(UN)CONFIDENT CODERS: WHAT GENDER DYNAMICS APPEAR WHEN CANADIAN CHILDREN LEARN HOW TO CODE?

MICHELLE L. ALI

Supervisor: Dr. Jennifer Jenson

Supervisor's Signature: _ 

A Research Paper submitted to the Graduate Program in Education
in partial fulfillment of the requirements
for the degree of
Master of Education

Graduate Program in Education
York University
Toronto, Ontario

September 2015

ABSTRACT

This paper reports on a mixed-methods study that examined the gender dynamics that could be observed when Canadian boys and girls learn to code in a formal classroom environment. The study involved sixty-four, sixth grade students in a suburban Toronto District School Board school who were taught basic computer programming skills using a curriculum developed by the PLAYCES lab at York University. The results showed that in all three classes, although the boys displayed more confident behaviours (e.g. willing to take risks while working, trouble shooing, persisting in the face of challenges etc.) than the girls, there were a few distinct situations in which the girls displayed a strong sense of confidence. The girl's behaviours were analyzed and linked to social contexts and social expectations.

Keywords: computer programming (coding); gender; children; confidence; Canada

(Un)Confident Coders:

What Gender Dynamics Appear When Canadian Children Learn How to Code?

Introduction

Teaching computer programming (coding) to 21st century students is an increasingly important, though under-researched, area of inquiry. The idea of formally and systematically teaching programming to children (which saw its ‘hay day’ in the 1980s) is at present making a notable resurgence within discourse surrounding education in technologically-“advanced” countries around the world. With the existence of a technology-enamoured society and an emerging DIY youth subculture engaged in coding, learning how to program is seen as a highly marketable and desirable 21st century digital skill (Richtel, 2014; Partnership for 21st Century Skills, n.d). Not surprisingly learning how to code has become a popular, trendy topic in education, catching the attention of curriculum developers and educators in many different countries, namely the United States and Europe. Accordingly, countries such as Estonia (Olson, 2012) and England (England’s Department of Education, 2013; Gardiner, 2014), have already mandated coding as a part of their official school curriculum. In Canada’s formal educational system, although optional computer programming courses are sporadically offered at the secondary level, coding is not a part of the official curriculum for any grade. Despite this, across the country schools of various age levels are slowly starting to show an interest in finding ways to include learning how to code in the classroom (Oliveira, 2014; Canadian Broadcasting Corporation, 2015). Unfortunately, this is happening without the support of research-based curricula or aids. To support the efforts of teachers and schools who are incorporating code into the classroom, as well as to meet and exceed international standards in this area, research is needed to understand what environments and supports are needed in order for children to learn code.

Within this aim, one area of emergent concern is understanding, addressing, and combatting gender-related issues that arise when girls and boys learn how to code together. It is commonly known that there is a stark imbalance between the number of women and men who enter into and remain in the Computer Science and Engineering (CSE) field, of which coding is a part of. Research has shown that gender related issues, such as battling confidence (Dreves & Jovanovic, 1998; Cohoon & Aspray, 2006), appropriating social norms that sustain stereotypes (Cooper, 2006), as well as the effects of negative home and school environments (Margolis & Fisher, 2002) predispose girls to perceive themselves as incapable of excelling with computers as early as the elementary school years.

Currently, not only does Canada lack systematic coding curricula, it also lacks a substantial body of academic work that studies the gender dynamics that can be observed when children learn to code, even though research surrounding learning code is a growing area of study in other countries such as, the United States and in the United Kingdom (Wilson, Connolly, Hainey, & Moffat, 2011; Pea & Kurland, 1984; Wilson & Moffatt, 2010 etc.). Research is needed to understand what happens when Canadian children learn to code in formal environments in order to adequately support girls and to close the gender gap in CSE. Consequently, the main questions addressed in this Master's Major Research Paper are: *How do Canadian children learn how to code? What gender dynamics are observed as Canadian children learn how to code?*

Personal Relevance

As a Media Literacy teacher in Ontario, I focused my curriculum on teaching my Grade 1-8 students how to critically think about and produce media texts. Within the context of the official Media Literacy strand of the Language Arts curriculum, I focused each unit on media theory, critical analysis of common media texts, and the production process of media text creation. Not surprisingly, the section that comprised the greatest part of each term and engaged the students' interest the most was Production. In this component, students completed a variety of media texts involving web-based programs such as Prezi and GlogsterEDU. These programs allowed them to gain 'hands-on' experience with diverse computer technologies, in which they learned how to present information in a multimedia fashion while learning computing skills, such as composing and arranging texts, images, and videos in both aesthetically purposeful and informative ways.

Although these skills are important because they are useful to develop as members of an increasingly technologically-mediated world, one glaring limitation caught my attention: even though I was teaching my students the valuable skills of clear and appealing visual communication, the means of achieving this goal were limited to working within the context, restraints, and aesthetics of existing software and templates, all of which are products sold by commercial companies, who require ad hoc subscriptions and costs. Thus, my students were not independent creators who could communicate digitally on their own terms. As a result, I found myself wondering if my students were learning to be 'media literate' or simply to be media users. I was also concerned that I was unknowingly propagating commercialism by my choice of educational programs. I also found myself questioning what I should teach my students to empower them to be independent creators and wondering what they would be capable of, if they were not restricted by templates and pre-determined software. These questions led me, unexpectedly, to the world of computer programming, also known as, ‘coding’, the building block of software engineering that uses control algorithms and formulas to create the structure, function, and aesthetics of any computer-based program, as a possible research focus, as it provides an avenue for students to create at the scripting-level without the restraints of predetermined programs. Having some constructional understanding of the underlying codes and scripts of the technological programs students use, gives them the agency to grow from consumers to creators. Moreover, females, should not be excluded from these central coding practices as they are forms of cultural and social literary power.

Overview

I begin this paper with a Literature Review that discusses how the gender divide is addressed through a constructionist learning paradigm (Papert, 1980), the main theory of learning that presently informs practical, pedagogical approaches to teaching programming to children. This is followed by an explanation of the methodology employed in this study, where I outline the demographics of the participants involved, the program and curriculum used, the evolution of the research questions, the data collection methods, and perspective in which the data is analyzed. Subsequently, a description of the findings of the research is presented which focuses on the gender dynamics that were evident in participation and demonstrations of confidence with coding. The analysis focuses on three profiles of the types of student that were observed in this study.

Literature Review

Overview of literature review

This literature review provides a brief description of the North American research that has studied the various gender dynamics that emerge when middle school boys and girls are taught how to program computers through a constructionist learning paradigm. The literature review begins by describing the CSE gender gap in Canada. This is followed by a description of the role confidence, (a sense of self-efficacy relating to one's self-perception of capacity to be successful at computer programming,) plays in the gender gap during the middle school years as children, particularly girls, learn to program. This is followed by a description of the core voices of constructionism where learning happens through the process of production which came forth from the foundation laid by Seymour Papert in the 1980s as well as an explanation of how they address the gender gap.

The gender gap in Canada

There is an established body of work that studies the gender gap in the Science, Technology, Engineering and Mathematic (STEM) fields of which CSE is a part of. It is commonly known that there is a stark imbalance between the number of women and men who enter into and remain in the CSE field. At the university level, women are statistically less likely to enrol and graduate in CSE. According to Statistics Canada (2011), of the 33,219 students enrolled in Mathematics, Computer, and Information Sciences, only 9,075 (27%) were women. Another study conducted by Statistics Canada found that according to the 2011 Canadian National Household Survey "women represent the majority of young university graduates, but are still underrepresented in STEM fields" (Hango, 2013). The gender gap also persists in the workforce. A recent report from the Natural Sciences and Engineering Research Council of Canada Chairs for Women in Science found that even though women comprise approximately half (48%) of the Canadian labour force, they make up less than a quarter (22%) of the professional STEM population (Franz-Odendaal, Mavriplis & Farenhorst, n.d.). The gender divide persists in Canada's digital game development industry. According to a 2013 report released by the Entertainment Software Association of Canada (2013), women comprised a mere 16% of the video game industry workforce in 2012; these women mostly work within the business and administrative departments (25% of the workforce) and work least within technical jobs (5% of the workforce).

