants' exposure to role models. This involved included looking for evidence that a participant had engaged in conversations with the instructor about technological fluency, received help from the instructor in regards to programming, and/or had participated in the field trip to MySpace during which they had the opportunity to meet with a group of female engineers and software developers who shared their experiences with the participants.

Personal interactions. Most participants attended the first session of the workshop during which the instructor talked about herself, her enjoyment of programming, and her experience as a software engineer. In addition, most participants attended the field trip during which the female engineers talked about themselves and their experiences in college and at work. Finally, all participant received help from the instructor although some more than others. No meaningful differences were found in regards to any of these activities and participants' identity or engagement. However, the data showed that three out of the four participants who showed a positive change had more interactions with the instructor during which they talked about the instructor going to college, what she studied, where she worked, etc., than those participants who showed no change or negative change.

Conclusion

Findings regarding participants' identity as someone who is able - and for whom it is appropriate - to engage with technology in complex ways vis-à-vis the characteristics of the learning environment proved elusive. In particular, no clear and meaningful differences were found in regards to participants' experience of the learning environment and their change (or lack of) in self-concept. The data did suggest however two characteristics that could have had a role on participants' identity development, perceiving the environment as emphasizing effort and engaging in personal interactions with a role model. On the other hand, the relationship between the characteristics of the learning environment and participants' motivation to engage in the workshop and with their projects was more discernible. In particular, meaningful and reasonable challenge, opportunities to develop responsibility and independence, and variety of tasks, all seemed to have played a positive role in participants engaging in programming during more sessions.

Chapter IX

Participants Becoming Technologically Fluent

Understanding how learning environments contribute to learners' development of technological fluency and their identity as someone who is technologically fluent was one of the objectives of this dissertation. Previous chapters have attempted to describe participants' development of technological fluency, changes in their identity in regard to computers, and the characteristics of the learning environment that might have contributed to both. A second objective was to investigate the reciprocal relationship between participants' development of technological fluency and their identity. This chapter presents the results of this investigation.

Methods

In this study, participants' development of technological fluency was based on a qualitative description of the types and number of programming activities they engaged in and the types and number of commands they used. Based on the field note and project data, participants were classified as having attained one of three levels of technological fluency. Similarly, participants' self-concept score was described as above or below average and their change in self-concept was qualified as positive change, no change, or negative change. Hence, the analysis of the relationship between participants' technological fluency and their identity included three categorical variables, two of them with three levels. Taking into consideration the small number of participants, the analysis was carried out using contingency tables and comparing number of concordant and discordant pairs of observations. A larger number of concordant pairs provide evidence of a positive association while the more prevalent the discordant pairs, the more evidence there is of a negative association (Agresti & Finaly, 1997).

Specifically, three analyses were conducted. The first analysis explored the relationship between participants' self-concept score previous to the workshop and level of technological fluency attained. The second analysis explored the relationship between participants' level of technological fluency attained and change in their self-concept score after the workshop, controlling for their self-concept score before the workshop. The third analysis explored the relationship between participants' level of technological fluency attained and their self-concept score after the workshop, again controlling for their self-concept score before the workshop.

Each analysis included two separate examinations of the data since participants missing sessions was previously shown to play a slight negative role in their level of technological fluency attained. The first examination was similar for all three analyses and included only participants who had attended eight to nine sessions and was based on their level of technological fluency attained by the end of the workshop. The second examination was similar for all three analyses in that it included all 14 participants but differed on the session at which participants' level of technological fluency level was measured.

For the first analysis, the second examination was based on participants' level of technological fluency attained by the 5th or 6th session they had attended. For the second and third analyses, the second examination was based on participants' level of technological fluency attained by the last session they attended. This difference in methodology was due to the fact that the post self-concept measure was administered at the end of the workshop and participants' responses were most probably given in reference to their complete experience and not just to the first five or six sessions they had attended. See Appendix F for analyses.

Results

Analysis I: Self-Concept (Pre) and Technological Fluency Level

Identity, and in particular perceptions of competence, plays a role on behavioral choices (Eccles, 2009; Novick, Cauce, & Grove, 1996; Wigfield & Wagner, 2005). To investigate the role that participants' self-concept may have played in their development of technological fluency an analysis was conducted that included participants' self-concept scores before the workshop and the level of the technological fluency they attained.

Negative association. As it was previously mentioned this analysis was conducted twice and both examinations suggested a negative association between participants' pre self-concept score and their level of technological fluency attained. Since technological fluency level was related to the different activities each participant engaged in and the different commands she used, this finding suggested that participants with a pre self-concept score above average engaged less during the workshop than participants with a pre self-concept score below average.

An examination of the field note and project data supported this finding. For example, although, on average, participants who scored below average and those who scored above average in the self-concept measure spent the same number of sessions on the programming aspect of their projects, participants who scored below average added and deleted more scripts and created more original scripts, on average, than participants who scored above average.

Table 22. Average number of programming sessions and added, deleted, and original scripts, participants grouped by self-concept score above or below average

	Programming Sessions	Scripts		
		Added	Deleted	Original
Above Avg.	5	8	2	4
Below Avg.	5	13	3	5

In addition, more participants who scored below average engaged in three to four programming activities than those who scored above average, and vice versa for those in each group who engaged in only one to two programming activities (see Figure 50).

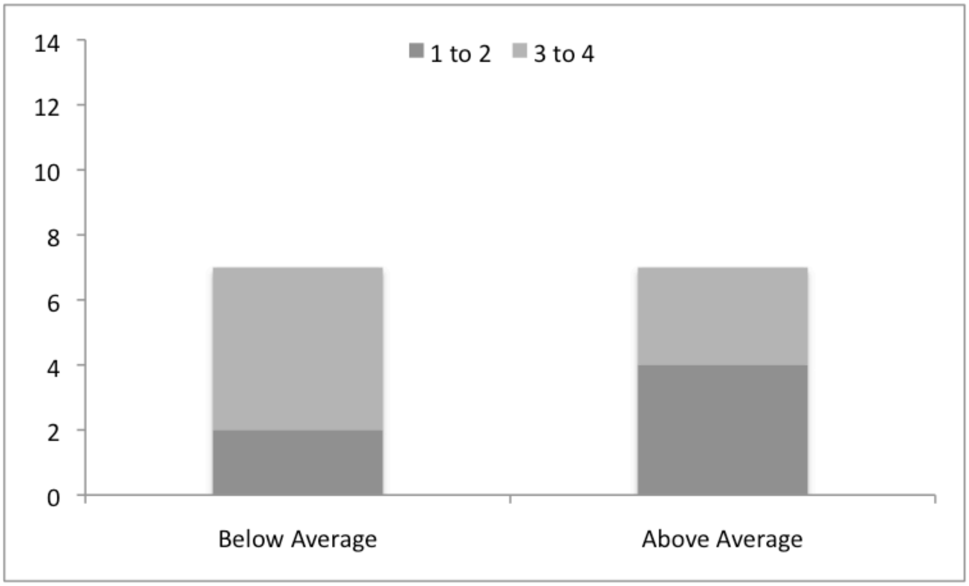

Figure 50. Number of participants who scored below or above average before the workshop and engaged in one or two or three or four programming activities

Although this finding is contrary to what might have been expected, it is conceivable when the subjective value of the participants' engagement is taken into consideration. While beliefs of competence influence task choice, their motivational power is, at least partially, also determined by the value individuals attach to engaging in an activity (Eccless, 2009, p. 84). Hence, although it might have been expected that participants with a higher self-concept would choose to engage more, and hence develop their technological fluency farther, there were other aspects of their experience that might have also played a role in their choice to engage more or less such as enjoyment of activity, timing of activity conflicting with another activity, or relationships (Blumenfeld, Kempler, & Krajcik, 2006; Eccles, 2009).

Analysis II and III: Technological Fluency Level and Self-Concept (Post)

It was proposed during the design of the study that participants' engagement in the workshop and with their projects, and hence their development of technological fluency, could play a role on how they saw themselves when it came to engaging with computers in complex and meaningful ways after the workshop and compared to how they saw themselves before the workshop. Identity development is a continuous process informed by performance in different activities (Eccles, 2009; Wigfield & Wagner, 2005; Marsh, Xu, & Martin, 2012). To explore the role that participants' engagement and performance in the workshop might have played, analyses that included participants' level of technological fluency attained, their self-concept score after the workshop, and difference between their score before the workshop and after. Since a previous examination of participants' change in self-concept suggested that their self-concept score before the workshop played a role, each analysis was conducted separately for participants who scored above average before the workshop and those who scored below average.

Differential Relationship. For participants whose self-concept score was above average before the workshop, examinations suggested a positive association between their level of technological fluency attained and their self-concept score after the workshop. Similarly, examinations suggested a positive association between their level of technological fluency attained and change in self-concept score. On the other hand, for participants whose self-concept score was below average, examinations suggested a negative association between their level of technological fluency attained and their self-concept score after the workshop, and similarly, examinations suggested a negative association between participants' level of technological fluency attained and change in self-concept score.

The relationship between participants' development of technological fluency and their self-concept could have been different for participants who scored above average and those who scored below average in part due to participants' interpretative processes, achievement goals, or frame of reference. For example, participants who scored above average before the workshop could have had a focus on ability and performance, in which case "expenditure of effort can threaten self-concept" (Ames, 1992, p. 262). In other words, within participants who scored above average before the workshop, those who may have found it easier to engage on the different programming activities did so "successfully" and this contributed to them maintaining or showing a positive change in self-concept after the workshop. While those who may have found it harder to engage chose to engage less and this contributed to them maintaining or showing a negative change in self-concept after the workshop.

