# CONSIDERING THE GLOBAL IMPACTS OF TECHNOLOGY TO ALTER THE PERCEPTIONS OF MIDDLE SCHOOL STUDENTS ABOUT THE FIELD OF COMPUTER SCIENCE: RECONSIDERING STEREOTYPES

By

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To Mom, Dora, Jack, Reilly, Heather & Courtney, Barry & Steven

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| ABI | Anita Borg Institute |
| AP | Advanced Placement |
| CP | Computer Programming |
| CS | Computer Science |
| CSP | Computer Science Principles |
| CSTA | Computer Science Teachers Association |
| CT | Computational Thinking |
| GBL | Game Based Learning |
| ISTE | International Society for Technology in Education |
| IT | Information Technology |
| K-12 | Kindergarten through Twelfth Grade |
| LMS | Learning Management System |
| NAS | National Academy of Sciences |
| NSF | National Science Foundation |
| MS | Middle School |
| PBL | Problem Based Learning |
| STEM | Science, Technology, Engineering and Mathematics |
| TA | Thematic Analysis |



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Abstract of Dissertation Presented to the Graduate School
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By

Joanne Barrett

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Today we are faced with a shortage of qualified candidates for the growing computer science occupations that are among the fastest growing fields in our nation. A current shortage of students in the educational pipeline coupled with a lack of diversity in the field is impacting our technological growth and expansion. It has been suggested that it is in our best interests as a nation to attract more women and minorities to the field so that we can insure the global awareness and advantages that diversity supports. Therefore it is important that we look for ways to increase and maintain diversity into the pipeline.

Historically barriers to entry for gender equality have included the beliefs that computing is for boys and the stereotypes about nerds created a hostile environment for girls. Similarly a lack of understanding of the field and what it has to offer limits student selections. Career theory indicates that students begin to form their career aspirations as early as middle school. For this reason, a middle school science class ($N$ = 71) was selected for an intervention utilizing the global impacts unit, one of the big ideas from the Computer Science Principles (CSP) course released by the College Board. The goal



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of the course is to attract underrepresented students to the field of computing. Modifications were made to focus on the global impacts unit of computing coupled with mentor interview opportunities. The perceptions of eighth grade students were evaluated with surveys and student created artifacts.

As a result of the intervention students showed their perceptions had changed about the global nature of the field and their understanding of what computer scientists do in their jobs. While only three percent of the students were aware of the gender disparities that existed in the field prior to the intervention, by the end of the intervention over half of the students acknowledged the problem in either the survey or artifacts. There was a statistically significant shift in the students indicating that they would consider taking a computer science course in the future. Implications and recommendations are provided.

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# CHAPTER 1
# INTRODUCTION TO THE STUDY

This dissertation is organized into six chapters. The first chapter includes an overview of the background of the problem highlighting the shortage of women in the field of computer science, the problem of practice as well as the research questions and the rationale for the study. The second chapter provides an overview of the related literature that served as the foundation for the study. The third chapter contains the lesson plans that make up the intervention created for the study. The fourth chapter covers the methodology of the study including the data collection and analysis methods. The fifth chapter contains the results of the data analysis as well as the analysis of the qualitative data contained in surveys, lesson artifacts and student interviews. The sixth chapter is a discussion of the results with the implications for research and practice.

## Background

According to the U.S. Dept. of Labor Bureau of Labor Statistics, the job market for computer occupations is projected to grow at a rate of twelve percent from 2014-2024, which is faster than the average for all occupations (Bureau of Labor Statistics, 2016). The Bureau has identified over ten fields that comprise the computer and information technology occupations that all share the prediction of higher growth rate as well as commanding higher median salaries than all other occupations. It is also predicted that today's enrollments in computer science degree programs are insufficient to meet workforce needs. It is predicted that the current U.S. computing labor shortage will progress until 2020 with less than a quarter of the available jobs being filled by any qualified applicants (Carnevale, Smith & Strohl, 2013). It should also be recognized that enrollments in computing and engineering programs are not keeping up with



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demand and that enrollments do not reflect the diversity within our society (Cheryan, Master & Meltzoff, 2015). Today, women hold fifty-seven percent of all professional jobs in the U.S. but only one quarter of the computer positions (Beede, Julian, Langdon, McKittrick, Khan & Doms, 2011). Even more alarming, the number of women earning degrees in computer science has decreased from thirty-seven percent in 1984, to less than twelve percent in 2011 (Carnevale et al., 2013). The occupations in the workforce that the Bureau of Labor Statistics has labeled as science or engineering have been dominated by white males (Stine & Matthews, 2009). Technology companies that were surveyed by the Anita Borg Institute (ABI) confirmed that barriers exist for women in the computing field (Simard, 2011). Simard and Gammal (2012) identified the barriers women face including inequities in encouragement from peers and supervisors as compared to male peers, isolation, family pressures and unconscious bias that are keeping the numbers low. While there have been attempts to try to offset these discrepancies, the underrepresentation of women in science, technology, engineering and mathematics (STEM) in the U.S. has been a concern of policy makers, academics, and industry leaders (Rosenbloom, Ash, Dupont & Coder, 2008). Additional factors that have been identified to contribute to the imbalance include a lack of female role models, gender stereotyping, and less family-friendly flexibility (Beede, Julian, Langdon, McKittrick, Khan, & Doms, 2011) as well as inequities of educational opportunities (Margolis. Estrella, Goode, Holme, & Nao, 2010). Computer science has one of the largest gender disparities among the STEM fields because girls are less likely to enroll in these courses, which in turn result in less diversity of those filling the jobs in the fields now and in the future (Master, Cheryan & Meltzoff, 2016).