The gender divide at middle school

The middle school period can often be the time when young females make decisions about future careers in CSE (American Association of University Women Educational Foundation, 1996). Whereas boys are described as having an early passionate, magnetic attraction to computers, not only enjoying using computers but also appreciating having the independence to tinker and explore (Margolis & Fisher, 2002), research has shown that these years may also be a time when girls "begin to lose confidence in their ability to learn Science" (Dreves & Jovanovic, 1998 as cited in Cabonaro et al, 2010). Kessels (2005) also found that middle school can be a time when girls are effected negatively by technology-related gender stereotypes, for example the perception or belief that girls are "not interested" in technology, nor even capable of succeeding in the Computer Sciences. Cohoon & Aspray (2006) suggest this decline can, in part, come from girls having a general negative outlook towards computers as well as come from a lack of confidence using computers, particularly with software and hardware tools.

The gender divide at middle school and beyond: The role of confidence

Confidence defined as a sense of self-efficacy relating to one's self-perception of capacity to be successful at computer programming, plays a significant role in how middle school girls relate to CSE at adolescence and beyond. According to the American Psychological Association, self-efficacy "refers to an individual's belief in his or her capacity to execute behaviours necessary to produce specific performance attainments" (Bandura,1977, 1986, 1997). Research on gender differences in Mathematics and Science (Seymour and Hewitt, 1997) has shown that self-efficacy plays a much more significant role than ability. A 2003 study on the digital divide in Canadian schools (Looker & Thiessen, 2003) found that the main difference in female and male ICT use (which identified computer programming specifically) is that males are "more confident and competent at using computers than the young women" (p.10). This disparity in confidence is reflected in the ways girls and boys engage in the classroom as boys can tend to aggressively dominate the computer spaces in the classroom. Observations made in a Kingston, Ontario middle school (Kosh, 1995) showed that girls did not use the computers because "boys always get there first… the same boys all the time" (p. 6). Cooper and Weaver (2003) also found that girls often ascribe to themselves a personal lack of ability as the reason for failure when working with computers. Research at the university level (Sax, 1994) showed that, while self-efficacy decreases for both genders during the requisite time it demands to obtain a computer science degree, there is a much steeper drop in women's confidence than in men's. In their influential book, *Unlocking the Clubhouse: Women in Computer Science,* Margolis and Fisher (2002) found that one of the main reasons women drop out of Computer Science in post-secondary education is due to a lack of confidence, particularly in their ability to problem solve.

A root cause of the gender divide: Socialization

There are many factors that cause these dispositions to be ascribed by girls. One significant factor is the socialization of both genders into stereotypical gender roles based on the belief that computers and computing are seen as men's territory. As a result, adults will praise and encourage boys' interest in computers much more than girls'. For example, at home, one of the most powerful socialization environments, Margolis and Fisher (2002) found that most of the male Computer Science undergraduate students they interviewed about their childhood experiences with computers, were tutored and encouraged to play with computers (notably by a close male figure), whereas the girls were often ignored. Similarly, at school, teachers can perpetuate gender-based stereotypes which also contributes to girls developing negative affinities towards computers. Cohoon & Aspray (2006) cite several studies (Li, 1999; American Association of University Women, 1998) that found that when it comes to Math and Science, "teachers make more eye contact with and interact more with boys than with girls; they also encourage boys more than they do girls" (p. 21).

Theories of Learning

Core Voices of Constructionism

One of the most prominent approaches to teaching computer programming to children is a theory of learning called constructionism. In a constructionist approach, students learn through a self-directed experiential process, typically through the creation of a product – be it a software program or a technological artifact. Epistemologically, constructionism it is based on Piagetian ideas of cognitive development in which children build their own mental learning structures as they interact with increasingly complex challenges in the external world. The teacher's role is to act as a facilitator who scaffolds students' understanding and development. Constructionism was, in fact, developed by one of Piaget's students, MIT professor Seymour Papert. Papert is largely accredited for laying the foundation for constructionism as a learning paradigm and also is recognized for developing the constructionist approach to computer programming education. In this approach to learning computer programming, presented in his foundational book, *Mindstorms* (1980), children develop an artifact (usually in the form of a program or game) and learn through engaged problem solving and hands-on creative design, in the context of a learning community.

Constructionism and the Gender Divide

Early on, when researching and enacting constructionist pedagogies, investigating gender differences was not a focal point, as the more general aim was for every student to successfully learn programming. This is evidenced in the early work of Yasmin Kafai, Papert's colleague, and proponent of constructionist pedagogy who took the reigns of constructionism research from Papert at MIT.[1] In her book, *Minds in Play*, Kafai (1995) only dedicates a five paragraph section to matters of gender. Here, she pragmatically describes gender differences, such as in the types of feedback a player receives if they make a wrong choice in the game. In addition, the book includes three case studies, one of which is about a girl, Amy, who is described as being a self-assured and competent programmer.

---

[1] Yasmin Kafai is he former International Society of the Learning Sciences (ISLS) president, an executive editor of the Journal of the Learning Sciences, the current Professor of Learning Sciences at the University of Pennsylvania Graduate School of Education,

Subsequent research by Kafai addresses issues of gender, though, once again, only superficially. In *Constructionism in Practice* (1996), a chapter is dedicated to examining the gender-related differences in game construction as a part of the Game Design Project. In this book, just as in *Minds in Play*, Kafai merely describes the thematic gender differences observed in the students' games, even though these differences, such as those involving violence, are worthy of unpacking, though with more detailed and granular attention to wider social, cultural and media contexts. *Connected Code: Why Children Need to Learn Programming* (2014) also discusses the gender divide, but when this occurs, it is usually included to demonstrate the need for educational reform more generally. For example, although the gender divide in programming is specifically addressed in the introductory chapter as "represent[ing] another significant hurdle in computational participation", it is seen as a much smaller issue in comparison to the need to create an educational ethos of "quality" technology education in mainstream schools. (p.11).

Even though most research by Papert's disciples simply glances at gender issues, combatting the gender divide is increasingly becoming a part of their conversation. For example, chapter 11 of *The Computer Clubhouse* (2009) describes some of the efforts Kafai has made to combat the gender divide, such as an initiative by the *Computer Clubhouse Network* entitled, Hearing Our Voices (HOV), created in response to a realization that there was a lack of participation by girls and young women in the Computer Clubhouses. HOV was designed "to connect girls more deeply to technology… [by] striv[ing] to make girls' voices heard, both literally and through their projects" (p.126). These efforts saw some success as after 7 months in the program, the girls willingness to try increasingly sophisticated programming activities rose from 10% to 20%. Additionally, *Beyond Barbie and Mortal Combat: New Perspectives on*

Gender and Gaming (2008), of which Kafai is an editor and an author, focuses entirely on gender issues by providing snapshots of research being conducted to understand and combat the gender divide.

Beyond Barbie is a part of a body of research within the general constructionist paradigm that focuses on combatting the gender divide by trying to understand and support girls as they learn to program. Like the HOV project, this body of research, often done in all-girl settings, has provided an opportunity to observe girls' strengths and abilities, rather than their weaknesses, while at the same time challenging stereotypes of girls in the Computer Sciences. For example, although Brunner, Bennett, and Honey (1998) found that girls often create games where they help others, only 15% of the girls' games in Denner and Campe's (2008) study helped others, despite the fact that leaders encouraged the girls to do so. Additionally, a study by Denner and Werner (2007) showed that girls are capable of being competent, confident programmers who are able to persist in the face of problems and challenges they encounter while creating video games.