In comparison, participants who scored below average before the workshop might have had a focus on mastery and achieving self-referenced standards. In which case, their degree of engagement and hence development of technological fluency was based on meeting their expectations and this contributed to them maintaining or showing a positive change in self-concept after the workshop. Moreover, a focus on mastery by participants who scored below average could have had contributed as well to them choosing to engage, on average, more than participants who scored above average and who might have had a focus on performance instead. Past research has shown that a focus on mastery leads to challenge seeking and persistence in the face of difficulties while a focus on performance is characterized by challenge avoidance and low persistence in the face of obstacles (Dweck, 1986).

Conclusion

Although the study did not collect data specifically related to participants' value of the workshop or their interpretative process, field note data and some of the data from the interview suggest the interpretations just presented could be in fact relevant. For example, three of the seven participants who scored below average had a previous relationship with the instructor and two developed a close relationship with the instructor during the workshop. In contrast, only one of the participants who scored above average had a previous relationship with the instructor and one develop a close relationship during the workshop. Furthermore, two of the participants who scored below average before the workshop mentioned not having close friends attending the workshop as something they had not liked, while none of the participants who scored above average did so. The existence of these relationships could have added value to participants' engagement in the workshop and with their projects. Past research has pointed to the importance of relationships for motivation and achievement (Blumenfeld, Kempler, & Krajcik, 2006) and successful participation in informal learning environments (for a review see, Vadeboncoeur, 2006),

In addition, more than half of the participants who scored above average before the workshop indicated that they had used someone else's project (i.e., instructor, friend, or website) as a model when asked about their source of inspiration. In contrast, more than half of those who scored below average indicated that they had made the project thinking about what they liked. Furthermore, while three of the participants who scored above average referred to their projects in comparison to that of the other participants when asked "what do you think about your project?", only one of those who scored below average did so. See Appendix G.

On the other hand, the difference in findings could be artificial due to the small size of the sample. Moreover, while three of the participants who obtained a self-concept score above average before the workshop showed a meaningful decrease in their post-score, none of the participants who obtained a score below average did so, and while three of the participants who scored below average showed a meaningful increase in their post-score, only one of those who scored above average did so. In addition, no meaningful differences were found in regards to the attendance of participants who scored below average and those who scored above average, a similar number of participants in both groups said they wanted to learn more when asked before the workshop why they had decided to attend, and their responses in regards to why it was important for them to learn more could not be clearly interpreted as endorsing a mastery or a performance approach. See Appendix G. Including measures in future studies that would directly address factors such as value and interpretative systems in addition to self-beliefs would help us better understand the relationship between developing technological fluency and identity.

Chapter X

Participants' Perceptions of the Learning Environment

As it was alluded in chapter three, the design of the learning environment focused on three areas: (1) help participants develop their technological fluency, (2) help participants see themselves as capable to engage with technology in complex ways, and (3) make the learning environment appealing to participants. Therefore, the design and implementation of the learning environment strived to include characteristics relevant to each of these areas. Chapters six and eight presented the analyses of these characteristics as they related to participants' development of technological fluency and identity, respectively. However, during these analyses emphasis was placed on the researcher's perceptions as to what constituted evidence of an instantiated characteristic and its role in participants' development. Moreover, the appeal of the learning environment was not a main focus of either analysis.

In this chapter, participants' perceptions of the learning environment are presented and compared to the researcher's perceptions. In particular, data obtained through interviews with the participants after the workshop ended was used in an attempt to examine the learning environment using participants' own perceptions and better understand what might have helped them learn, what might have played a role in regard to their identity as technologically fluent, and what might have made the learning environment appealing to them. The analysis was also informed, when relevant, by participants' comments made during the workshop sessions and recorded in the field notes.

Development of Technological Fluency

After the workshop ended, participants were interviewed about their experience in the workshop. Although they were not directly asked about technological fluency, some of the questions dealt with what they thought they had learned during the workshop.

Three main themes emerged from the analysis of their responses. First, more than half of the participants talked about learning more about computers, however none of their responses included specifics. Second, all of the participants talked about learning to use new programs. In particular, all of the participants mentioned learning to use Scratch, but half mentioned learning other programs as well (i.e., web browser and Photo Booth). Finally, more than half of the participants talked about learning "to control the computer" and "telling the computer what to do", two thirds of them specifically mentioned building a program to do so.

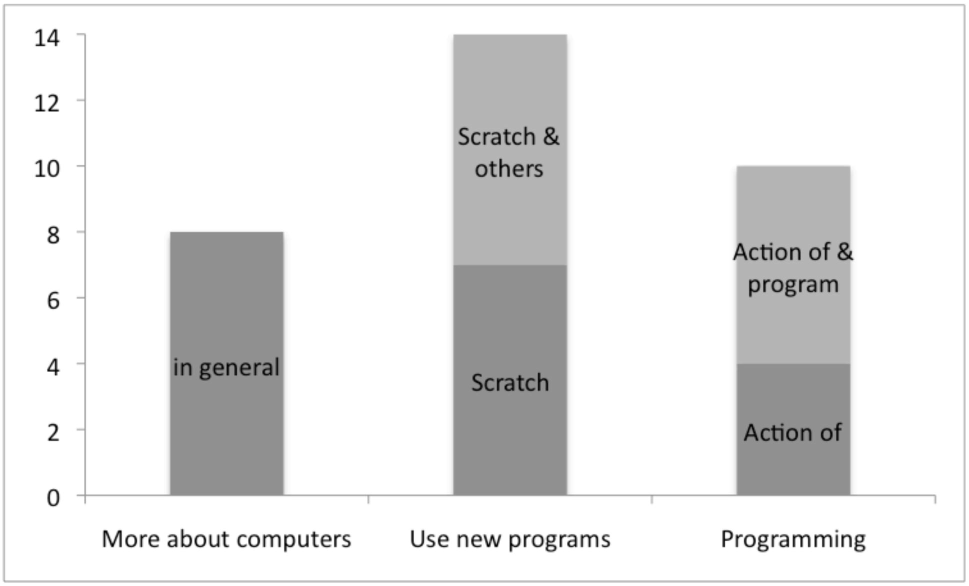

Figure 51. Number of participants who gave answers in each theme in regards to what they had learned during the workshop

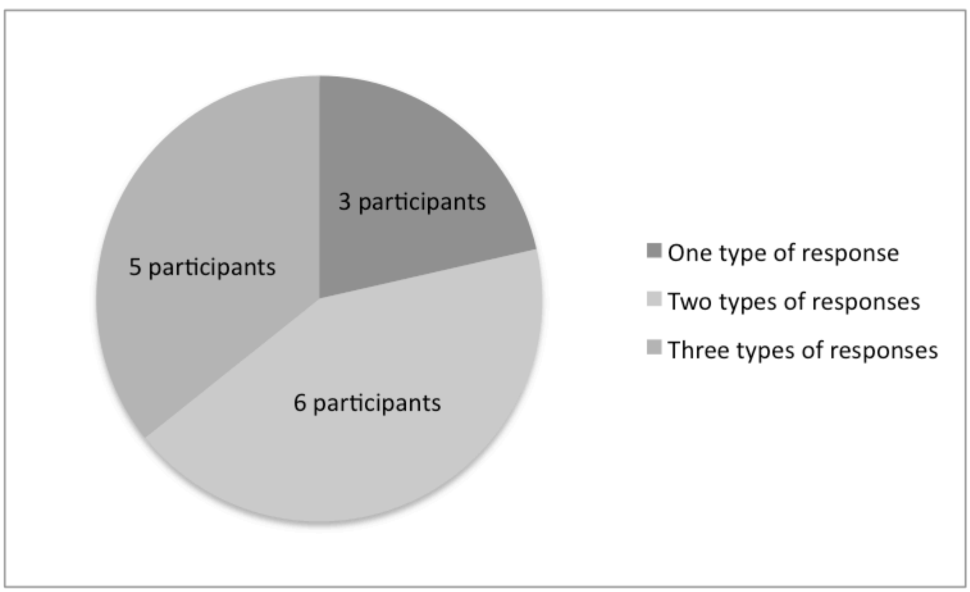

Figure 52. Number of participants who gave one, two, or three different types of responses in regards to what they had learned during the workshop

Overall, the data showed that all of the participants saw the workshop as an opportunity to learn how to use new programs and specifically to learn how to use Scratch. Moreover, the data also showed that at about two thirds of the participants developed a basic understanding of what programming is.

The Learning Environment and their Development of Technological Fluency

Building from Concrete to Abstract Knowledge

About half of the participants mentioned that concrete examples provided by the Scratch cards, the instructors' project, or a project from a friend was something that had helped them learn, most of them did so in relation to understanding what programming is. This extends the finding from the analysis based on the researcher's perceptions that suggested a positive relationship between building scripts and understanding programming by indicating that simply observing a concrete example was also useful to participants' development of programming knowledge and skills.

On the other hand, although the researcher perceived the programming environment, i.e., Scratch, as a tool that had helped participants develop their programming knowledge and skills by presenting them with concrete representations of what programming entails and some of its concepts, Scratch as something that had helped them learn was mentioned by only two of the participants. The discrepancy between the researcher's perceptions and those of the participants could be due in part to the fact that the researcher is not only a more experienced programmer but also has experience with traditional programming environments, where scaffolding focuses on proper syntax and achieving the desired output of a program.

Opportunities for Articulation and Scaffolding

All of the participants mentioned having access to just in time, personalized help as something that had helped them learn (although none of the participants made a distinction between engaging in articulation and reflection and scaffolding); half of them did so in relation to understanding what programming is. In particular, two thirds mentioned receiving this help from the instructor and one half mentioned receiving it from other participants. (One participant mentioned helping others as something that had helped her learn as well). This is partially in line with the finding from the analysis based on the researcher's perceptions that suggested that participants having opportunities for articulation and reflection, and receiving scaffolding had supported their development of programming knowledge and skills.

Unforeseen Distractions.