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Another problem for STEM and Information Technology (IT) fields is that current students are not choosing majors that will lead to filling these types of positions in a way that is reflective of the diversity in our society. A lack of diversity will negatively impact organizations as they look to compete globally and locally (Margolis & Fisher, 2003; Simard, 2009). It is imperative to our economic success as a nation that we have the ability to not only fill the vacancies, but that we also fill them in a way that represents all members of society. Otherwise, we will suffer from the lack of perspectives, ideas and experiences that diversity can bring.

**Computer Science as STEM**

While the Bureau of Labor brought the STEM labor shortage for qualified workers to our attention a few years ago, the needs to fill positions in STEM fields have continued to grow and expand (Honey, 2014). Initially, the focus was on the overall gaps for STEM fields in general. Ironically, computer science was not identified as an official part of STEM until 2016 (Smith, 2016). Part of this oversight was in the roots of the acronym, which was created by the National Science Foundation with the intent of bringing attention to the disciplines within education where there was concern that students were not making the grade (National Research Council, 2014). Although not originally recognized as an official part of STEM, computer science has since been identified as its' own field and shares much literature in common.

In 2013 the nonprofit organization Code.org was launched and their mission was to bring computer science education to all students and schools with special attention to those underrepresented in the workforce. Their first initiative, Hour of Code, inspired millions (http://code.org/about), including students, teachers, celebrities and a President to try their hand at writing a computer program. As technology becomes more



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integrated into our daily lives, it is more important than ever that students not only are consumers of technology, but also should begin to understand its language and creation. As stated by Code.org:

> Computing is a fundamental part of daily life, commerce, and just about every occupation in our modern economy. It is essential that students are exposed to the field of computer science in our K-12 system—as it is foundational in transforming the way a student thinks about the world. It not only teaches them about technology, it also teaches them how to think differently about any problem (Make Computer Science in K-12 count! 2015).

Code.org's initiative the Hour of Code resulted in millions of students and teachers trying applications and lessons that have led to an increasing awareness and a subsequent demand for computer science education in our schools (Code.org 2015 Annual Report, 2016). Challenges remain in how that demand can best be met.

Today, more than ever, computer science education is important, yet the number of students having access to computer science remains low (Wilson, Sudol, Stephenson & Stehlik, 2010). In November of 2016 the K-12 Computer Science Framework, an ambitious joint undertaking by ACM, Code.org, CSTA, Cyber Innovation Center and the National Math & Science Initiative was released. The K-12 Framework provides a roadmap of potential standards to integrate into K-12 curriculum. These organizations indicated that the key to achieving diversity in filling future jobs is to provide equal educational opportunities to all students.

A basic understanding of computer science concepts is now becoming recognized as part of the future vision for K-12 education. The newly released K-12 framework points out that students should "develop a foundation of computer science knowledge and learn new approaches to problem solving that harness the power of computational thinking to become both users and creators of computing technology"



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(The K-12 Computer Science Framework, 2016, p. 10). Increased awareness of the importance of STEM including computer science raises problems of practice that need to be addressed within K-12 education.

## Problem of Practice

If current trends persist, the enrollment pipeline at the collegiate level for women and minorities will not meet the growing workplace needs (Simard, 2009). This coupled with the current imbalance of the make-up of the field is problematic. Recognizing that computer science plays a vital role in education, Google and Gallup initiated a survey and found that while students, parents, teachers, and administrators value computer science education, administrators do not see computer science as a priority (Google, 2015). Administrators site the lack of qualified personnel to teach computer science as well as a lack of resources for why they are not more actively pursuing computer science in their schools, even though students and parents want it (Google, 2015).

We have a growing awareness today of the importance of coding, but still many people do not have a clear understanding of what the field entails. Possible interventions within the middle school and high school populations are often overruled because of the unwillingness to give up time that has traditionally been dedicated to the pursuit of other subjects (Wang, Hong, Ravitz & Moghadam, 2016). One thing that has changed is that parents now believe computer science is an important field, yet the “education infrastructure does not equitably provide all students with the exposure and encouragement” needed to support all students learning (Wang et al., p.650). To change the existing climate it is important to find ways to influence the attitudes and experiences in a way that do not perpetuate past biases in the classroom.