Computational thinking

Another influential theoretical approach to learning to program computers which is somewhat influenced by and built upon similar ideas to constructionism, was put forth by Jeannette M. Wing, the President's Professor of Computer Science and head of the Computer Science Department at Carnegie Mellon University. Wing's 2006 paper describes computational thinking (CT) as a mindset like that of a computer scientist which involves: "solving problems, designing systems, and understanding human behaviour, by drawing on the concepts fundamental to computer science" (p. 33). A key component of computational thinking is the skill of abstraction, the ability to break down a complex task into smaller, manageable components. Wing and others argue that computational thinking is just as vital to a child's education as the traditional 3Rs (reading, writing, and arithmetic) and signifies an approach to critical problem solving that is not limited to working with computers or (rote) programming.

Computational thinking is not a new idea, having been around for decades in conversations on educational technology (Papert, 1980, 1991; Kay & Goldberg, 1977, diSessa, 2000) before it was articulated by Wing in 2006. There have been quite a few definitions of CT that have emerged since Wing's 2006 article (Aho, 2012; Royal Society, 2012; National Science Foundation) including an updated version by Wing herself (2011) which defines CT more specifically as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" (p.1). Although one of the criticisms of CT is lack of clear boundaries and parameters as a discipline, in a 2013 review of literature on the discourse of CT, Pea and Grover (2013) identify nine "widely accepted" core concepts of CT:

1. Abstractions and pattern generalizations (including models and simulations)
2. Systematic processing of information
3. Symbol systems and representations
4. Algorithmic notions of flow of control
5. Structured problem decomposition (modularizing)
6. Iterative, recursive, and parallel thinking
7. Conditional logic
8. Efficiency and performance constraints
9. Debugging and systematic error detection (p. 39)

In *Connected Code*, Kafai's fundamental premise is that computational thinking should be expanded to encompass a more community-based paradigm, one she calls "computational participation", in which the social context and learning environment (rather than the discrete learning outcome) are the primary variables that support the learning and mastery of computational practices.

Computational Thinking and the Gender Divide

Closing the gender divide in the Computer Science realm has been a topic of discussion in the discourse on computational thinking (Margolis & Fisher, 2002; Cooper & Cunningham, 2010). A prevalent point of discussion is unearthing the ideal types of environments and tools to engage girls in Computer Science. Some examples of this include providing "low floor, high ceiling" environments, using programs considered to be more gender-neutral, such as the MIT App Inventor or "E-textile" kits, such as the Lilypad Arduino, where students "combine traditional arts and crafts, such as sewing and sketching with computation and electronics" (Pea & Grover, 2013). Other examples include working collaboratively in pairs (Hughes, 2005) and building self-confidence with less traditionally male-coded tools, environments and contexts.

Methodology

The research project

This research project took the form of an ethnographic case study of an extracurricular coding program for three sixth grade classes in a highly immigrant populated suburban Toronto District School Board elementary school, where students were introduced to coding by creating simple video games, using the program "Game Maker" in same-gender pairs which were assigned by each classes' respective teachers. This program, entitled*,* Think Design Play (TDP), ran over a six-day schedule, five of which took place in the students' classrooms during ninety minute sessions. The sixth day was a full day that took place in the Technology Enhanced Learning Building at York University's Keele campus, where students learned more advanced programming tasks, finished their games and were served a complementary pizza lunch. The game development program was created to introduce students to the basics of computer programming, drawing upon a constructionist learning framework, with the overarching purpose of inspiring confidence and an interest in coding through making games. TDP was connected to the PLAYCES Lab at York University and involved approximately eight facilitators who worked on a rotational schedule.

Research questions

Initially, the research questions for this project focused quite generally on students capacity for computation thinking and, in turn, understanding the impact of being introduced to hands on, to programming, in ‘maker’ contexts. My initial the questions were: *How do Canadian children learn how to code? Do children creatively code or do they simply ‘cut and paste’ algorithms? Is coding empowering for children?* However, once the research began, I found it was very difficult to address these questions with feasible data collection techniques. First, it seemed nearly impossible to observe cognitive processes through ethnographic field notes, and I realized that I needed to find a method that might more reliably collect data, and account for what was transpiring at the level of human-computer and social interaction. Secondly, it would be very difficult to measure and discern the impact the program might have on students, particularly given the relatively short duration of the project. Obtaining these aims and theorizing impact would require research to be conducted after the program was complete. As a result, my focus shifted to gender dynamics. The limitations in my original research plan actually opened up, fortuitously, important and fruitful orientations to what was happening in the classroom in terms of gender dynamics. For this topic, I focused on these questions: *What programming competencies do Canadian children display? What do they (un)successfully do? What differences are observed between girls and boys in programming contexts?* I made one final modification to narrow the focus to a manageable scope in which I specifically focused on the gender differences in *confidence*. The answers to these more specific questions emerged as the focal point of my final analysis. These questions were: *How do Canadian children learn how to code? What gender dynamics are observed as Canadian children learn how to code? Who has greater confidence, girls or boys?* These modifications emerged as result of critical conversations with seasoned researchers (a PhD student and another researcher who both managed the project) who had more experience than myself in the area of gender and technology.

The curriculum

The curriculum was developed over two months by the PhD student in conversation with a team of facilitators who led the program in the school. This was a team of video game developers and a student teacher who worked with the PLAYCES Lab for a number of years, running coding summer camps as well as other research projects in previous years. Although the curriculum underwent some significant changes after the first session, the final version (employed in the last two classes) involved lessons that included exercises and tutorials that students would follow along with on their laptops to develop an Atari-like breakout game, followed by time to work on developing their own original games. Through the curriculum, students were taught basic software skills such as saving, locating and loading project files as well as code-specific skills such as creating assigning and placing sprites, objects, and rooms within the game. Students were taught how to create events (e.g. creating a ball that has direction and speed and is able to bounce off other objects, collisions between objects etc.), use various variables, functions, and conditional statements. Students were given folders that contained handouts with pieces of commonly used code and concepts such as the Cartesian coordinate systems for programming that students could use as a reference as they worked.

Qualitative data collection methods

Ethnographic observation

Ethnographic field note observation was the primary data collection technique. It was also the method that changed the least from the planning to execution. During the first session, I wrote my notes by hand and transcribed them on the computer later on, as I used my laptop as a video camera to record the sessions. However, during the second and third sessions, I typed my notes directly onto my laptop. I took notes on the sights, sounds, smells, and overall feeling of the classroom including the social interactions I observed between students, between students and facilitators, students and their computers, within and between social groups, as well as, conversations that I intentionally had with students,. I had initially thought that there would be time carved out for all the facilitators to share their observations with me, though that did not occur as regularly as I expected.

Observation techniques: Non-participant to participant

The data collection techniques that were actually used were slightly different than the ones that were planned. Initially, I planned to use the qualitative data collection techniques (Hammersely & Atkinson, 1995) of non-participant observation. In reality, instead of using non-participant observation, participant observation was employed. I did not plan on being directly involved in the activities of the program. I anticipated that I would help with set-up and to offer support to the facilitators, but I did not think I would be needed to support the students as much as I did, for example, answering students' programming questions. Because of this, I interacted with the students more than originally expected and I became directly involved in the program's activities which ultimately provided me with more nuanced and granular data.