During the interview, participants not only talked about what had helped them learn but also about aspects that had interfered with their development of technological fluency. In particular, half of the participants mentioned getting distracted as an impediment for their learning. Among the distractions mentioned were participants going in and out of the computer lab, talking too much, or having the music too loud, also boys trying to get their attention through the window. These types of characteristics were not taken into consideration during the design of the learning environment or the analysis based on the researchers' perceptions. However, that some of the participants explicitly talked about it indicates that an effort should have been made to minimize distractions and/or improve engagement.

The Learning Environment and their Identity

Meaningful and Reasonable Challenge

Most participants mentioned a desire to learn more about computers as a reason for attending the workshop and therefore had found their attendance to the workshop meaningful since they had learned to use a new computer program and/or about programming. In addition, about one third of the participants commented having found the project challenging at first but then becoming easier as they participated in the workshop and worked on it. For example, both Katia and Martha commented that not knowing what to do was hard, but as their engagement with their project progressed they had to ask less often for help. Luna had the following to say about her participation in the workshop and her project, "At first I did not know what to do but then, I was like, Wow!" No participant mentioned the project as something they had not liked or that they had found it too hard. This is in line with the finding from the analysis based on the researcher's perceptions that suggested that participants found working on their project meaningful and reasonably challenging. On the other hand, neither analysis indicated that this characteristic had played a meaningful role in regards to participants' identity.

Emphasis on Effort

Although most participants described their experiences and projects as good, about one third also indicated that it had not been completely successful. For example, some participants thought their projects could have been better and some talked about having had some difficulties during the workshop. However, all of those who elaborated on this sentiment attributed their less-than-perfect success to effort and not ability. For example, Adriana, Alma, and Rebecca suggested their projects could have been better if they had spent more time on them. Jacqueline, Alexandra, and Laura talked about getting distracted and not paying attention as factors interfering with their performance.

The participants' responses just described were not specific to them perceiving the learning environment as emphasizing effort over ability and hence could not be compared to the researcher's perceptions. However, the participants who provided these responses spanned all three identity groups (i.e., positive change, no change, and negative change), suggesting that although the workshop may have encouraged participants to emphasize effort over ability, additional factors were at play in participants' development of identity as technologically fluent. Moreover, this suggests that although their experience in the workshop and with their project may not have felt as successful to these six participants (a completely erroneous notion as demonstrated by their projects and given that this was their first experience with programming for most of them), it also didn't make them doubt that they are capable of engaging with technology in complex ways. It may be that the learning environment should not have only strived to encourage a focus on effort but also help them make the connection between effort spent and success.

Role Models.

Although several participants were observed during the session following their visit to the headquarters of MySpace, talking about the fact that one of the engineers they met was a Latina like them and a few commented on the fact that the instructor (a Latina as well) was a "professional", only two participants explicitly observed that attending the workshop had helped them believe that it was ok for them, as girls, to be interested in computers. (In fact, all of the participants agreed that the workshop had met this objective however only two gave an explicit reason as to why they thought so.) The analysis based on the researcher's perceptions suggested that interacting more frequently with the instructor had played a positive role in three of the four participants showing a positive change in identity. However, given that only one of them offered any evidence of this being a possibility, it was not possible to ascertain based on the participants' perceptions if this was the case or not.

Perceptions of the Workshop's Appeal

Girls-only Environment

The analysis into the workshop being a girls-only activity as something that would make it more appealing to the participants included data from the interviews before and after the workshop as well as data from the focus session during which participants talked about their experiences using computers in a mixed environment, mainly the computer lab at the CTC.

The majority of the participants liked the idea of the workshop being a girls-only activity when asked about it before the workshop started, and many referred to uncomfortable past experiences during the interview. For example, Paulina talked about boys making girls feel uncomfortable because of their choice of activities: "It is good [that the workshop is girls-only], boys judge us, they think what we do on the computers is too girly", about half of the participants expressed similar sentiments. In addition, one third talked about being harassed by boys when using the computers; one of them, Laura, commented: "It is really cool; boys make fun of what happens to you on the computer." During the focus group, several participants voiced similar feelings again and also talked about not having much access to the computers at the lab because of the boys:

> ***Adriana:*** *The boys always want to take all the computers. We'll be walking towards the lab and they run past us and push us out of the way.*

Martha: *Many times there are a lot more boys than girls [at the lab] and this makes it feel uncomfortable.*

Cristina: *One time, I put my backpack on one of the chairs so I could go to the bathroom, a boy came and grabbed it, and he said that I couldn't save it [the computer].*

Katia: *Yesterday, I was at the computer lab and this boy, out of nowhere, told me "you are dumb".*

Gloria: *Yeah, sometimes the lab feels like kind of not safe.*

After the workshop, about half of the participants mentioned the fact that the workshop was a girls-only activity as something they had particularly liked, although their reasons were not related to technology per se. For example, both Natalia and Jacqueline referred to expectations for their behavior when they were with boys by saying that they had liked not having the boys around because they "could talk about girl stuff" and "there were no boys to get distracted with flirting".

Although the researcher had not expected for this characteristic to be mentioned by participants as something that had helped them learn, she had expected that most participants would have mentioned it as something they particularly liked. The discrepancy between the researcher's expectations and the participants' perceptions could be due to timing. In making the workshop a girls-only activity, negative interactions, such as the ones described above by the participants, were prevented and this may have contributed to a more comfortable environment for them. Moreover, the pressures of having to behave a certain way when they are around boys were not there. In turn, a more comfortable environment, without the added pressures of having to behave a certain way, could have helped participants focus on their development and feel more confident to engage in the different programming activities; as their development increased it became more relevant, resting saliency to the fact that it was happening in a girls-only environment and to past experiences interacting with boys while engaged with computers.

Emphasis on Design and Creativity

Participants' projects showed that participants who chose to make their designs more elaborate (i.e., they added more sprites and scripts) and pursue their creativity further (i.e., they build more original scripts and/or added and deleted scripts more often), spent more sessions on programming and developed their programming knowledge and skills further. Although none of the participants mentioned these features as something that might have helped them learn, about half mentioned the project as something they had particularly liked. Their answers referred to its creative quality and its personalized design. For example, Natalia and Katia both commented that they had liked that "it was a creative project". Martha called it "our own original creation". Thalia and Laura pointed out that they had liked that "the projects were personal". Luna observed, “We got to create our own personalized projects.” These participants who provided these answers spanned all three identity groups (i.e., positive change, no change, and negative change).

Scratch contributed to the learning environment’s emphasis on design and creativity through its graphical language and highly interactive environment. In addition, it allowed participants to easily add and mix graphics, animations, photos, music, and sound while creating a project. In fact, when asked their opinion about Scratch at the end of the workshop, one third of the participants commented how easy it was to add their own pictures and images to their projects. In contrast to about half of the participants indicating the project as something they had particularly liked, however, only two participants’, Adriana and Alexandra, mentioned Scratch when asked what they had liked about the workshop. On the other hand, it is possible that is was partially due to Scratch and its capabilities that some of the participants might have found the project appealing.

Collaboration

During the interview before the workshop many of the participants indicated that they liked the fact that at least one friend had decided to attend the workshop as well. They shared that having a friend in the workshop would provide them with someone they could ask for help, someone to share their learning with. After the workshop, once again, many of the participants indicated that something that had helped them learn was asking a friend for help or taking a look at their friends' project. In spite of this, only a third of the participants mentioned the fact that they were able to interact with friends while working on their projects as something they had particularly liked. This could be in part because although participants were observed at times asking for help from a friend or offering to help a friend, no participants engage in this type of interactions during all of the workshop's sessions. Hence this was not a salient characteristic at the time the interview occurred.

Conclusion

Analysis of the participant's perceptions indicated that similarly to the researcher's perceptions several of the characteristics of the learning environment (i.e., concrete examples, opportunities for articulation, and scaffolding) played a meaningful role in participants development of technological fluency. In addition, about one half of the participants found the workshop being a girls-only activity appealing, and one third particularly liked having friends with whom to share the experience. Finally, similarly to the analysis based on the researcher's perceptions, there was no clear relationship between the participants' perceptions and their identity. However, based on participants' comments, about one half seemed to have found working on their project meaningful and challenging but not too hard and emphasized effort over ability when talking about their performance. It is important to note that the timing of the interview might have contributed to what participants' found relevant and shared at the moment. Asking at different points in time might have provided with additional or different information. In addition, participants were a lot less expressive than the researcher expected them to be.

Chapter XI

Discussion

Underlying this study is the belief that we should think of individuals as becoming technologically fluent rather than being technologically fluent; in particular, we should consider individuals' development of both technological fluency and an identity as people who are technologically fluent as they engage in complex technological activities. In this study I examined the experiences of 14 young, bilingual, low-income Latinas as they engaged in a girls-only programming workshop offered as part of the afterschool program at a local Computer Technology Center (CTC). I looked at the characteristics of the learning environment in relationship to their development of technological fluency and their identity as someone who engages with technology in complex ways. I also tried to better understand the role that their development of technological fluency had on their identity and vice versa.

In particular, this study investigated whether characteristics of learning environments found by past research to have a positive role on students' learning and identity development in other domains helped participants become technologically fluent. In addition, it aimed to contribute to a better understanding of individuals becoming technologically fluent by investigating the relationship between the participants' development of technological capabilities, concepts, and skills as they engaged in the programming workshop and their identity. Hence, this investigation drew on past research in the fields of learning sciences, computer science education, identity development, and women and technology. The study's methodology was mostly qualitative. Data collected included observations of the workshop's sessions, structured interviews with the participants conducted before and after the workshop, and copies of the participants' programming artifacts at the end of each session.