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**Courses Needed**

The low secondary school enrollment pipeline and the lack of courses and preparation in K-12 education are also contributing factors to the status quo.  Recently, the perceived needs have begun to be identified by government as evidenced by the Computer Science for All initiative of the White House (Smith, 2016).  These needs have resulted in a call for increasing K-12 computer science education.  Included in these measures are state level graduation requirement changes that have allowed high school computer science courses to count towards math or science credits in half of the states (Zinth, 2016). However, it is not as easy as that, because finding ways to incorporate computer science education comes at a price. Schools already have a full curriculum and they focus on fulfilling standards.  If something is added to the curriculum, it means that something else will be taken away (Yadav, Hong & Stephenson, 2016). Finally, computer science courses are still electives and not requirements, which means that students need to self-select these courses. Research has shown that women select these courses in high school at much lower percentages resulting in the lower enrollments (Osborne, Simon & Collins, 2003).

**Development of CSP**

In 2008, the College Board announced that it was suspending the Computer Science AB exam the following year due to a steady decline in enrollment for the five preceding years (AP Central - Important Announcement about AP Computer Science AB, 2016) At this time, the College Board affirmed that it was committed to computer science education and began the research and development of a new course. The course was developed with a great deal of support from the National Science Foundation and was branded the Computer Science Principles (CSP) course (AP



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Computer Science Principles - A New AP Course - Advances in AP® - The College Board | Advances in AP, 2016). The College Board created and implemented the new Advanced Placement Computer Science Principles (CSP) as a way of "attracting and engaging those who are traditionally underrepresented with essential computing tools and multidisciplinary opportunities" (College Board, 2016). This course went live in 2016, and with the help of the National Science Foundation, the adopted curriculum framework has been set with computational thinking practices that are the foundation for the seven big ideas of computing (AP Computer Science Principles, 2014). The course is intended to mirror a college level introductory course for non-computing majors, and only one of the seven ideas has a focus on coding. This is intended to serve a broader audience and to cast a wider net for all students, not just the typical male coders.

## Conceptual Framework and Study Overview

### Purpose of the Project

The focus of this project examined a particular aspect of this complex enrollment problem in computer science. The purpose of this study was to perform an intervention on middle school student attitudes with the hope of persuading girls to study computer science courses in high school. The project implemented a version of the connecting computing unit from the CSP course curriculum. This global impacts unit was selected to identify the influence of computing and its implications on individuals and society for implementation into an eighth grade physical science course.

Hopefully exposure to this unit in middle school can influence students, especially female students, to identify themselves as potential participants in the discipline of computer science in the future. The unit provided avenues for female students to identify with professionals in the field, as an opportunity to change their



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overall perceptions of the field. Furthermore, it is hoped that the unit that was developed for this research project can be used by other middle school science teachers to assist with their instruction of students to stimulate further interest in the discipline of computer science that would not require further instruction in the coding concepts. This intervention in congruence with the freely available coding activities could hopefully assist with student attitudes and perceptions about computer science.

**Conceptual Framework**

The model presented in Figure 1-1 suggests that there are two important aspects to consider in the development of student attitudes about computer science. The first aspect is the knowledge that students have constructed about the field and the second derives from career theory that claims students begin considering possible career options starting in middle school. Previous research has determined that elementary school children can find a great deal of difficulty in computer science concepts like variables. Instead, elementary schools focus on a constructivist framework that builds on what a child already knows in computer science as an approach to solve this problem (Meetoo-Appavoo, 2011). Here, the constructionist learning theory of Papert (1980) that evolved from Piaget's constructivism provides tools that students use to construct their knowledge like building blocks. The block-based languages that middle school students are most familiar with today have descended from the tools that Papert developed with his early work on Logo.

The second important aspect outlined in the framework in Figure 1-1 is how the students develop their views of the field of computer science. If the intent is to help with the creation and formation of student perceptions it is important to recognize any preconceived notions or predispositions that students may already hold. Some sources



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of influence of their perceptions can include the experiences with the people they interact with as well as their media exposure. The career theory of Super and Hall (1978) is a developmental theory that focuses on how the sense of self is developed and recognizes that a person will change over time. Super and Hall (1978) identify phases that an adolescent will pass through in the formation of the concept of self. In addition to this work, social cognitive career theory offers a lens that identifies the importance of self-efficacy, outcome expectations and goals impact how one views a potential career (Lent, Brown & Hackett, 1992). Career theory provides a lens for understanding how knowledge of the world leads one to make career choices (Patton & McMahon, 2014).