Interviews and digital artefacts

I also planned to conduct semi-structured and structured interviews of the children involved in the program. The purpose of the interviews was to understand students' feelings, thoughts, and experiences of learning how to code in the program and these interviews were supposed to be audio-recorded. In reality, when interacting with the students, I found myself asking questions to gauge their programming proficiency as well as propensity to take initiative to independently problem solve. Consequently, the "interviews" took the form of ethnographically-recorded "on the fly" sound bites of short, intentional interactions with students. This is because I did not anticipate how demanding supporting the facilitators would be, as well as being a bit overwhelmed by the complexity and contingency of school-based research. For these reasons, I was unable to carve out time to interview students. I also planned to collect photographs of the students' project as it progressed. Although I was able to take photographs of the students and their work, I did not consistently take progressive photos of the students' work as their games were developed.

Quantitative data collection methods

Although I had planned to only collect qualitative data, I ended-up using quantitative data as well. I used four questions from the Media Use Survey, as well as used a system for tallying the students' participation in class lessons, which I created as part of the quantitative analysis.

The participation tally

The participation tally was an unplanned addition to the data collection techniques. In fact, I decided to perform the tally two days into the first class of the program when I thought it would be helpful to get a sense of how the students participated by gender. I did this by creating a seating plan for the class labelled with students' names in which I put a tally mark every time I saw a student put their hand-up to participate in the lesson portion of the day in response to prompts and questions posed by the facilitator who was teaching. I also made a note of: "A" if the student was called upon to answer by the facilitator who was teaching and "H" if I noticed a student helped another. These two tallies were not used in the analysis; because I did not consistently observe these actions, they are not an accurate indication of these incidences. Although I wasn't able to record every time each student put their hand-up, nor was I able to know what each student put their hand-up in response to, it was helpful in getting a sense of how each gender as a whole participated in class. Students' participation scores were calculated by adding each tally that indicated a hand was raised and for each "A" (if they were called upon the teacher to answer). Each tally mark was assigned one point. Notably, the least reliable tally out of the three classes was the first group. Because there were a lot of logistical and organizational issues that had to be smoothed out, I was not able to give the tally enough attention and as a result the first class' scores are much lower than the other two classes.

Media use survey

The Media Use Survey consisted of approximately seventy-five Likert scale and short answer questions which students completed independently before the program began. The survey asked questions about their daily ICT use and their attitudes towards media technology. For this research, four questions specifically focused on students self-reporting on computer and programming confidence were chosen:

1. *I feel comfortable using the computer at home*
2. *I am confident I can fix the computer if it stops working*
3. *I am comfortable with learning computer programming*
4. *I have a lot of self-confidence when it comes to computer programming*

Although there were other questions on the survey that could have been used to gauge confidence, four were chosen because it was a manageable size to record and analyze. Because each question was on a scale from zero to five, students' responses to the questions were added out of a total score of twenty to compare the students' levels of self-confidence. Additional data from the Survey, such as the types of video game consoles students have access to at home, was used in the analysis stage.

Data Analysis

The conceptual framework employed in this study was grounded in a transformative, critical theory orientation (Mertens, 2007), as the data analysis was linked to "wider questions of social inequity and social justice" (Teddlie & Tashakkori, 2009, p. 346). The analysis sought to understand the ways each gender demonstrated confidence as they learnt to code in order to better understand and combat the gender divide in computer science classrooms and computer programming environments. Confidence was defined as a sense of self-efficacy (Bandura, 1977, 1986, 1997) to one's self-perception of capacity to successfully computer program. The demonstration of confidence was seen as "risk-taking" as expressed in behaviours such as independent tinkering (without teacher instruction), trial-and-error, experimenting, inventing own challenges (e.g., willingness to create and fix bugs or create unique game events), persisting under duress, troubleshooting, seeking out-of-class-resources and web tutorials, DIY, etc. In doing so, I constructed 3 composite 'profiles' of participants based on both the qualitative and quantitative data.

Data Description

Description of the Learning Environment

At the time of the research, each of the three classrooms were equipped and set-up nearly identically within a typical rectangular portable classroom. The ceiling height is approximately three metres, the floor appeared to be laminate, and the walls were painted white brick. There were two white boards set-up on perpendicular walls. These white boards, as well as the other walls, were mostly lined with teacher and commercially produced educational posters reflective of the topic and concepts students are learning at the time; however, they were also used as projector screens to teach during programming lessons. The teacher's desk was set-up at the front of the classroom, in front of one of the white boards. The students' desks were set-up in groups of approximately five to six, relatively evenly-spaced around the classroom. The classroom also had typical furnishings such as bins, cupboards, and shelves for books and classroom supplies. The classroom was equipped with a portable electronic projector, a portable overhead projector, and a class set of white Macintosh laptops encased in a lockable portable charging station.

Although the room was stuffy and smelly from containing twenty or so pubescent students with little air circulation, it was bright due to a fair amount of natural light that streamed through the two big windows near the door. The temperature in the room varied throughout the week due to an old heating system that took a while to start-up, leaving the classroom cold on Monday (having been off for the weekend) and very warm and muggy by Friday. Although the stuffiness of the portables did not seem to bother the students, it was a source of distress for the facilitators, several of whom would often pop outside of the classroom for a few moments to breathe in the fresh air.

Description of the Students

Demographics

This research project involved sixty-four multicultural Grade 6 students in a suburban Toronto District School Board elementary school. Twenty-seven of the students were females and thirty-seven were male. The school has a high density of recently immigrated families, many of whom come from war-affected areas, particularly in the Middle East. The school has a robust ELL program and, because of this, there was a sizeable group from each class that did not participate in this particular project and participated in another coding project that was tailored specifically for ELL students.

Teacher descriptions

‘Megan’ (all of the teachers and students’ names are pseudonyms) off-handedly described her class to the research group as not very attentive learners who, in comparison to other classes she taught in the past, did not display a keen interest in daily classroom activities. Megan thought her students were particularly inattentive during this research project because it took place during the first period of the day. Georgina was not as forthcoming with a description of her students; however, she seemed to have a kind and respectful relationship with her students. Abigail seemed to make a conscious effort to speak well of her students to the research group by repeatedly beaming about how smart and overall wonderful she felt her students were.

General observations on classroom dynamics

In all three groups, there was a general trend observed in regard to students' collective behaviour whereby, as a class, the students were very quiet at the beginning of the seven-day cycle and became very lively towards the end. During the first few days of the project, students (both genders) were very quiet during the lesson portion of the day, except for mild responses such as light excited chatter, when the ball bounced off the brick in the Atari-like breakout game the students where learning how to create for the first time during the lesson. During the time allotted for independent work, there was a bit more energy in the room as students worked quietly and communicated with each other in soft tones. By the fourth day, students chatted much more during the lesson, and the facilitator had to repeatedly remind the students to remain quiet during the lesson and to raise their hand if they wanted to participate in class, which could be a signal of increased involvement. Out of all the days, the students were most engaged during the field trip to York. There, the atmosphere was upbeat and full of energy.

PARTICIPATION: WHO DOMINATED THE CLASS?

Statistically boys participate more than girls

In all three of the classes, the boys participated during class lessons the most by raising their hands in response to prompts and questions posed by the facilitator who was teaching. According to the statistics taken on participation, a boy always held the highest participation score. In Megan’s class, the highest participation score was eleven, in Georgina’s class, it was thirty-three, and in Abigail’s class, it was thirty-seven. As the first class to participate in TDP, Megan’s class had the lowest participation score due to logistical and organizational issues that had to be dealt with. Because I was not able to give the tally as much attention as the other classes this class’ scores were much lower than the other two classes.

When the students in each class were ranked from highest score to lowest, the boys were the top five scorers in participation much of the time. In Georgina’s class, they occupied all five spots, in Abigail’s class they occupied four out of five spots (with a girl ranking third) and in Megan’s class, they occupied three out of five spots (with two girls ranked third and fourth). Although it was difficult to say why Megan’s class had the most even ratio of gender participation, one possible explanation could be that in Megan’s class, the participation tally was implemented later (a few days after the project started) whereas the tally was implemented from the first day of the project in the other two classes.