As expected, in line with the research that informed the design and implementation of the learning environment, the analyses showed that its characteristics motivated and supported the participants in their development of technological fluency. Specifically, all of the participants developed several of the technological capabilities, concepts, and skills included in the framework for technological fluency put forward by the National Research Council (1999), and in particular programming knowledge and skills. Moreover, although a significant change in participants' identity was not observed at the end of the workshop, the diversity of experiences, learning outcomes, and self-beliefs reflected in the data suggested that participants' identity, as much as their development of technological fluency, was at play as they engaged in the workshop. An important contribution of this study, then, is that it presented a learning environment informed by past research that successfully supported young Latinas in sophisticated engagement with technology, provided them with an image of programming, a complex technological activity, as something "not only boys and nerds do" (Alma, interview after the workshop), and attested to the feasibility of CTCs as a viable alternative for making complex and meaningful technological activities accessible to girls.

A Programming Workshop for Girls

A valid question about this study is, why programming? The reasons behind the decision to have the participants engage in programming during the workshop were varied. First, the presence of technology in individuals' lives is only growing and younger generations are being afforded greater physical access to it. However, greater physical access does not always translate into engagements that could lead to the development of technological fluency (for a review see Warschauer & Matuchniak, 2010). This can be particularly true for girls. For example, just as larger studies have found (for a review see Singh, Allen, Scheckler, & Darlington, 2007), most girls in this study engaged with technology in less sophisticated ways than did their male counterparts at the CTC even though they had access (physically) to the same equipment and software (e.g., scanner, camera, video editing software, music software). Hence, the programming workshop offered an opportunity for the participants to engage in a more complex technological activity than they were used to in a safe learning environment in which they could take an active role in their learning, and an opportunity for the researcher to better understand how to support them in becoming technologically fluent.

Second, identity development is a process characterized by a reciprocal relationship between development of competence and sense of competence during which the two are constantly mutually reinforcing each other (for a review see Marsh, Xu, & Martin, 2012). Creating something provides a good opportunity to understand participants' identity development as it promotes engagement with the self (Upitis, 2010). Moreover, creating a computer program privileges the process of solving a problem over obtaining a final outcome, i.e., the right solution. In this case, this engagement in the process of creating a computer program included both a reflection on the participants' current identities as they chose the different images, pictures, and music they included in their programming projects and also a reflection on their competence and ability to engage in a complex technological activity as they made decisions during each session in regard to the different scripts they included in their projects. In addition, the instructor was able to act as an extension of this reflection by presenting a possible self (Wigfield & Wagner, 2005); she was Latina like the participants and being technologically fluent in general and having programming knowledge and experience in particular are very much part of her identity. In fact, engaging in personal interactions with the instructor seemed to have been a positive factor in at least three of the participants' identity development.

Finally, programming is stereotypically regarded as a male field, engaging in it in a meaningful way could have provided the participants with the opportunity to question this stereotype. As it turned out, however, none of the participants seemed to have developed any stereotypes prior to the workshop in regard to programming. This could be due mostly to the fact that only one of them knew what programming was or knew someone who engaged in programming before the workshop. One of the advantages of this workshop was that most of the participants were still in middle school, and with the exception of one, had not been exposed yet to stereotypical notions of what programming is and who does it. If they had been in high school where electives are more predominant and, when available, computer science programs and courses already reflect the culture and domain of a subset of more experienced males (Goode, Estrella, & Margolis, 2006), it could be possible that they would have held stereotypical notions about programming and been less open to this activity. Although the lack of opportunities for girls to gain pre-college computing experience in middle school is troublesome, it may also have provided us with a unique opportunity. In general, technology is regarded as a male field. However, when girls have not yet developed stereotyped notions for particular technological activities, this presents us with opportunities to show them that complex technological activities are also for girls, as was the case with this programming workshop.

Working Concertedly to Support Development of Technological Fluency

Overall, the workshop was well received; most participants attended frequently (attendance rate was at least 80 percent; i.e., any given session was attended by at least 12 of the 15 participants) despite a variety of competing activities (e.g., a hip-hop dance contest, a hamburger BBQ, and cheerleading practice), and even requested that the workshop continue after the study had ended. Most importantly, they all developed their technological fluency by acquiring meaningful computing experience and a budding understanding of programming.

Creating an environment that motivated and supported the participants as they engaged in programming was an important goal of this study given that learning to program is hard (Clancy, 2004; Kelleher & Pausch, 2005), and the programming environment selected for the workshop, Scratch, was unknown to all of them. In fact, data analyses showed that programming and Scratch were challenging for the participants to learn at times. However, the analyses also showed that the characteristics of the learning environment, including the type of project the participants built, and Scratch worked concertedly to motivate and support them as they developed their programming skills and knowledge.

Supporting Learning

To achieve its goal to support the participants' development of programming skills and knowledge, from its inception, the workshop strived to provide opportunities for them to engage in articulation and reflection, have their learning scaffolded, and increase their understanding by building from concrete to abstract. The data showed that the participants did in fact engage in these types of learning activities and that doing so positively contributed to their development of programming skills and knowledge. Furthermore, the data showed that by encouraging collaboration and putting an emphasis on design and creativity the workshop promoted and provided the space for the participants to engage in these types of learning activities. Finally, the data showed that their engagement in these activities was greatly aided by Scratch, the programming environment.

Although any one of these activities and characteristics alone could have contributed to the participants' development of programming skills and knowledge alone, together they created a more powerful learning experience. For example, research has shown that students learn better from verbal explanations and corresponding visual representations rather than from words alone or pictures alone (Moreno, 2012). In this case, participants' engagement in these activities often happened during conversations with other participants and/or the instructor, and the ability, which Scratch provides, to observe a script that they had built and its outcome next to each other facilitated their understanding of the concept being discussed, the different commands, and the process of building scripts. In particular, as the participants built scripts they were able to both engage in conversation about them and observe a concrete representation of their developing understanding which facilitated their process of reflection.

Compared to other environments that provide novices with on-screen graphical representations of their programs close by (e.g., Squeak Etoys, and Boxer), Scratch has added scaffolding when it comes to syntax; “one of the largest and most frustrating challenges for novice programmers ” (Kelleher & Pausch, 2005, p. 89). However, as much as Scratch eliminated the need to pay attention to syntax, and its graphical language made the choice of which commands to use more intuitive, receiving personalized help from the instructor often helped participants verbalize an idea and hence better understand which commands to use. A common source of difficulties, and possible bugs, for novices is the misconceptions that emanate from “linguistic transfer” and their view of programming as “analogous to conversing with a human” (Clancy, 2004). Furthermore, talking to each other about the project was in fact a source of frustration at times for several participants, who as Rebecca put it, “could not understand what [the other participant] was saying” (interview) and a limitation that Scratch was not able to address. Participants’ difficulty in verbalizing their ideas and “translating” them into a script could have been in part due to the abstract nature of programming or simply lack of experience; in such cases communicating with the instructor, who has both knowledge of and experience with programming, was helpful.

In addition, with its emphasis on design and creativity, the workshop’s main project allowed the participants to develop technological capabilities, concepts, and skills as they engaged in the construction of a variety of short scripts, all of their own choosing. The construction provided participants with a variety of opportunities to engage in articulation and reflection, have their learning scaffolded, and improve their understanding by building from concrete to abstract. Students encode information more deeply when explanations are personalized and they are participants in rather than observers of the learning environment (Moreno, 2012). In addition, participants' learning was enhanced by their ability to immediately observe the results of their experimentation in adding different elements to their projects, building scripts and revising them; this was facilitated by their ability to drag and drop the programming blocks, adding and removing them, or simply putting them aside in case they decided to use them later. Students learn better from representations that mutually refer to each other when they are presented physically close rather than separated (Moreno, 2012).

Motivate Engagement

A contributing factor to the success of the workshop was that the characteristics of the learning environment created a motivating environment for the participants. In particular, the environment strived to provide youth with an authentic learning space by looking at their daily lives. Authentic activities create a meaningful context to apply content and skills and transform knowledge. In turn, meaningful activities create a "need-to-know" situation to learn specific ideas and concepts and provide a reason to understand; learners' interest and level of engagement are enhanced (Blumenfeld, Kempler, & Krajcik, 2006). Like most youth in the United States (Roberts, Foehr, & Rideout, 2005; Warschauer & Matuchniak, 2010), the participants had some access to digital technologies and engaged with them when possible. For example, all stated that they used a computer and the Internet on a daily basis. Hence, opportunities for low level technological fluency development in their daily life arose often in an informal way. Often this occurred through meaningful activities, a variety of tasks, short-term goals, and personal choice, all characteristics of the programming workshop.

Data analysis showed that the project the participants worked on during the workshop came to be regarded in essence as similar to building a profile page for MySpace.com, a popular social networking web site frequented by almost all of the participants. Building a profile page for an online social network is a common activity youth engage in today. In a recent US survey of 2000 students (9–17 year olds), 71 percent reported they use social networking sites at least once a week, and 25 percent reported they update their profiles at least once a week (National School Boards Association, 2007). In this case, when asked what activities they used a computer for, all of the participants mentioned using social networking sites and specifically mentioned MySpace.com. A profile for MySpace includes, among other things, pictures of oneself, friends, and family members, images of things one likes, and a personalized background. The projects the participants built during the workshop included several of these things as well, participants often referred to their projects as “my profile” and many of them used their MySpace.com profile as sources for pictures and music. Equating their projects to their MySpace profiles of course was limited to the aesthetic similarities between the two artifacts and the fact that both provided them with a space to explore their identity (Greenhow & Robelia, 2009) and does not include the activities participants had to engage in to create it. That is, while programming was the main activity participants engaged in during the creation of their “profiles” in the workshop, this is not the case for profiles created on MySpace.com; participants were well aware of this distinction.