The intervention utilized in this research exposed students to fields that they may not have previously considered or understood. In so doing, the framework will provide guidance for students to begin to self identify with a new field by explorations that allowed students to evaluate their potential abilities and self-efficacy as outlined in the conceptual framework. Regardless of their current views towards computer science, the importance of the field is something that is useful for all of today's students to understand. Before a student will consider a field it needs to align with their future goals, so it is important for students to consider computer science regardless of previously held viewpoints. Furthermore, existing views of the field can be challenged as a result of taking part in the intervention.

The diagram labeled as Figure 1-1 shows how the two theories combine to create the student's knowledge of the field. The developmental theories in concert with



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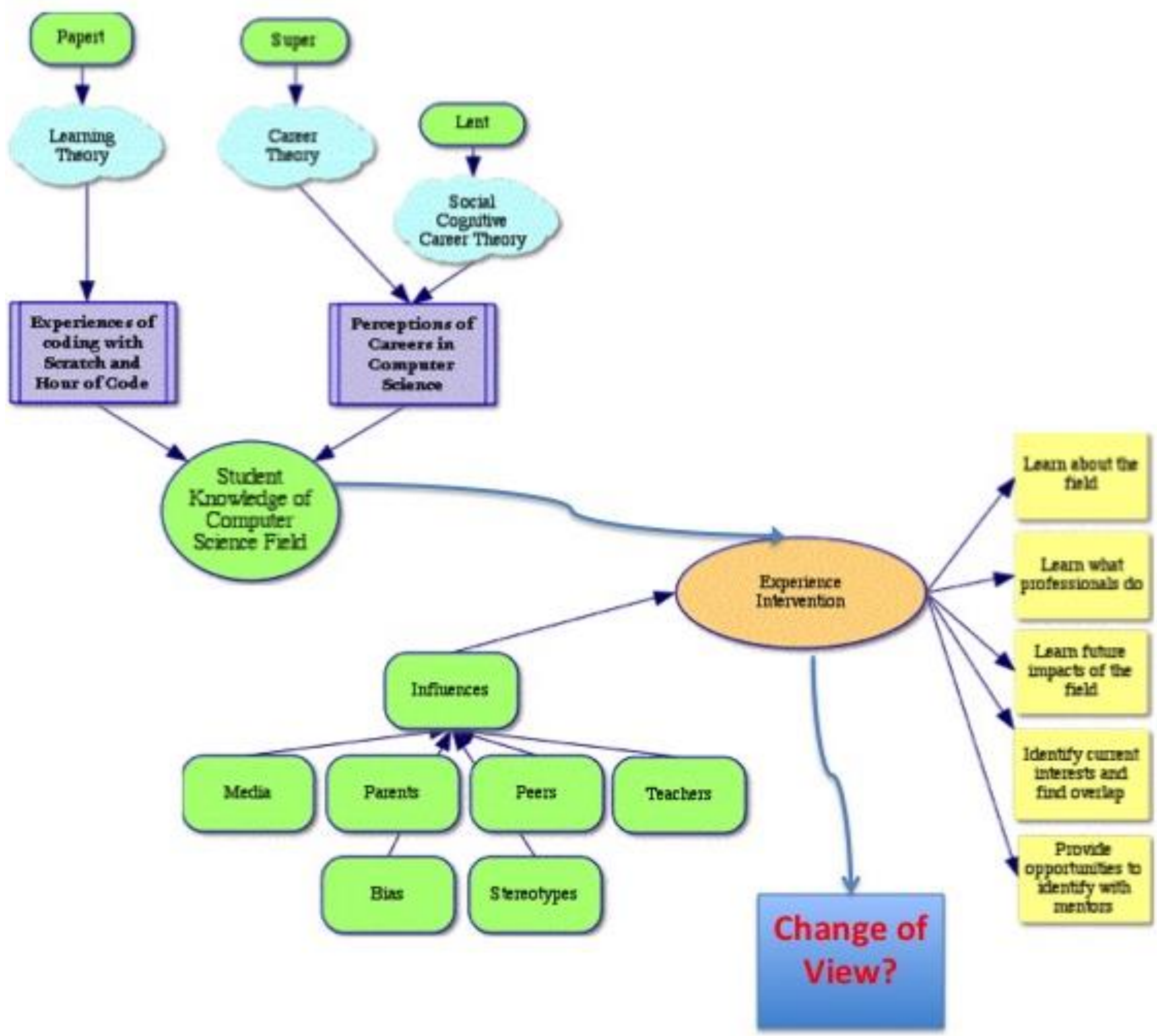


Figure 1-1. Conceptual Framework

the influences on the life of the student are joined by the rollout of the intervention. The intervention sought to enhance the student views by presenting information about the field in general as well as providing specifics about what computer programmers do in their line of work. Students had the opportunity to think about the overall impact of the field in the future. They were given opportunities to interact with professionals and have any of their questions answered with the potential of identifying with a role model



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currently involved the field.  Student attitudes were then reassessed at the conclusion of the intervention to identify changes.