Comparing the highest girl and boy in each class produced varied results. The difference between the boy's highest participation score and the girl's highest participation score was moderate for two of the classes (Megan and Abigail) and quite dramatic for another (Georgina). In Megan’s class, the girl with the highest participation score fell behind the boy with the highest participation score in the class by five points. In Abigail’s class, the girl with the highest participation score fell behind the boy with the highest participation score by seven points. In Georgina’s class, the girl with the highest participation score, fell behind the highest boy in the class by twenty-five five points. (See Table 1.)

Trends in those with high participation scores

When the boys who had a very high participation score took part in the lesson, they notably answered code-specific questions, and often did so correctly. For example, Brian, who scored the highest in Georgina's class, used code language such as “s_breakable” and “lives = 0” when called on by a facilitator during the lesson. When the girls with high participation score were involved in the lesson, for the most part, they volunteered to participate in lesson-based activities, rather than to answer code-specific questions. A typical example of this was seen in Kim, who often volunteered to participate in activities, such as a kinaesthetic conditional object lesson in front of the class. Although this was a typical act of girls who had a high participation score, it was not always the case. For example, another high scoring female, Anthea, (who didn't score as high as Kim) answered a code-specific question in which she fixed a 'bug' by saying “in the bracket, change the word ‘yellow' to ‘green’”. It is important to note that although general commonalities were observed, it was difficult to find all-inclusive trends. Due to the complexity and inconsistencies of school-based research, and the large number of facilitators providing observations, it was difficult to obtain notes on the same topic in each class.

TABLE 1

Participation Score Chart						
Rank (highest to lowest)	Megan's Class		Georgina's Classs		Abigail's Class	
	Gender	Score	Gender	Score	Gender	Score
1	M	11	M	33	M	37
2	M	8	M	25	M	35
3	F	6	M	21	M	35
4	F	6	M	15	F	30
5	M	5	M	12	M	19

Confidence: Who was willing to take risks while working?

The ethnographic observational data showed that, in all three classes, while the students worked on creating their video games; the boys displayed more behaviours that could be interpreted as confidence than the girls as; however, there were a few distinct situations in which a few of the girls demonstrated behaviours that could be interpreted as a strong sense of confidence. As mentioned above, the demonstration of confidence was seen as "risk-taking" as expressed in behaviours such as independent tinkering (without teacher instruction), trial-and-error, experimenting, persisting under duress, troubleshooting, seeking out-of-class-resources and web tutorials, DIY, etc.

Boys were willing to take risks

The ethnographical data demonstrated that in all three classes, the boys seemed to be willing to take risks when working on their video games. An example of this is James, one of the highest scoring students in participation and one of the more proficient coders. During class lessons, on at least one occasion, James typed code to make one of the objects move left and right, even though that was not a part of the directions given by the facilitator. Another example of this is Owen, who with his partner Noah figured out how to change the screen view so that the view moved with their main object. It is not clear if the boys figured this out entirely on their own, as, at times, the facilitators provided support to students who asked for help, by thoroughly guiding them through a task. This is probably not the case in this situation as Owen often went home and researched Game Maker tutorials on YouTube; not only was there a good possibility that he learned how to complete that task from research he completed but it also showed that he had an interest in the process and not simply the end goal. Additionally, even if these boys received support executing this task, they demonstrated a sense of confidence by exhibiting a willingness to tackle a complex task.

Even the boys who were not as proficient in code as James and Owen demonstrated a willingness to trouble shoot, take risks, and tinker. An example of this was seen with Michael and Fred, who had to deal with various bugs they unintentionally created in their games on a daily basis. When errors arose in their game, Michael would expressively raise his hands or bury his head in his hands exclaiming things like "Why isn't it working?", but he continued to work and tried to figure out how to solve the problem. Fred also responded to challenges by attempting to problem solve as seen on another occasion, and when the balls were not colliding with the bricks, Fred suggested to “Just restart it.”

Many girls were apprehensive to take risks

In contrast to the majority of boys who seemed willing to take risks while working on their games, many of the girls seemed apprehensive to take initiative to solve the problems they encountered while working on their games and relied on the facilitators to problem solve for them. One example of this is seen in Natasha and Kim. Although they (especially Kim) participated a lot in class, they were not able to independently problem solve much of the time. On one occasion, Natasha and Kim put their hands up, asking how to increase the size of their sprite. I came over to them and tried to get them to look for the answer themselves by asking “Where do you have to go to find help?” or “Where do you go to deal with how something looks? They did not seem to know where to look and they did not offer any possible solutions. Notably, as we chatted, they looked at me eagerly for answers and seemed a little bewildered when I prompted them rather than being immediately forthcoming with the answers they were looking for. Another example of this was seen with another student, Diana, who tried unsuccessfully to get an object in her game to jump. Even though she cut-and-pasted jumping code from the demonstration game, she did not have the correct code and, as a result, the object remained stationary. Diana's response was to give up and work on something else. She was eventually able to get her object to jump after one of the facilitators helped her.

Risk-taking girls

Although the majority of the girls seemed afraid to tinker, there were also a few girls that seemed much more confident. The most prominent example of this was seen in Melissa and

Katherine's behaviour. They were one of the pairs in all three classes (including boys) that demonstrated a strong willingness to try new pieces of code. There were several recorded examples of tinkering that was observed. On one occasion, Melissa experimented with code very briefly. She correctly wrote code for the direction of the ball before the facilitator leading the session typed it in on the projector (even though on this occasion, she quickly deleted it). On another occasion, a few days later, both were ahead of the lead facilitator's tutorial and typed in the code 'move_bounce solid' before he explained that was the next step. They also created invisible bricks so the character was confined to the room by taking code from Brick Breaker before it was explained to the class during the lesson. Another example of a girl who was not afraid to tinker was Anthea. I noticed Anthea troubleshoot on several occasions. On one occasion, she figured out how to make two characters move at the same time by using different keys for movement. When asked how she did that, she explained that she figured it out using trial and error.

Student-self reporting on confidence: Media use surveys

Students' responses to the following four questions from the Media Use Survey provided another angle into understanding the students' confidence in relation to computers and programming.

1. *I feel comfortable using the computer at home.*
2. *I am confident I can fix the computer when it stops working.*
3. *I am comfortable with learning computer programming.*
4. *I have a lot of self-confidence when it comes to computer programming.*

Overall, the boys tended to have the higher scores; however, a girl tied a boy for the highest score. Not surprisingly, this was Melissa, who was one of the strongest and most confident students in all three classes. The majority of students, both male and female, who exhibited a strong sense of confidence in the ethnographic notes self-reported higher confidence than the students who did not exhibit a strong sense of confidence in the ethnographic notes, with scores in the sixteen to nineteen range out of twenty. The students who demonstrated less confidence in the field notes had scores in in the range of thirteen and fourteen out of twenty (in the survey). The exceptions to this were Owen and Anthea, who both scored fourteen. See Table 2.