Another feature of the workshop that was similar to participants’ engagements with technology in their daily lives was the emphasis on learning within social interactions and mediated by more experienced adults and peers. Although relationships and the role they played in participants becoming technologically fluent were not investigated per se, relationships both between the instructor and the participants and among the participants were an important aspect of the workshop. Relationships fostered the youths’ participation in the workshop, which allowed them in turn to increase their technological fluency. For example, the workshop’s instructor had been volunteering at the afterschool center for about a year prior to the beginning of the workshop and had led a different workshop for girls for some of the time. This allowed her to establish a relationship with some of the participants that in turn encouraged participation in the workshop of at least three of them. Other times, it was the participants who encouraged each other, as when Jacqueline saw that Alma was not at the workshop and proceeded to call her on her cell phone and talk to her about coming to the workshop (FN, 10/23/08). More importantly, relationships often provided the space within which participants' development of technological fluency occurred as they engaged in articulation and reflection. Social interactions in caring relationships are often the medium through which youth meet and surpass goals set for and with them (Vadeboncoeur, 2006).

Several environments have been developed to help youth learn the basics of programming through meaningful activities, and continued efforts are being made to embed these activities in contexts, such as the arts (Kafai & Peppler, 2011), that prove attractive and motivational to youth. In this case, the programming environment, Scratch, was a key component in achieving an environment that proved motivational for the girls. In contrast to other programming environments that have been designed with girls in mind and that provided a very specific context within which the creation of programs occurred (e.g., telling a story, a simulated world, a dance competition), Scratch supports many different types of projects (stories, games, animations, simulations), so youth with widely varying interests are all able to work on projects they care about (Maloney, Peppler, Kafai, Resnick, & Rusk, 2008; Resnick et al., 2009; Tangney, Oldham, Conneely, Barrett, & Lawlor, 2010) and which may reflect more closely the informal technological activities in which they engage on a daily basis. It allowed them to have choices and make decisions as to what their projects should be like and to personalize them. For example, Alexandra had the following to say about Scratch: "I like it because you can do a bunch of different stuff for your project" (FN, 10/30/08). Moreover, it allowed them to utilize popular culture media relevant to them in their projects. Research has shown that when youths' popular culture is valued students are more motivated to engage (Dyson, 1997; Nixon & Comber, 2006). Finally, not only did Scratch make available to the participants many different types of images and sounds, it also made it easy for them to create their own images and sounds by including recording capabilities and a paint tool. In fact, when asked their opinion about Scratch at the end of the workshop, one third of the participants commented how easy it was to add their own pictures and images to their projects.

Limitations of the Design and Implementation

For all the emphasis on collaboration and design and creativity the learning environment strived for, participants still collaborated less than expected and about half were quick to copy the sample project's or another participant's design instead of coming up with their own design. This was unfortunate given that when they interacted participants tended to benefit from it and past research has shown that collaboration is conducive to learning and girls enjoy collaborating while working with technology (Barker & Aspry, 2006). In addition, working on their own design gave them more opportunity for experimentation and learning.

The paucity of collaboration could have been due to the fact that the project was individually based and the computers were arranged in rows making the environment not particularly conducive to collaboration. It could also be due to the computers being, as Alexandra called them, the "good" computers and available at the ratio of one computer per participant for all sessions except one, so that girls were especially motivated not to share. Finally, it could be due to the fact that the girls were not used to engaging in collaboration at school, as several participants expressed, where most of their structured learning occurs and for some reason carried that model into the afterschool program.

Similarly, the participants resorting to copying the sample project's or another participant's design instead of coming up with their own could have been influenced by the fact that, as Hennessey and Amabile (2010) state in their review of creativity research, creativity is not always encouraged in schools (p. 585). In addition, research has shown that novices have a hard time coming up with ideas (references, xxxx), and although participants looked to obtain ideas for individual scripts by talking to the instructor about a task they wanted to achieve or perusing the Scratch cards, this was not the case in regard to the overall design of their project. Finally, without a major extrinsic reward to motivate them, it may have been participants doing just enough work to satisfy the instructor, although for most of the participants this did not seem to be the case. A possible strategy for fostering collaboration and creativity could be to design a project that presents a problem and not a solution; a sample project can be seen as akin to presenting the solution to a problem and hence thwart creativity. In addition, the project could appeal to the participants at the group level and hence require a communal effort to be accomplished.

Although designing a project that encourages collaboration and creativity may be an easier adjustment to make, it could be difficult to achieve because the placement of computers in CTCs is not always under the control of the designer of the learning environment. Moreover, the other two factors are socioeconomic and cultural factors that will probably be encountered when making opportunities to become technologically fluent accessible to youth similar in background to the participants in this study. For example, due to their low-income background participants might not have had access at home to technology as new as the computers they used during the workshop, and even at the CTC, the use of the "good" computers was often reserved for workshops. Moreover, recent data show Hispanic families having a ratio of nearly four people per household computer (Warschauer & Matuchniak, 2010), lowering the opportunities for household members to gain individual computer access. Finally, the latest data available show that teachers in low-SES schools are more likely than those in high-SES schools to view computers as valuable for teaching students to work independently and/or have students use them for remedial computer-based drills or practice activities with a focus on low-order skills (Warschauer & Matuchniak, 2010).

Identity at Play during Development of Technological Fluency

A great deal of research conducted to better understand the underrepresentation of women in computing and other technology related fields has focused on factors related to identity (e.g., stereotypes, confidence, assertiveness) since technology is often perceived, stereotypically, as a male oriented field. Findings from this research have shown that these factors as much as prior knowledge have played a role in girls' experiences and decisions to engage in complex ways with technology (Barker & Aspray, 2006; Farmer, 2008; Singh, Allen, Scheckler, & Darlington, 2007). Although this study found no clear and significant differences in regards to participants' experience of the learning environment and their change (or lack of) in self-concept, two meaningful themes related to their identities in regard to technology emerged: (1) all participants saw themselves as "users" and (2) there was a mismatch between perceived competence and actual competence for several participants.

Users, Creators

Both before and after the workshop, when talking about their engagements with computers currently and for future employment, all participants saw themselves as "users." None of them imagined themselves actually creating the technological tools that others may use. This is consistent with past research that has shown that although girls use technology and enjoy doing so, most think of it as a tool when it comes to their relationship with it (Farmer, 2008).

With the emergence of a participatory culture and a do-it-yourself (DIY) movement (Kafai & Peppler, 2011) as the current ways of engaging with technology, it becomes relevant more than ever that we think of individuals as becoming technologically fluent. As Kafai and Peppler (2011) pointed out, today's youth may engage with technology not only as consumers of media and users of technology but also as creators, producing blogs, videos, personal pages on social networking sites, and even computer programs using newer and more accessible programming tools (e.g., http://scratch.mit.edu/). In order to take advantage of the affordances that these new ways of engaging with technology may offer, youth need to develop technological fluency as well as an identity as someone who engages in the creation of media and technology.

One can, however, question whether today's youth and in particular today's girls see themselves as creators of media and/or technology, and if so at what stage of their technological fluency development? As was mentioned above, none of the girls in this study saw themselves as creators even though all of them had at least created one profile page on MySpace.com previous to the workshop and programmed an interactive version of a similar artifact during the workshop. A contributing factor to participants not seeing themselves in the role of creators could have been the lack of access to role models who were creators of technology or lack of opportunities to engage with computers as creators prior to the workshop. In addition, a more explicit and/or greater emphasis on programming as an activity that leads to the creation of technology during the workshop could have been needed.

Perceived Competence, Actual Competence

It was clear from the data that although all participants developed their technological fluency, they developed it to different degrees. Interestingly, for several participants there was a mismatch between their development of technological fluency as measured by their projects and their sense of how much they had achieved as indicated by their opinions of their projects and performance. In particular, several participants perceived that they had achieved less than their projects showed while others perceived they had achieved more. It is important to point out that none of the participants who perceived that they had achieved less thought they lacked the ability to become better or that learning programming was not an appropriate technological activity for them to engage in. In order to be able to perceive level of performance there must be some sort of measure against which to judge performance. In the absence of one provided during the workshop, it would have been interesting to learn what kind of measure the participants used. In addition, it is interesting that despite the researcher's efforts to minimize focus on performance, it still was a salient issue for the participants. It may be that many of youths' achievement experiences come from school; overall, the current educational system is performance-oriented

(Patrick et al., 2000), and as students advance, classrooms become more focused on competition and ability (Meece & Askew, 2012).

Research Implications

With the increased popularity of socially oriented technologies, which tend to be preferred by girls (Ito et al., 2008; Rideout, Foehr, & Roberts, 2010; Roberts, Foehr, & Rideout, 2005), and as physical access to technology increases, research that more faithfully reflects today's youths' experiences is needed. For example, Barker and Aspray (2006) and Singh, Allen, Scheckler, and Darlington (2007) reported that, in general, research showed that girls and women were less confident using computers than were boys. However, most of the studies included in their reviews are about a decade old or were conducted with adult women. It would be interesting to know if today's girls, often considered as part of the millennium generation that has always lived in a digital world (Farmer, 2008), have changed their attitudes towards computers and confidence in using them. For example, although the sample in this study was small and the data limited, findings suggested that this might be the case. All of the participants in this study thought that computers were as much for girls as they were for boys and that although girls and boys may use them differently both are as capable to use them. Furthermore, many of them reported using computers for schoolwork and believing that they would probably use them as part of their chosen profession in the future. Finally, none of them ever expressed that the programming workshop would have been more suited for boys than girls independently of how hard they thought the workshop might have been or the level of technological fluency they achieved.

However, while the participants felt confident on their use of computers and their ability to learn programming using Scratch, they only saw themselves as users. The lack of findings in regards to participants and their identity may have been due to the short duration of the experience; it may also have been that a greater emphasis was needed in helping the participants develop an identity as someone who is capable and for whom it is appropriate to engage with technology in a more complex role than that of user. It would be interesting to investigate the impact of an overt effort to help individuals develop this identity. For example, the workshop could include activities that actively promoted participants' reflection of their achievements and their budding identity as capable of engaging with computers in complex ways. In addition, the workshop could put greater emphasis on the process of creating as opposed to producing a finished product and participants as creators as opposed to users.