**Research Questions**

As previously stated, the purpose was to perform an intervention to change middle school student perceptions with the hope of persuading more girls to study computer science courses in high school.  The intervention presented lessons for students for understanding the field in general as well as learning about career possibilities while simultaneously debunking current myths surrounding this career path.  Hopefully the intervention allowed students to see beyond their pre-existing stereotypes and maybe even identify with the possibility of some day seeing themselves in the field.

**Research Question 1** - How can exposure to an intervention that incorporates some CSP materials, specifically the global impact unit, lead to a more authentic perception of the professional field of computer science among an eighth grade student population?

**Research Question 2** - How can exposure to a CSP unit about the field of computer science and what computer scientists actually do, result in positive changes to student views about the profession of computer science, especially among female students?

**Context**

The school in the study is an independent K-12 day school on the west coast of Florida.  The lower school (preK-5) is located on a barrier island and the middle and upper schools share facilities on fifty-one acres in a newly developed community in Florida.  The eighth grade consists of seventy-one students comprised of thirty-nine



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females. The middle school science program was redesigned in order to address institutionally identified deficiencies in twenty-first century skills. The eighth grade science curriculum continues to include physical science as well as the addition of computer science (with part of it modeled after the CSP curriculum) to be team-taught by myself and another experienced science instructor. Both of us have had experience teaching the traditional physical science course in the eighth grade in the past as well as working together on the seventh grade science curriculum. Anecdotally, previous attempts at increasing diversity within the enrollment of the high school computer science classes and the middle school computing and robotics clubs have achieved little to no success. The schedule in the middle school has been redesigned and four sections of students were divided equally across two class periods and two teachers. Having the ability to swap and move students within and between two of the four sections created a great deal of flexibility in how the students met. This has enabled students to work at their mastery level. For example, during a unit on density, students that performed poorly on a quiz were grouped and given extra help while the students that did well experienced an additional task which allowed all of the students to achieve mastery of the density concepts.

**Role of the Researcher**

In my early career I worked as a computer programmer as a consultant to the Federal government and later as a Federal employee. My interactions with high school students as a volleyball coach led me to want to become a teacher and to teach computer science. Twenty-one years ago, I became an independent schoolteacher and I have taught grades 6 – 12 as both a technology integration specialist and as a science and a computer science teacher. I have taught AP Computer Science for eight years.



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The first half of my teaching experience was in single sex (female) education, however, upon my arrival in Florida I have taught co-ed classes. Prior to my arrival eleven years ago, our school did not have any computer science in the curriculum. After teaching there for a year I was given permission to begin teaching computer programming. I researched different options for curriculum through the International Society for Technology in Education (ISTE) and I learned of the work of the Computer Science Teachers Association (CSTA). CSTA had specific course recommendations that I followed as I created an Introduction to Computing Course for the high school students. Eventually I added more advanced courses including AP Computer Science A. Throughout the last decade I have always had small classes, but they always contained significantly more boys than girls. I have always wanted to grow my enrolment in my programming courses and I have always struggled with attracting female students to my advanced programming classes. Last year my AP CSA course was all males despite my recruitment efforts. I wanted to use this research opportunity as a time to reflect and examine what role I can have in helping my middle school students consider computer science classes in high school and beyond. One of the ways that I believe might help with the lack of diversity within our computer science enrollment is to increase exposure to computer science within our middle school. This last year, we modified my position and I am teaching solely in the middle school because the headmaster and I share a vision that the best way to grow the computer science program would be to focus my time and attention among the middle school students. We are trying to grow the program in the high school by exposing the middle school students to computer programming. We have modified the eighth grade science curriculum this year to



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include computer programming with both the block-based language of Scratch and the Java based language of Processing.

**Involvement**

Being the researcher, I was directly involved in every aspect of this study. This included being the science teacher for the participating students. Because the teacher and researcher are the same, it is clear that bias was present. Due to the fact that I taught the unit independently from my teaching partner in the class there was the possibility that my values and ideas influenced my students.

I recognized the potential for my bias so I decided to implement the methods for participatory action research as outlined by Dana and Yendol-Hoppey in *The Reflective Educator's Guide to Classroom Research* (2014) and kept daily notes throughout the study. According to Dana and Yendol-Hoppey the research process is cyclical so I continued to ask questions that identified and regulated my bias as I collected and analyzed data.