TABLE 2

Media Use Survey Results: Self-Reporting on Confidence					
Students	Questions (Likert scale from 0-5)				Total out of 20
	I feel comfortable using the computer at home	I am confident I can fix the computer when it stops working	I am comfortable with learning computer programming	I have a lot of self-confidence when it comes to computer programming	
Boys					
Brian	5	5	5	4	19
James	5	4	3	5	17
Noah	4	4	5	4	17
Fred	5	3	5	3	16
Owen	5	1	5	3	14
Michael	5	2	2	4	13

Girls					
Melissa	5	5	4	5	19
Katherine	5	0	5	5	15
Anthea	2	4	5	3	14
Diana	5	3	3	3	14
Kim	5	4	3	1	13
Natasha	4	3	3	3	13

Analysis

The aim of this Master's Research Project was to investigate the following questions: *How do Canadian children learn how to code? What gender dynamics are observed as girls and boys learn to code together? Who has greater confidence, girls or boys?* In answering these questions, several trends emerged that demonstrated that although, overall, the boys dominated the classroom space in terms of participation in classroom lessons by being very responsive to the lead facilitator's prompts during the lessons and seemed to display more confidence (as defined above), there were a few unmistakable examples of girls who excelled (in confidence) just as much as the boys did. Within the context of these trends, I constructed 3 composite 'profiles' of participants, which I describe below. First, the boys as a whole provided a rather homogenous group who were characterized by a willingness to participate in class lessons by raising their hands in response to the prompts posed by the facilitator who was teaching, demonstrating a sense of self-confidence as seen in their Media Use Survey responses, as well as a willingness to independently problem solve and tinker while working on their games. Second, there was the image of the "stereotypical girl"; who was responsive during class lessons but ultimately enacted the self-expectations they held surrounding their performance and confidence with computers (from their Media Use Surveys), as they were not very willing to independently problem solve or tinker while working on their games. Third, was an atypical girl who, according to the ethnographic observations was willing to independently problem solve or tinker and self-reported fairly high self-confidence on the Media Use Surveys, even though she was not very responsive to the facilitator's prompts during class lessons.

Profile 1: Trends in relation to boys

According to statistical data based on hand raising, the boys participated more than the girls and notably answered code-specific questions, often doing so correctly. Overall, the boys demonstrated a strong willingness to take risks by independently problem solving or trying new pieces of code while they created their video games. For the most part, the boys scored themselves fairly high on self-confidence in their survey with the exception of two (Michael and Fred). The most notable difference between these two group of boys is that those who scored themselves highly on participation, excelled at coding and the two boys who scored themselves a little lower were not as proficient.

Profile 2: Trends in relation to girls

Although the boys participated more overall, the girls also participated a great deal during class lessons. When they did so, they put their hands-up to answer general lesson-based activities, rather than to answer code-specific questions. They seemed to be comfortable with "doing school" but they shied away from questions that there were specifically computer or Computer Science-related. While working on their games, these girls did not independently troubleshoot and/or experiment with new pieces of code. For the most part, the girls in this research study seemed apprehensive to take risks as they would not take much initiative to solve problems they encountered and relied on the facilitators to problem solve for them. Looking at additional data from the Media Use Survey might be helpful in understanding why. Their surveys indicated that only one of the three less proficient girls in the table above own a video game console unit at home. Perhaps, one of the reason why these girls were not as confident was because they were unfamiliar with these types of games, unlike Melissa and Katherine, who are discussed below in profile 3.

Profile 3: Confident, atypical girls

Melissa and Katherine

These girls demonstrated a strong sense of confidence as they would independently troubleshoot and experiment with new pieces of code. Melissa and Katherine described themselves to the facilitators as "gamers" who frequently play video games at home, such as Grand Theft Auto or Call of Duty. The four Media Use Survey questions used to measure confidence indicated that these girls scored themselves higher than most of the other students on self-confidence; however, they did not participate much during class lessons. Interestingly, the confident females had several things in common with the majority of the confident boys as they viewed programming in a favourable way; additional responses to the Survey also demonstrated that, like the boys, they own several game console systems, felt very comfortable using computers, and perceived programming as a skill that could be potentially useful in the future, as well as found the challenges of computer programming intrinsically interesting.

Anthea

Although Anthea displayed confidence, she was different from Melissa and Katherine. Unlike Melissa and Katherine, Anthea did not have any video game consoles at home. Her Media Use Survey results showed that compared to other high participatory students, she did not describe herself as a particularly confident programmer, as her total score on confidence was fourteen out of twenty. Notably, she describes herself as a two out of five in response to the Likart statement “I feel comfortable using the computer at home”. In contrast to Melissa and Katherine, she did not describe herself as finding the challenges of computer programming interesting, had a moderate view of women’s ability to do well in programming and did not see programming as being helpful for her future. Her responses to a couple of questions might provide a bit of insight. She described herself as feeling comfortable using software that she is unfamiliar with and enjoyed learning new programs on the computer.

Understanding this gap

The stark imbalance between the number of women and men who enter into and remain in the CSE field in Canada instantiated itself in the class trends as, overall, the boys dominated the classroom space by participating more and demonstrated a greater willingness to persist in the face of challenges. These results were not surprising as, for example, Margolis and Fisher (2002) describe how boys gravitate to computers and computer-related endeavours from a very young age. Additionally, results on students’ confidence also mirrored discourse on the subject, as for example, Canadian research by Looker and Thiessen (2003) found young males “feel more confident and competent using computers than do the young women” and tend to have higher views of their ability (p. 9). However, these results can serve as an encouraging reminder that although the young males in this study tended to dominate the class, there was a group, albeit small, of girls who displayed confidence by demonstrating a willingness to persist in the face of the challenges they encountered while working on their games. If these girls (and others such as Denner & Werner 2007[2]) are evidence that there is the potential for girls to demonstrate confidence while programming, an important question left lingering is: Why did some girls exhibit confident behaviours while others did not? What factors contribute to confident behaviours?

These questions are first answered by a section that addresses the data collection issues that could have contributed to the girls not exhibiting confident behaviours. This is followed by a description of three links that were made to understand why some girls exhibit confident behaviours and others do not, all of which are connected to social contexts and social expectations. Finally, a possible solution to help address the gender gap is presented.

Data collection issues

One of the reasons more problem solving was not observed had less to do with the girls themselves and more to do data collection methods. First, the participation scores provided a glimpse into the overall dynamics of the classroom, demonstrating that the boys unsurprisingly dominated the classroom space; however, it inadequately served as an indicator of confidence. Notably, the very confident girls (Melissa and Katherine) did not have high participation scores even though they exhibited behaviours, such as tinkering that are much more reliable indicators of confidence. Furthermore, putting one's hand up in class does not conclusively equate

[2] There were admittedly different supports systems set in place and environmental conditions in the Denner and Werner study (i.e. all-girl setting, 17 more sessions and voluntary participation) in this research study that the project I was a part of did not have

confidence and could have very well been caused by another factor, such as having a personality that is generally predisposed to engage in classroom activities. Secondly, there is a strong possibility that more problem solving happened during the study than what was observed. My ethnographic observations were able to capture observed gender dynamics (which are notably mediated and limited by the researcher's perspective and biases) but were probably unable to capture the entire problem solving processes. Additionally, the quantitative data provided insight into students' behaviours and practices but was unable to provide explanations to understand them. Consequently, many of the female students may have been actively thinking about or working through problems even though it was not observed.

1. Confidence is linked to identities formed in out-of-school contexts

Two of the girls (Melissa and Katherine) who exhibited confident behaviours, such as risk-taking and tinkering, had experiences with video games in out-of-school contexts. The confident behaviours that they exhibited can be linked to their self-identification as video game players. Without prompting, the girls described themselves as "gamers" to the facilitators during one of the sessions. Having done so independently is noteworthy as it could signify a strong identification with that subculture.[3]

2. *Even confident girls default to stereotypical social expectations*

The majority of the girls involved in TDP were predisposed to displayed behaviours, such having an apprehension towards problem solving and not persisting in the face of challenges, where they enacted the social expectations surrounding their performance and confidence with

[3] Anthea does not fit into this category as she did not have experience with video games in out-of-school contexts. Her behaviours (and the root of her behaviours) are a bit of an anomaly serving as a reminder that students are unique and do not easily fit into pre-determined boxes. In order to understand, Anthea's behaviours, a one-on-one interview would have been helpful in understanding her.

computers. Also, but to a lesser extent, these behaviours were also observed in the girls that displayed more confidence. Despite mostly exhibiting confident behaviours, these girls also defaulted to social expectations of how girls should act around computers. For example, even though Melissa tinkered and self-identified as a part of the video game community, she self-censored herself by deleting a piece of code that she was experimenting with.