Hence, just as socio-economic and cultural factors can exert influence through external mechanisms, such as school settings and knowledge networks (Goode, Estrella, & Margolis, 2006; Margolis, Estrella, Goode, Holme, & Nao, 2008; Barron, Martin, Takeuchi, & Fithian, 2009), internal factors can also play a role in shaping an identity not conducive to the development of technological fluency (Goode, 2010). Just as a redefinition of the digital divide calls for an expansion of our understanding to include factors beyond physical access, it is also necessary to expand the framework utilized to describe individuals' fluency with technology, to include not only technological capabilities, concepts, and skills but also identity.

Research Limitations

Completely replicating this work might not be possible due to local constraints or lack of available resources. For example, the curriculum employed was not set and no detailed primer or guide exists that could be used to replicate this workshop. In addition, many of the opportunities of this research were made possible by the researcher's knowledge and time investment. A limitation for practical implications is lack of individuals with enough knowledge both about programming and how to best guide learners.

A related limitation is the fact that the instructor acted as the researcher as well. This most probably had an impact on how the data were collected (e.g., which episodes were more salient and hence recorded) and how data were analyzed (e.g., the experience of being a participant colored the conclusions made). This limitation could maybe have been alleviated by the prior development of guidelines and forms to guide data collection, more time spent on training the two research assistants, and the inclusion of more research assistants.

Another limitation is the lack of guidelines related to evaluating development of technological fluency and in particular programming knowledge. Although, in this case I consulted programming texts in order to develop a system that would allow me to compare participants' development, my process was also very much informed by my personal experience as a computer science student and software engineer, and which has been that developing technological fluency and programming expertise is not a linear process and what may be easier for some may be hard for others and vice versa.

Studies like this one can contribute by providing guidelines that individuals interested in providing similar opportunities to youth could implement regardless of level of knowledge and experience. Furthermore, future studies could further shed light on the relationship between development of technological fluency and identity. For example, a limitation of this study was the short duration of the workshop and limited data, which could have played a role in the apparent lack of results in regard to participants' self-concept, and the role the learning environment might have played in changing it.

In addition, the lack of results could have been due to the measure used not being specific enough. Research on academic self-concept, for example, has shown that students can have separate self-concepts when it comes to their verbal and math competence and that these are not necessarily correlated. Furthermore, intervention effects are specific to the target components of self-concept and no significant effects are observed in areas of self-concept unrelated to the intervention (for a review see Marsh, Xu, & Martin, 2012). This was one of the limitations of the study. The measure used to assess participants' self-concept targeted their use of computers in general while the workshop was specifically about programming. Moreover, this study utilized only one measure to assess participants' self-concept. It may be that multiple indicators of the construct were required to truly capture participants' self-concept and the role the workshop might have played in their development of identity (Marsh, Xu, & Martin, 2012). Finally, this was a very small sample of self-selected participants— some of which were encouraged to attend the workshop by a previously established relationship with the instructor— who may have had already a relatively well-established concept of their competence to use computers. A sample of randomly selected participants may have produced different results.

A possible limitation of the workshop itself and other similar opportunities for youth to engage with technology in complex ways is the fact that, for example in this case, programming in Scratch is not among the practices favored in academic environments at the college level or professionally. Shaffer (2006) argued that by students incorporating epistemic frames into their identities, i.e., not only developing declarative and procedural knowledge but also self-identification as a person who engages in such forms of thinking and ways of acting, they can use the ways of knowing embedded in a particular activity in other contexts. By providing learning environments that help youth not only develop technological fluency but become technologically fluent, we can foster youths' ability to use knowledge and skills acquired by engaging in technological practices such as this workshop to those favored in academic and professional environments may they choose to follow a technology-oriented career path.

Future Research

While no clear and significant differences were found in regards to participants' experience of the learning environment and their change (or lack of) in self-concept, the exploration of participants' self-concept and their development of technological fluency suggested the existence of a possible relationship. In a previous chapter I suggested a possible explanation could be the girls having different approaches in regard to their achievement goals. It is believed that students adopt mastery goals when their reason for engaging in an achievement activity is the development of competency and performance goals when their reason for engaging in an achievement activity is to demonstrate their competence relative to others. The goals students adopt have important implications for their engagement, persistence, and understanding (Elliot, 2005).

Technology is created by a variety of individuals and for the most part technology concepts are abstract concepts, hence developing technological fluency is many times a trial-and-error process. In fact, the NRC's framework for technological fluency included the following intellectual capabilities: engaging in sustained reasoning, managing faulty solutions, and expecting the unexpected, among others. In other words, individuals need to understand that even the best-designed technologies can exhibit unanticipated behavior and that engaging with and/or creating technology in order to achieve a goal may require multiple attempts. Moreover, as it was mentioned before, developing technological fluency is a lifetime process. Hence, the development of technological fluency calls for a mastery-approach style as part of one's identity, and in so far as girls might hold performance-oriented goals in regard to their engagements in complex technological practices, this would interfere with them becoming technologically fluent. "No one wants to continue [engaging in an activity] if the result is shame and self-recrimination" (Covington, 2000, p.190).

Looking at the types of goals they adopt could be a productive avenue for future research that looks at girls and their identities as technologically fluent. Dweck (1986) suggested that gender differences in mathematics achievement and later interest might be due to differing motivational patterns and the nature of the academic subject, for example, failure and confusion is likely to be experienced when new material is encountered. Similarly, developing technological fluency involves failure and confusion. Moreover, the computer is a machine that goes beyond all others in its promise to reflect human competence (Turkle, 2005). Hence, the types of goals girls may adopt when engaging with technology may play a role in them seeing themselves as technologically fluent or not and/or choosing technology-oriented majors and careers.

Overall, more work is needed that examines gender differences in achievement goal orientation; few studies have done so and the findings are inconclusive (for a review, see Meece & Askew, 2012). Becoming technologically fluent could be a productive area in which to do this work. For example, the data in this study were insufficient to positively discern if the participants in fact held different types of goals and if so, what role this might have played in them becoming technologically fluent. However, the study found that the characteristics of the learning environment contributed to participants' motivation to engage with their programming projects. Furthermore, when examining the relationship between participants' development of technological fluency and self-concept, differences were found between participants who scored above average before the workshop and those who scored below average, and it was suggested that any differences observed in the nature of the relationship could be due to the type of achievement goals each participant held. The type of goals each participant held could have been in part due to the learning environment helping them focus on competency development. Classroom goal structures have been shown to play a role in students' achievement goals (Meece & Askew, 2012). By being aware of the types of goals girls bring to their engagements with technology the designer of the learning environment can begin to address them. This could be especially relevant when providing opportunities for low-income girls given that research has shown that an emphasis on performance is more prevalent in schools that serve low-income students (Patrick et al., 2000).

Conclusion

This study was designed to contribute to a better understanding of the development of technological fluency and its associated identity. More specifically, this research had two main goals. The first one was to contribute to a knowledge base about how to design learning environments that support girls' development of technological fluency and an identity as someone who is able– and for whom it is appropriate– to engage in complex technological activities. Many researchers have argued for the need to develop technological fluency. However, very little research that addresses how to do it is available. We need to move from the argument that developing technological fluency is a desirable outcome, to questions of how to achieve it in an equitable way. From this perspective, the relevance of this work lies in the development of possible models for creating learning environments that could be shared with teachers, researchers, and the broader educational community and eventually generalized.

The second goal was to contribute to a better understanding of the interrelationship among girls between the development of technological fluency and the development of an identity as some who is able to engage in complex technological activities. Kirkpatrick and Cuban (1998) found that females and males can do equally well in computer classes and classes using computers when they have had the same amounts and types of experiences with computers. Moreover several studies have demonstrated that when given the opportunity girls will engage deeply and in complex ways with technology (e.g., Campe et al., 2005; Countryman at al., 2002; Edwards, 2002). Yet women are still underrepresented in both postsecondary computing education (Cohoon & Aspray, 2006) and the IT workforce (Zarret, Malanchuck, Davis-Kean, & Eccles, 2006) to the detriment of their and society's well-being. For example, according to the latest statistics from the U.S. Bureau of Labor Statistics (2010) less than 2% of women in the labor force work in professional technology related occupations. Yet the median earnings in these occupations are the third highest behind law and medical related occupations (U.S. Bureau of Labor Statistics, 2010). Additionally, a homogenous workforce is more likely to overlook the needs and interests of different segments of the population or fail to provide them with role models to follow (Margolis & Fisher, 2003) and contribute to the perpetuation of the status quo. From this perspective, the relevance of this work lies in the light it shed on the role that identity plays in minority girls' engagements with technology. This relationship could then be further investigated in different contexts and with different populations and our understanding eventually generalized.

Finally, this study aimed to support the importance of both redefining the digital divide to include aspects beyond physical access and expanding the framework utilized to describe individuals' fluency with technology to capture how those aspects contribute to individuals' engagements with technology. As the data showed, a meaningful gender gap still exists in regard to youths' opportunities to engage with it in complex and meaningful ways. Based on what the participants shared about their experiences, there were several factors contributing to their less sophisticated engagements with technology such as the types of workshops they had access to, seeing boys and girls engage in different computer activities, and being the target of aggressive behavior by boys in the computer lab. As it was previously mentioned, that this gap exists is especially relevant to the subject of technological fluency and its development, as it is within complex and meaningful engagements that the development of technological fluency is most likely to occur. Redefining the digital divide and what it means to be fluent with technology to include aspects beyond physical access and inclusive of an individual's identity will help us better understand how to support in an equitable way individuals' process of becoming technologically fluent.