My students are enrolled in an academically rigorous school and they are always very conscientious about their grades. It was made clear to the students that their participation on the surveys was completely voluntary and was not graded. The students understood that they could opt out of all or part of the survey at any time with no impacts to their grades whatsoever. The artifacts that they created were part of the learning unit and were graded according to a rubric that was provided to them with each of the assignments. Because I co-taught the course, I had the ability to have the artifacts graded independently by my colleague as well for further corroboration. The development of interview questions was also a voluntary opportunity and was not a graded requirement of their science course. Students are required to keep notes in



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class daily on their iPads and they continued to do so throughout this unit the same as is required in the other units of the course. All of the eighth grade students participated as one of their science units. All attempts were made to avoid bias in teaching in terms of not trying to directly influence student attitudes by inserting any kind of editorial information and instead, I as the researcher needed to make all attempts at presenting the information in as neutral a fashion as possible. All attempts were taken to avoid having the students answer the surveys in a manner they perceived that their teachers would want. The students received the survey through Google Forms, a component to the G Suite for Education that is used daily. They were required to log in to their accounts for access, therefore their login names were automatically recorded so they didn't fill out their names. Students were told that their records could be identified so that their pre and post-surveys could be linked, and during data analysis once the records were linked and their gender was recorded their names were removed. In terms of sampling, the entire grade level that presented signed permission forms took part in the study so the data is only applicable to this cohort, but may or may not extend to the population outside of the school. Therefore, completion rates should not be an issue.

**Overview of the Research Design**

The intervention is presented as a case study design. The data sources for review are summarized in Table 1-1. A research question looking at changes in attitudes will be tricky to quantify. Attitudes lie within the affective domain:

> the domain of learning that involves interests, experience, and enthusiasm-is a critical component of science education. There is a substantial body of research that supports the close connection between the development of concepts and skills in science and engineering and such factors as interest, engagement, motivation, persistence, and self-identity. (National Research Council, 2013, p. xviii)



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Table 1-1. Research Design

| Question | Data Collected |
|---|---|
| How does exposure to the intervention that incorporates some CSP materials, specifically the global impact unit, lead to a more authentic perception of the field of computer science among an eighth grade student population? | • Pre intervention survey<br>• Lesson 1 – artifact about computer programmer<br>• Lesson 2 – elevator pitch and artifact about future invention<br>• Lesson 3 – artifact about CS impacts on chosen field<br>• Lesson 4 – Creation of interview questions for guests in the field and discussion posts |
| How does exposure to a CSP unit about the field of computer science including what computer scientists actually do, result in changes of student views about the profession especially among female students? | • Student impressions about interviews of guests as recorded in an online homework discussion post<br>• Student interviews<br>• Post intervention survey<br>• Spring course selections |

Because motivation and attitudes are so personal and highly correlated, we cannot always count on middle school students to answer honestly about their feelings. Tweens are trying to figure out who they are and often reflect what they think their teacher, their parents or their peers expect to hear, rather than what they are truly feeling, which becomes challenging to measure. In an attempt to dig deeper into student attitudes it was useful to employ a mixed methods design. Mixed methods research can enhance the body of knowledge that the researcher has by being able to assist the researcher to generate more questions (Caruth, 2013). Mixed methods allows for the corroboration of results from both quantitative and qualitative data



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(Burrows, 2013). By using both methods you can have opportunities to find new information that may not have been as obvious from one method, akin to the idea that two heads are better than one, to arrive at more trustworthy results.

This study followed the mixed method exploratory design as outlined by Creswell (2014). Additionally, the teacher inquiry methods of Dana and Yendol-Hoppey (2014) were implemented including a daily updated weblog that provided deeper reflection. The surveys and lessons were administered sequentially, but the addition of interviews helped to inform the design of the intervention as it evolved. Initially, students were surveyed about their understanding of what computer science is and what computer scientists do as well as their attitudes about the field with Likert scale and free response items. The survey intended to identify if the students current knowledge reflected the stereotypes that have been identified in the literature (Stoilescu & McDougall, 2011). When the survey was presented to students it looked like many of the knowledge assessments that they took throughout the school year because it was in the Google quiz format. It was imperative that the students understood that the point of the surveys was for their teacher to gather information about their opinions, and their responses didn't affect their grades in any way. Multiple items were presented so that students couldn't identify the answers they thought their teacher would prefer. The focus of the survey were questions about the students attitudes and beliefs about the field and what professionals in the field do as well as the influence of distal factors like friends and family. The CSP unit intervention expands students' awareness of the tools that are used and to explore the key roles that technology plays in their lives. Topics covered within this unit included identification of the field and the professionals that work



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in it. Students compared the impacts of technology in the past to current impacts of the newest inventions of today. Students also completed a future technology project that is outlined as part of the CSP global impact unit that focuses on the influence of computer science on society.

Within this unit I invited professionals to answer questions from the students. I engaged in an effort to recruit volunteers from former students who are working at tech companies and actively participating in biotechnology research but have backgrounds in computer science. I also contacted some agencies like Million Women Mentors to attempt to find as diverse a group of interviewees for students as possible to experience. I wanted the students to have the opportunity to interact during the interviews, so they composed the questions that were then provided to our guests ahead of time.