3. Confidence is linked to self-expectation

There is an interesting link between self-expectation (in the Media Use Survey) and observable performance. The girls who exhibited confident behaviours scored themselves fairly high on the four Media Use Survey questions used to gauge confidence. Contrastingly, the girls who did not exhibit confident behaviours had Media Use Survey scores that indicated a lower sense of self-confidence. This observation could be an indication that girls will act out the prepositions they hold on to, which can exist even before entering the learning environment, as well as demonstrate the power that self-expectation can have on a girl's experience with computers. Furthermore, this observation demonstrates the power negative stereotypes have on girls' experiences with computers, as girls ascribe these dispositions from social scripts (Margolis & Fisher, 2002; Li, 1999; American Association of University Women, 1998).

Closing the divide

Closing the gender divide is a monumental task. As Margolis and Fisher (2002) rightly point out, in order to do so there must be a change in the systems, structures, and ideologies associated with the video game industry. This is especially difficult for a researcher to tackle as these factors are beyond the scope of the research environment. It is impossible for a researcher to change the social scripts and environments of each girl they come in contact with; however, the place where they do have an influence is in the research environment. Modelling the types of behaviours associated with confidence such as tinkering, problem solving and persisting in the face of challenges could be one way to support the female students who are having trouble due to a lack of confidence. A note in the ethnographic notes by one of the lead researchers on this project points this out by saying: “[This pair of girls] don’t see the connection to their own very basic level of coding, so cannot self-regulate what a logical next step for them is this is OUR JOB” [emphasis original]. Although this statement was concerned with competency, it can also relate to fostering confidence. If students cannot see themselves as confident, an appropriate response is also to support them. Although confidence is already, to some extent, shaped by prior experience, self-expectation, and social mediation, the presence of positive roles models have been shown to benefit girls while learning programming (for example: Ettenheim, Furger, McLester, & Lisa Siegman, 2000; Johnsn & Wiest, 2005; Kafai, Peppler, & Chapman, 2009). Although the chaos and demands of school-based research can make it difficult to meet every need, the girls in this study, as well as others, have the potential to be competent and confident computer programmers, as middle school students and beyond, if provided with support in the learning environment. This would be a positive step in the effort to narrow the gender divide in the Computer Sciences.

Conclusion

This project aims to understand the way Canadian females interact with computers in order to empower and support them. The aim of this Master’s Research Project was to investigate the gender dynamics that are observed as Canadian children learn computer programming, particularly in the area of confidence. Through ethnographic field notes, a participation tally and results from the Media Use Survey, several insights have emerged from this study. Even though the boys were more responsive to the teacher in classroom lessons and were more willing to take risks while working, there were a few examples of girls who displayed just as much confidence as the boys did. Throughout the study, three profiles of students emerged. First, the boys provided a rather homogenous group who, on the whole, demonstrated a willingness to participate in class, independently problem-solve, and tinker. Second, a profile of the "stereotypical girl" was re-constructed; this stereotypical girl would participate in class but would not be very willing to independently problem solve or tinker, and in doing so enacted the myth of their given social self-expectation. Finally, there was an "atypical girl" who was characterized by a willingness to independently problem solve or tinker even thought she did not participate much through the specific means of hand raising in class. Additionally, this project also highlighted the challenges of doing school-based research, which unexpectedly included having to, somewhat ironically, navigate through a personal lack of confidence also through tinkering of a different nature. In future research, it would be helpful to look at the universality of the three profiles that were observed with much more reliable data collection methods as well as conduct follow-up interviews with the three girls to learn more about how their experience and dispositions were shaped in relation to "confidence". Additionally, research could be done to understand what types of support would most effectively assist girls in research environments. As computer technology continues to become increasingly a part of the fabric of society, it is essential that girls and women are not excluded from new literacies (coding) and related cultural practices and sites of power. This is especially important in light of the glaring gender divide in

CSE that needs to be continually understood and combatted in order to create a more balanced, equitable society.

Even though the work to bridge the gender gap in CSE is growing, continued work is needed to understand the way in which girls can thrive as computer programmers. Furthermore, much of the work that has been done has been in American and European contexts, which leaves Canada lagging behind other nations in supporting girls and young women in this area. The research of this Major Research Project was carried out with the support of the Institute of Research on Digital Learning (IRDL) at York University, under the direction of Dr. Jennifer Jenson, who has published work on gender and computing.

Works Cited

Aho, A. V. (2012). Computation and computational thinking. *Computer Journal*, *55*, 832–835.

American Association of University Women Educational Foundation. (1996). Girls in the middle: Working to succeed in school. Retrieved from www.aauw.org/research/girlsinMiddle.cfm

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84(2), 191-215.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall.

Bandura, A. (1997). Self-Efficacy: *The exercise of control*. New York, NY: W. H. Freeman.

Brunner, C., Bennett, B., & Honey, H. (1998). Girls and games and technological desire. In J. Cassell and H. Jenkins (Eds.) *Beyond Barbie and Mortal Kombat: Gender and Computer Games* (pp. 298-327). Cambridge, MA: MIT Press.

Canadian Broadcasting Company. (2015). Code Studio, a free learning tool, allows Courtenay school to teach kids to code. Retrieved from http://www.cbc.ca/news/canada/british-columbia/code-studio-a-free-learning-tool-allows-courtenay-school-to-teach-kids-to-code-1.3009591

Cohoon, J. M., & Aspray, W. (2006). A critical review of the research on women's participation in postsecondary computing education. In Cohoon. J.M., & Aspray, W.. (Eds.), Women and information technology: Research on underrepresentation (pp. 137–180). Cambridge MA: MIT Press.

Cooper, J. (2006). The digital divide: The special case of gender. *Journal of Computer Assisted Learning, 22(5)*, 320-334. Retrieved from http://journals2.scholarsportal.info/details/02664909/v22i0005/320_tddtscog.xml?q=girls&search_in=anywhere&op=AND&q=stereotypes&search_in=anywhere&op=AND&q=computers&search_in=JOURNAL&date_from=&date_to=&sort=relevance&sub=

Cooper, S., & Cunningham, S. (2010). Teaching computer science in context. *ACM Inroads*, *1*, 5–8.

Cooper, J., & Weaver, K.D. (2003). *Gender and computers: Understanding the digital divide*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Denner, J., & Campe, S. (2008). What games made by girls can tell us. In Kafai, Y.B., Heeter, C., Denner, J., & Sun, J.S. (Eds.) In *Beyond Barbie and Mortal Kombat: New perspectives on gender and gaming*. (pp. 129-144). Cambridge, MA: MIT Press.

Denner, J. & Werner, L. (2007). Computer programming in middle: How do pairs respond to challenges? *Journal of Educational Computing Research, 37(2),* pp. 131-150. *Retrieved from http://jec.sagepub.com.ezproxy.library.yorku.ca/content/37/2/131*

diSessa, A. A. (2000). Changing minds: Computers, learning, and literacy. Cambridge: MIT Press.

England’s Department of Education. (2013). *Statutory guidance: National curriculum in England: computing programmes of study.* Retrieved from https://www.gov.uk/government/publications/national-curriculum-in-england-computing-programmes-of-study/national-curriculum-in-england-computing-programmes-of-study

Ettenheim, S.G., Furger, R., McLester, S., & Siegman, L. (2002). Tips for getting girls involved. *Technology & Learning, 20(8),* pp. 34-36. Retrieved from http://go.galegroup.com.ezproxy.library.yorku.ca/ps/i.do?ty=as&v=2.1&u=yorku_main&it=search&s=RELEVANCE&p=EAIM&qt=SP~34~~IU~8~~SN~1053-6728~~VO~20&lm=DA~120000000&sw=w&authCount=1

Dreves, C., & Jovanovic, J. (1998). Male dominance in the classroom: does it explain the gender differences in young adolescents' science ability perceptions? *Applied Developmental Science, 2(2)*, p. 90–98.