Appendix A — Interview Protocol A

Interview Protocol A: Participants' experiences with technology

Q1: What do you think about computers?

Q2: How did you learn to use a computer?

Q3: Do you have a computer at home? Where? Who else uses it?

Q4: Where else you use a computer?

Q5: How often do you use a computer?

Q6: What computer programs do you know how to use?

Q7: What computer activities do you like?

Q8: Do you think you have as much access to a computer as you would like?

Q9: Do you have Internet access at home?

Q10: Where else do you use the Internet?

Q11: How often do you use the Internet?

Q12: What websites do you like?

Q13: Do you think you have as much access to the Internet as you would like?

Q14: Do you play computer games? Examples?

Q15: Do you play video games? Examples?

Appendix B — Interview Protocol B

Interview Protocol B: Participants' identity as users of computers

Q1: How good are you at using computers?

Q2: Do you think you are as good at using computers as you could be?

Q3: Do you think using computers is: really easy, easy, not easy but not hard, hard, really hard?

Q4: Do you think that learning how to do new things on the computer is: really easy, easy, not easy but not hard, hard, really hard?

Q5: Do you think you are a computer person, why?

Q6: Do you think your friends are computer persons, why?

Q7: When you are using the computer and you have trouble doing something or something goes wrong, what do you do?

Q8: Do you think that computers are more of a boy thing than a girl thing?

Q9: Do you think you would like to work with computers when you grow up?

Q10: Have you taken any computer classes or workshops before?

Q11: Do you think you should know about computers?

Q12: Do you think others think you should know about computers?

Q13: Do you think girls should know about computers?

Q14: Do you think others think girls should know about computers?

Q15: Describe for me someone who knows how to use the computer really well.

Q16: Do you help family or friends use the computer?

Q17: Do you know anyone who works with computers for a living? Do you know what they do?

Q18: Why did you sign up for the workshop?

Q19: What do you think that it is a "girls only" workshop?

Q20: Was it important that your friends sign up for the workshop as well? Why?

Appendix C — Interview Protocol C

Interview Protocol C: Participants' opinions of the workshop

Q1: In general, what did you think about the workshop?

Q2: What did you like about the workshop? Why?

Q3: What did you not like about the workshop? Why?

Q4: What would make the workshop better? Why?

Q5: What did you learn?

Q6: What do you think helped you learn?

Q7: Do you think it was good for you to participating in the workshop? Why?

Q8: Do you think the workshop helped you understand computers better? Why?

Q9: Do you think the workshop helped you become better at using computers? Why?

Q10: This workshop was designed with three goals in mind:

a. First, to help girls learn programming. Do you think I achieved this goal?
b. Second, to help girls believe that they are able to use technology and able to learn new technology things easily. Do you think I achieved this goal?
c. Third, to help girls believe that it is ok for her, as a girl, to be interested in technology. Do you think I achieved this goal?

Q11: What do you think about your project?

Q12: What was the hardest part?

Q13: What was the easiest part?

Q14: Where did you look for inspiration?

Appendix D — Technological Fluency Groups

Table 2. Activities participants engaged in and commands they used, by development group

Development	Participants	Activities	Commands
Higher	Adriana	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Luna	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Alma	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Paulina	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion
	Martha	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion
Medium	Katia	Script, sequence not significant; script, sequence significant; additional scripts	Looks, sound, control
	Rebecca	Script, sequence not significant; script, sequence significant; additional scripts	Looks, sound, motion
	Thalia	Script, sequence not significant; script, sequence significant; introduction	Sound, motion
	Jacqueline	Script, sequence not significant; script, sequence significant	Looks, sound, motion, control
	Alexandra	Script, sequence not significant; script, sequence significant	Looks, motion, control
Lower	Gloria	Script, sequence not significant	Looks, sound, control
	Cristina	Script, sequence not significant	Looks, control
	Laura	Script, sequence not significant	Looks, control
	Natalia	Script, sequence not significant	Looks, control

Table 3. Description of activities participants engaged in and commands they used, by development group (participants who attended more than six project sessions)

Development	Participants	Activities	Commands
Higher	Adriana	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Alma	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Luna	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Paulina	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion
	Martha	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion
Medium	Katia	Script, sequence not significant; script, sequence significant; additional scripts	Looks, sound, control
	Rebecca	Script, sequence not significant; script, sequence significant; additional scripts	Looks, sound, motion
	Jacqueline	Script, sequence not significant; script, sequence significant	Looks, sound, motion, control
	Alexandra	Script, sequence not significant; script, sequence significant	Looks, motion, control
	Natalia	Script, sequence not significant;	Looks, control

Table 4. Description of activities participants engaged in and commands they used, by development group (data from the first six project sessions each participant attended)

Development	Participants	Activities	Commands
Higher	Adriana	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Alma	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Luna	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion, control
	Paulina	Script, sequence not significant; script, sequence significant; additional scripts; introduction	Looks, sound, motion
Medium	Katia	Script, sequence not significant; script, sequence significant; additional scripts	Looks, sound, control
	Martha	Script, sequence not significant; script, sequence significant; introduction	Looks, motion
	Thalia	Script, sequence not significant; script, sequence significant; introduction	Sound, motion
	Alexandra	Script, sequence not significant; script, sequence significant;	Looks, motion, control
	Rebecca	Script, sequence not significant; script, sequence significant;	Looks, motion
Lower	Gloria	Script, sequence not significant	Looks, sound, control
	Jacqueline	Script, sequence not significant	Looks, control
	Cristina	Script, sequence not significant	Looks, control
	Laura	Script, sequence not significant	Looks, control
	Natalia	Script, sequence not significant	Looks

Appendix E — Self-Concept Groups

Table 10. Groups used during analysis of the characteristics of the learning environment, including participants who were placed in each one

Change	Group	Score (before workshop)	Participants
Positive	A	Above Average	Paulina
		Below Average	Rebecca Gloria Katia
No Change	B	Above Average	Luna Alexandra Cristina
	C	Below Average	Laura Martha Adriana Alma
Negative	D	Above Average	Natalia Thalia Jacqueline
	N/A	Below Average	No participants

Table 11. Percentage of sessions each participant attended and engaged in the programming aspect of her project

Participant	Pre Score	Percentage of Sessions	Change
Martha	B	88%	
Paulina	A	80%	Pos
Alma	B	67%	
Thalia	A	67%	Neg
Adriana	B	67%	
Luna	A	66%	
Alexandra	A	55%	
Katia	B	55%	Pos
Jacqueline	A	50%	Neg
Rebecca	B	50%	Pos
Laura	B	43%	
Cristina	A	33%	
Natalia	A	30%	Neg
Gloria	B	17%	Pos

Appendix F — Contingency Tables and Analyses

Self-Concept score (Pre) and Technological Fluency level: Participants who attended at least 8 to 9 sessions (n = 10)

Table 12. Number of participants who scored below or above average in the self-concept measure before the workshop and attained a Technological Fluency level of 1, 2, or 3 after attending 8 to 9 sessions.

Self-Concept Score (Pre)	**Technological Fluency Level**		
	1	**2**	**3**
Below Avg.	*N/A*	2	3
Above Avg.	*N/A*	3	2

Calculation of number of concordant and discordant pairs.

	1	2	3
Below Avg.	N/A	2	
Above Avg.			2

Concordant Pairs = 2(2) = 4

	1	2	3
Below Avg.			3
Above Avg.	N/A	3	

Discordant Pairs = 3(3) = 9

Self-Concept score (Pre) and Technological Fluency level: Participants who attended at least 5 to 6 sessions (n = 14)

Table 13. Number of participants who scored below or above average in the self-concept measure before the workshop and attained a Technological Fluency level of 1, 2, or 3 after attending 5 to 6 sessions

Self-Concept	**Technological Fluency Level**		
Score (Pre)	**1**	**2**	**3**
Below Avg.	2	3	2
Above Avg.	3	2	2

Calculation of number of concordant pairs.

	1	2	3
Below Avg.	2		
Above Avg.		2	2

	1	2	3
Below Avg.		3	
Above Avg.			2

Concordant Pairs = 2(2+2) + 3(2) = 14

Calculation of number of discordant pairs.

	1	2	3
Below Avg.			2
Above Avg.	3	2	

	1	2	3
Below Avg.		3	
Above Avg.	3		

Discordant Pairs = 2(3+2) + 3(3) = 19

Technological Fluency Level and Change in Self-Concept Score: **Participants who scored below average in the self-concept measure administered before the workshop and attended at least 8 to 9 sessions (n = 5)**

Table 14. Number of participants who attained a Technological Fluency level of 1, 2, or 3 after attending 8 to 9 sessions and showed negative change, no change, or positive change in self-concept

Technological Fluency Level	**Change in Self-Concept**		
	Negative	**No Change**	**Positive**
1	*N/A*	*N/A*	*N/A*
2	0	0	2
3	0	3	0

Calculation of number of concordant pairs.

	Neg	NC	Pos
1	N/A		
2	0		
3		3	0

	Neg	NC	Pos
1		N/A	
2		0	
3			0

Concordant Pairs = 0(3+0) + 0(0) = 0

Calculation of number of discordant pairs.

	Neg	NC	Pos
1			N/A
2			2
3	0	3	

	Neg	NC	Pos
1		N/A	
2		0	
3	0		

Discordant Pairs = 2(0+3) + 0(0) = 6

Technological Fluency Level and Change in Self-Concept Score: **Participants who scored below average in the self-concept measure administered before the workshop and attended at least 6 to 5 sessions (n = 7)**

Table 15. Number of participants who attained a Technological Fluency level of 1, 2, or 3 after attending 5 to 6 sessions and showed negative change, no change, or positive change in self-concept

Technological Fluency Level	**Change in Self-Concept**		
	Negative	**No Change**	**Positive**
1	0	1	1
2	0	0	2
3	0	3	0

Calculation of number of concordant pairs.