Once they were confirmed the mentor interviews took place in class and occurred between March 29, and April 5th. All students had their first interview in class on the 29th, as there was one for each class that day. Friday March 31st both classes again had an interview, although they were with different mentors. Interview questions were developed by students handing in a minimum of two questions as a homework assignment during the first week of the unit. This allowed time for review of the questions and they were then condensed and combined into a uniform list to be sent to the mentors on Monday, March 27th, so they would have time to review the questions before the interviews took place. All of the mentors responded and indicated that the questions were fine and all of them were excited to participate and help out the classes. The backgrounds of the mentors are briefly identified in Table 1-2



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Table 1-2. Mentor backgrounds

| Mentor | Experience | Location |
|---|---|---|
| Akele | Student currently pursuing CS degree with one semester remaining. Completed internship with social media company in San Francisco | Skype (South Carolina) |
| Keri | Third career position, currently working on software quality control for missiles for a defense contractor | Facetime (Nevada) |
| Meriem | Ph.D. candidate in computer science while working at a university in Hong Kong | Skype (Hong Kong) |
| Kristan | Former Silicon Valley career evolving to current position as entrepreneur owning a software design company specializing in geolocation applications | In Person |
| Kaylee | Recent graduate, completed internship with NASA and working on advanced space projects in a new position | Facetime (Virginia) |
| Brittany | Former school alum, finishing final semester at Duke and accepted to medical school two years ago. Former Google International Science Fair Grand Prize winner | Facetime/Skype (North Carolina) |

The current unit curriculum provided from CSP includes an assignment for students to design a future technology project. This was incorporated as the second lesson of the unit. The third lesson had students create something from their current fields of interest with the additional requirement of identifying how computer science impacts their chosen selections. Reviewing student artifacts provided data about student interests are and if they made connections between their chosen fields and the overall impact of computer science. However, through the work of Grover, Pea and Cooper (2016) there is a cautionary tale to not exclusively rely on artifacts to assess student learning. Students were also required to keep notes on their iPads and were



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required to make posts to an online discussion board as a homework assignment during this unit.

Finally, at the completion of the unit, students retook the survey to identify if their attitudes changed as a result of the intervention. Questions also addressed if they would be interested in taking computer science classes and if they think it is important for people in their fields of interest to have an understanding of computer science. In order to insure reliability of the measures, multiple artifacts were evaluated from the students throughout the unit to be sure that there was consistency in the performance of the individual students. Examining and matching the artifact scores to the learning objectives and rubrics of the individual assignments addressed content validity. Items were further evaluated for both content and face validity. The artifacts were also evaluated to measure both process and product to corroborate scores (Morrison et al., 2011).

**Ethical Considerations**

The students involved in the study were minors, and participation in the unit that included surveys and interviews was part of their regular course work. The survey assessments about their attitudes about computer science were not graded and students were informed and reminded of this by both teachers. All attempts were made to assuage any possible fear of grade retaliation for their views so as to not impact their decisions about participation. Consent for the study was obtained from school administration, their parents and through the IRB process at the University of Florida.

**Potential Design Limitations**

The outcomes of the intervention only apply to the students in the study. While it was hoped that the curriculum intervention changed attitudes and resulted in students



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seeking additional courses in computer science, there is no guarantee that these results are only the product of the exposure and experiences of what students received in the course. There is also the possibility that distal experiences could impact students during any intervention. This study measured student attitudes indicating there is more than one domain at work. Students can be influenced by role models, success in courses, self-efficacy, and parents to name just a few (Aschbacher, Ing, & Tsai, 2014).

**Significance of the Study**

Overall, since the content of the CSP course was designed for high school, this was an important opportunity to see how effective scaling some of the concepts to a middle school classroom could be. Because the course is and was designed as a brand new AP course, the concepts were carefully researched and created for a high school audience. It was hoped that this research resulted in the creation of a unit that is appropriate for any middle school audience. The team-based approach is new at our school and allowed for the flexibility of implementing a CSP instructional unit into the curriculum. Therefore, evaluations throughout the year continued to be formative with the intent of arriving at a summative assessment at the end of the course. Influencing student attitudes about computer science was critical to seeing changes in future enrollments, so any progress in this direction will be useful to the field. Ideally, the data gathered helps us to understand how the perceptions of the students either supported their pre-existing beliefs or can help shape or even redevelop their beliefs about the field and its careers. Enrollments in computer science courses at our school have remained low overall for both genders, but are much lower for girls than boys. Decisions were made about the experience of the intervention to attempt to make the field more appealing to girls. Working to understand student knowledge of stereotypes



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can be two-fold. There is a difference between understanding stereotypes and agreeing with them (Stoilescu & McDougall, 2011). The surveys for this study both confirmed and corroborated student views about the field. While there are examples of the effects of introducing programming components from the CSP in the literature, there were no studies identified that looked at changing student perceptions of stereotypes of the field in order to affect future enrollments. Enrollments in computer science courses are at the root of the lack of diversity in computer science professions.