Entertainment Software Association of Canada. (2013). Canada's video game industry in 2013: Final report. Retrieved from http://theesa.ca/wp-content/uploads/2013/10/ESAC-Video-Games-Profile-2013-FINAL-2013-10-21-CIRC.pdf

Franz-Odendaal, T., Mavriplis, C., & Farenhorst, A. (n.d.). Empowering women in STEM. Retrieved from http://wiseatlantic.ca/pdf/Interview%20with%203%20chairs/NSERC_Part_Two_03.pdf

Gardiner, B. (2014, May 23). Adding coding to the curriculum, *The New York Times*. Retrieved from http://www.nytimes.com/2014/03/24/world/europe/adding-coding-to-the-curriculum.html?_r=0)

Grover, S., & P., R. (2013). Computational thinking in K-12: A review of the state of the field. *Educational Researcher, 42(1),* 38-43. Retrieved from http://search.proquest.com.ezproxy.library.yorku.ca/docview/1322243887?accountid=15182

Hammersley, M., & Atkinson, P. (1995). What is Ethnography? *Ethnography: Principles in Practice*. 2nd *Edition,* New York, NY: Routledge.

Hango, D. (2013). Gender differences in science, technology, engineering, mathematics and computer science (STEM) programs at university. Retrieved from http://www.statcan.gc.ca/pub/75-006-x/2013001/article/11874-eng.pdf

Hughes, K. (2005). Designing opportunities to spark and nurture scientific inquiry in middle school girls. *Proceedings of the 2005 conference on Designing for User eXperience*. San Francisco, CA, AIGA: American Institute of Graphic Arts.

Jenson, J., & de Castell, S. (2008). Theorizing gender and digital gameplay: Oversights, accidents and surprises. *Eludamos. Journal for Computer Game Culture, 2(1)*, 15-25. Retrieved from http://www.jenjenson.com/wp-content/uploads/2013/08/2008-Gender-and-Digital-Gameplay.pdf

Kafai, Y.B. (1995). *Minds in play*: *Computer game design as a context for children's learning*. New York, NY: Lawrence Erlbaum Associates

Kafai, Y. B., & Burke, Q. (2014). *Connected code: Why children need to learn programming*. Cambridge, MA: The MIT Press.

Kafai, Y.B., Heeter, C., Denner, J., & Sun, J.S. (2008). *Beyond Barbie and Mortal Kombat: New perspectives on gender and gaming*. Cambridge, MA: MIT Press.

Kafai, Y. B., Peppler, K.A., & Chapman, R. N. (2009). *The computer clubhouse: Constructionism and creativity in youth communities*. New York, NY: Teachers College Press.

Kafai, Y.B. & Resnick, M. eds. (1996). *Constructionism in practice: Designing, thinking, and learning in a digital world*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Kay, A., & Goldberg, A. (1977). Personal dynamic media. *IEEE Computer*, *10*, 31–41.

Kessels, U. (2005). Fitting into the stereotype: how gender-stereotyped perceptions of prototypic peers relate to liking for school subjects. *European Journal of Psychology of Education, 20,* pp. 309–323.

Kosh, C.. (1995). Is computer time fair for girls? A computer culture in a grade 7/8 classroom. Unpublished paper, Queen's University, Kingston, Ontario.

Looker, E. D., & V, Thiessen. (2003). The digital divide in Canadian schools: Factors affecting student access to and use of information technology. *Statistics Canada.* Catalogue No. 81-597-XIE.

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

Mertens, M.. (2007). Transformative paradigm: Mixed methods and social justice. J*ournal of Mixed Methods Research, 1(3),* 212-225**.** Retrieved from http://mmr.sagepub.com/content/1/3/212.short?rss=1&ssource=mfc

Oliveira, M. (2014, April 30). Code kiddies: Canadian elementary schools teach computer programming. *The Globe and Mail.* Retrieved from http://www.theglobeandmail.com/technology/tech-news/code-kiddies-canadian-elementary-schools-teach-computer-programming/article18337552/

Olson, P. (2012, May 9). Why Estonia has started teaching its first-graders to code. *Forbes Magazine*. Retrieved from http://www.forbes.com/sites/parmyolson/2012/09/06/why-estonia-has-started-teaching-its-first-graders-to-code/

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York, NY: HarperCollins Publisher.

Papert, S. (1991). Situating constructionism. In I. Harel & S. Papert (Eds.), *Constructionism*. (1–11). Norwood, NJ: Ablex.

Partnership for 21st Century Skills (n.d.). *Framework for 21st century learning*. Retrieved from http://www.p21.org/about-us/p21-framework

Pea, R. D., & Kurland, D. M. (1984a). On the cognitive effects of learning computer programming. *New Idea Psychology 2(2)* 137-168 Retrieved from http://www.tcnj.edu/~ijims/previous/Readings/Week1/Cog_Effects_Prog.pdf

Pea, R. D., & Kurland, D.M. (1984b). *On the cognitive effects of learning computer programming : a critical look*. New York, NY: Bank Street College of Education, Center for Children and Technology.

Richtel, M. (2014, May 10). Reading, writing, arithmetic, and lately, coding. *The New York Times.* Retrieved from http://www.nytimes.com/2014/05/11/us/reading-writing-arithmetic-and-lately-coding.html?action=click&module=Search&region=searchResults&mabReward=relbias%3Ar%2C%5B%22RI%3A8%22%2C%22RI%3A18%22%5D&url=http%3A%2F%2Fquery.nytimes.com%2Fsearch%2Fsitesearch%2F%23%2Freading%2C%2Bwriting%2C%2Barithmetic%2Band%2Bnow%2Bcoding%2F

Royal Society. (2012). Shut down or restart: The way forward for computing in UK schools. Retrieved from http://royalsociety.org/ education/policy/computing-in-schools/report/

Seymour, E. & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: WestviewPress.Schofield, J. (1995). *Computers and classroom culture*. Cambridge, MA: Cambridge University Press.

Statistics Canada. (2011). University enrolment by field of study and gender. Retrieved fromhttp://www.statcan.gc.ca/daily-quotidien/100714/t100714a2-eng.htm

Wiest, L., Johnson, S.. (2005). Providing female role models in mathematics and computer Science. *Australian Primary Mathematics Classroom, 10(1),* pp. 12-17. Retrieved from http://search.proquest.com.ezproxy.library.yorku.ca/eric/docview/61911548/76C036AB31DD4EFFPQ/8?accountid=15182

Wilson, A., & Moffatt, D. C. (2010). Evaluating Scratch to introduce younger schoolchildren to programming. Paper from *22nd Annual Workshop of the Psychology of Programming Interest Group.* Leganés, Spain.

Wilson A., Connolly, T., Hainey T., & Moffatt, D. (2011). Evaluation of introducing programming to younger school children using a computer game making tool. Paper from *5th European Conference on Games Based Learning.* Athens, Greece. Retrieved from http://scratched.gse.harvard.edu/sites/default/files/Evaluation%20of%20Introducing%20Programming%20to%20Younger%20School%20Children%20Using%20a%20Computer%20Game%20Making%20Tool_rev.pdf

Wing, J.M. (2006). Computational thinking. *Communication of the ACM, 49(3),* 33-35. Retrieved from https://www.cs.cmu.edu/~15110-s13/Wing06-ct.pdf

Wing, J.M. (2011). Research notebook: Computational thinking—What and why? *The Link Magazine*, Spring. Carnegie Mellon University, Pittsburgh. Retrieved from http://link.cs.cmu.edu/article.php?a=600