	Neg	NC	Pos
1	0		
2		0	2
3		3	0

	Neg	NC	Pos
1			
2	0		
3		3	0

	Neg	NC	Pos
1		1	
2			2
3			0

	Neg	NC	Pos
1			
2		0	
3			0

Concordant Pairs = 0(0+2+3+0) + 0(3+0) + 1(2+0) + 0(0) = 2

Calculation of number of discordant pairs.

	Neg	NC	Pos
1			1
2	0	0	
3	0	3	

	Neg	NC	Pos
1			
2			2
3	0	3	

	Neg	NC	Pos
1		1	
2	0		
3	0		

	Neg	NC	Pos
1			
2		0	
3	0		

Discordant Pairs = 1(0+0+0+3) + 2(0+3) + 1(0+0) +0(0)= 9

Technological Fluency Level and Change in Self-Concept Score Participants who scored above average in the self-concept measure administered before the workshop and attended at least 8 to 9 sessions (n = 5)

Table 16. Number of participants who scored above average in the self-concept measure before the workshop, attained a Technological Fluency level of 1, 2, or 3 after attending 8 to 9 sessions, and showed negative change, no change, or positive change in self-concept

Technological Fluency Level	Change in Self-Concept		
	Negative	No Change	Positive
1	*N/A*	*N/A*	*N/A*
2	2	1	0
3	0	1	1

Calculation of number of concordant pairs.

	Neg	NC	Pos
1	N/A		
2	2		
3		1	1

	Neg	NC	Pos
1		N/A	
2		1	
3			1

Concordant Pairs = 2(1+1)+ 1(1) = 5

Calculation of number of discordant pairs.

	Neg	NC	Pos
1			N/A
2			0
3	0	1	

	Neg	NC	Pos
1		N/A	
2		1	
3	0		

Discordant Pairs = 0(0+1) + 1(0) = 0

Technological Fluency Level and Change in Self-Concept Score: **Participants who scored above average in the self-concept measure administered before the workshop and attended at least 5 to 6 sessions (n = 7)**

Table 17. Number of participants who scored above average in the self-concept measure before the workshop, attained a Technological Fluency level of 1, 2, or 3 after attending 5 to 6 sessions, and showed negative change, no change, or positive change in self-concept

Technological Fluency Level	**Change in Self-Concept** **Negative**	 **No Change**	 **Positive**
1	1	1	0
2	2	1	0
3	0	1	1

Calculation of number of concordant pairs.

	Neg	NC	Pos
1	1		
2		1	0
3		1	1

	Neg	NC	Pos
1			
2	2		
3		1	1

	Neg	NC	Pos
1		1	
2			0
3			1

	Neg	NC	Pos
1			
2		1	
3			1

Concordant Pairs = 1(1+0+1+1) + 2(1+1) + 1(0+1) + 1(1) = 9

Calculation of number of discordant pairs.

	Neg	NC	Pos
1			0
2	2	1	
3	0	1	

	Neg	NC	Pos
1			
2			0
3	0	1	

	Neg	NC	Pos
1		1	
2	2		
3	0		

	Neg	NC	Pos
1			
2		1	
3	0		

Discordant Pairs = 0(2+1+0+1) +0(0+1) +1(2+0) + 1(0) = 2

Level of Technological Fluency attained and Post Self-Concept score: Participants who scored below average in the self-concept measure administered after the workshop and attended at least 8 to 9 sessions (n = 5)

Table 18. Number of participants who scored below average in the self-concept measure before the workshop, attained a Technological Fluency level of 1, 2, or 3 after attending 8 to 9 sessions, and showed negative change, no change, or positive change in self-concept

Technological Fluency Level	**Self Concept Score (Post)**	
	Below	**Above**
1	N/A	N/A
2	0	2
3	3	0

Calculation of number of concordant and discordant pairs.

	Below	Above
1	N/A	
2	0	
3		0

Concordant Pairs = 0(0) = 0

	Below	Above
1		N/A
2		2
3	3	

Discordant Pairs = 2(3) = 6

Level of Technological Fluency attained and Post Self-Concept score: Participants who scored below average in the self-concept measure administered before the workshop and attended at least 5 to 6 sessions (n = 7)

Table 19. Number of participants who scored below average in the self-concept measure before the workshop, attained a Technological Fluency level of 1, 2, or 3 after attending 5 to 6 sessions, and showed negative change, no change, or positive change in self-concept

Technological Fluency Level	**Self Concept Score (Post)** Below	Above
1	1	1
2	0	1
3	3	1

Calculation of number of concordant pairs.

	Below	Above
1	1	
2		1
3		1

	Below	Above
1		
2	0	
3		1

Concordant Pairs = 1(1+1) + 0(1) = 2

Calculation of number of discordant pairs.

	Below	Above
1		1
2	0	
3	3	

	Below	Above
1		
2		1
3	3	

Discordant Pairs = 1(0+3) + 1(3) = 6

Level of Technological Fluency attained and Post Self-Concept score: Participants who scored above average in the self-concept measure administered before the workshop and attended at least 8 to 9 sessions (n = 5)

Table 20. Number of participants who scored above average in the self-concept measure before the workshop, attained a Technological Fluency level of 1, 2, or 3 after attending 8 to 9 sessions, and scored below or above average in the self-concept measure after the workshop

Technological Fluency Level	**Self Concept Score (Post)** Below	Above
1	N/A	N/A
2	2	1
3	0	2

Calculation of number of concordant pairs.

	Below	Above
1	N/A	
2	2	
3		2

Concordant Pairs = 2(2) = 4

	Below	Above
1		N/A
2		1
3	0	

Discordant Pairs = 1(0) = 0

Level of Technological Fluency attained and Post Self-Concept score: Participants who scored above average in the self-concept measure administered before the workshop and attended at least 5 to 6 sessions (n = 7)

Table 21. Number of participants who scored above average in the self-concept measure before the workshop, attained a Technological Fluency level of 1, 2, or 3 after attending 5 to 6 sessions, and scored below or above average in the self-concept measure after the workshop

Technological Fluency Level	**Self Concept Score (Post)**	
	Below	**Above**
1	2	1
2	2	1
3	0	2

Calculation of number of concordant pairs.

	Below	Above
1	2	
2		1
3		2

	Below	Above
1		
2	2	
3		2

Concordant Pairs = 2(1+2) + 2(2) = 10

Calculation of number of discordant pairs.

	Below	Above
1		1
2	2	
3	0	

	Below	Above
1		
2		1
3	0	

Discordant Pairs = 1(2+0) + 1(0) = 2

Appendix G — Participants Features and Response (Selected)

Table 23. Participants' features and responses about their projects, separated by level of Technological Fluency attained from highest (top) to lowest (bottom), only those who scored below average before the workshop

Participant	Features		Project	
	Change in Self-Concept	Added Value	Inspiration	Evaluation
Adriana	No Change	Previous relationship with instructor Workshop conflicted with cheerleading practice	Instructor's project	Too simple (compared to others)
Martha	No Change	Previous relationship with instructor	What I liked	Ok
Alma	No Change	Used Scratch outside of workshop	What I liked	Ok for beginner
Katia	Positive	Emerging relationship with instructor	What I liked	Cool
Rebecca	Positive	Emerging relationship with instructor Used Scratch outside of workshop	Website	Sucked because not enough effort
Gloria	Positive	Previous relationship with instructor	What I liked	Cool
Laura	No Change	Workshop conflicted with homework time	What I liked	Cool

Table 24. Participants' features and responses about their projects, separated by level of Technological Fluency attained from highest (top) to lowest (bottom), only those who scored above average before the workshop

Participant	Features		Project	
	Change in Self-Concept	Added Value Characteristics	Project Inspiration	Project Evaluation
Paulina	Positive	Emerging relationship with instructor	Instructor's project	Good but not as good as others
Luna	No Change	Previous interest No friends	What I liked	WOW!
Alexandra	No Change	Best friend was Rebecca	Friend's project	Ok but not enough effort
Jacqueline	Negative	Previous relationship with instructor Workshop conflicted with cheerleading practice	Website	Cheated some but better than others
Thalia	Negative	Problem with friends	What I liked	Sucked (not enough effort)
Natalia	Negative	Best friend was Paulina	Instructor's project	Cool
Cristina	No Change	No friends	Friend's project	Ok (compared to others)

Table 25. Participants' features and responses about their attendance and learning, separated by level of Technological Fluency attained from highest (top) to lowest (bottom), only those who scored below average before the workshop

Participant	Features		Responses	
	Change in Self-Concept	Attendance (Prj. Sessions)	Why Attend	Why Learn More
Adriana	No Change	9	Learn more and have fun	To not struggle
Martha	No Change	9	Interesting	To not ask for help as much
Alma	No Change	9	Have fun and dared by male staff member	To not break something
Katia	Positive	9	Interesting	To help others
Rebecca	Positive	10	Learn more	Use computers better
Gloria	Positive	6	Have fun	To teach others
Laura	No Change	7	Interesting	Computers are interesting

Table 26. Participants' features and responses about their attendance and learning, separated by level of Technological Fluency attained from highest (top) to lowest (bottom), only those who scored above average before the workshop

Participant	Features		Responses	
	Change in Self-Concept	Attendance (Prj. Sessions)	Why Attend	Why Learn More
Paulina	Positive	10	Learn more	Use computers better, help my family
Luna	No Change	9	Learn more	Better jobs
Alexandra	No Change	10	Interesting	To help others
Jacqueline	Negative	8	Learn more and have fun	Help my family
Thalia	Negative	6	Learn more	Use computers better
Natalia	Negative	10	Have fun	Interesting
Cristina	No Change	6	Learn more, interesting	Use computers better

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