## Definition of Terms

### Abstraction

As defined by The K-12 Computer Science Framework abstraction is a process or a product. The abstraction is a process of reducing complexity by focusing on the main idea, and as a product is a new representation of a system (The K-12 Computer Science Framework, 2016).

### Algorithm

An algorithm is a step-by-step process to complete a task (The K-12 Computer Science Framework, 2016).

### Computer Programming

Programming is the craft of analyzing problems and designing, writing, testing, and maintaining programs to solve them (The K-12 Computer Science Framework, 2016).

### Computer Science

Computer science (CS) has been identified as the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society (Barr & Stephenson, 2011).



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**Computational Thinking**

The term computational thinking is attributed to the work of Wing (2006), when she described its relationship to problem solving. To Wing, computational thinking is the way that humans solve problems, it is not thinking like a computer, rather it is thinking that complements and combines the processes of mathematics and engineering. Critical thinking is reflective and reasonable thinking that is focused on deciding what to believe or do (Ennis, 1985).

**CSUnplugged**

CSUnplugged is a collection of free learning activities that teach computer science through games and puzzles and do not require the use of a computer (Bell, Witten & Fellow, 2006).

**K-12 Computer Science Framework**

The recently released K-12 Computer Science Framework (November, 2016) identifies core concepts and practices and describes how they can be implemented at different grade bands. Intended as a guide for those setting standards, curriculum, assessments or other related programs, the framework represents a cooperative effort of some of the largest and most influential computer education proponents. Clearly, the Framework has come at a time when computer science is being recognized as something that parents want for their students in schools (Yadav, Hong & Stephenson, 2016). While it is a move forward that there is a growing awareness about the field, we will still need to find ways to interest all students in the field, otherwise we cannot hope to change the status quo.



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**Information Technology**

The definition of information technology has changed over time, but it is now often considered as a synonym for computer technology. However, information technology remains a broader term because it can include computer technology as a component or relate to more of the networking rather than just the processing of information (Odintsova, Kenesova, & Sarsekeyeva, 2013).



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# CHAPTER 2
# LITERATURE REVIEW

This review summarizes prior research about middle school computer science education. Middle school computer science education is a relatively new field so a preliminary investigation was undertaken to understand as many aspects of the developing discipline as possible. STEM literature seemed to be a logical starting point because of the overlap within the subjects. Additionally, the research about higher education and the gender digital divide provided relevant resources for understanding the field as it relates to the research questions.

## Computer Science and STEM

### Defining STEM Education

The strong parallels between STEM and CS workforce challenges make them complementary issues. While their solutions may prove to be different, it makes sense to use the research within both disciplines to inform the other. Therefore, the literature reviewed is sometimes different, but at the same time complementary. Today's growing awareness that we need computer science education has evolved with the recent focus on STEM education. One key feature that both STEM and computer science education have in common within the studies is that middle school is identified as the critical juncture where students, especially girls, begin to lose interest in science and math and become less likely to aspire to careers in STEM (Blanchard, et al., 2015; Brickhouse et al., 1998; Stoeger, Duan, Schirner, Greindl & Ziegler, 2013).

The National Science Foundation created the acronym of STEM with the intent of bringing attention to the disciplines within education where there was concern that students were not performing to expectations (National Research Council, 2014). While



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there have been recent initiatives and financial incentive programs in the news like Race to the Top, the White House Science Fair, US2020 and others that have spotlighted STEM, special attention to math and science can be traced back several decades. More recent attention to the acronym has led to an implied suggestion that we view the four previously distinct disciplines together (Guzey, Harwell & Moore, 2014). The more unified path, which is implicit in the acronym, has had many interpretations, however, beyond the four terms, there is no consistent definition of what constitutes STEM, yet the term has launched many initiatives in American schools (DeJarnette, 2012).

There are many STEM programs, but interestingly, what constitutes STEM education has different interpretations in different articles. This may have resulted from the word technology itself having been included in many different things such as techniques, skills, methods and processes that encompass and overlap the other three parts of the acronym. The NAS STEM summary of 2011 states that

> The T in STEM has always been easy to overlook, because it is difficult to define. Is it educational technology? Is it technology as a result of engineering? Technology has not been well incorporated into science standards, and although there are separate standards for it, its place has not been clearly established. (Beatty, 2011, p. 58)

STEM implementations have been within individual courses, integrated between courses or can even be an entire school dedicated to a program (Honey, 2014). According to Laforce, Noble, King, Holt, and Century (2014) a STEM school is defined as one which is rigorous, problem-based, personalized, teaches career and life skills as well as providing students with an internal and external community.

In 2011 the National Research Council of the National Academies convened a workshop to identify successful STEM education (Beatty, 2011). The workshop focused



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on determining criteria for success by examining models that were considered best practices and exemplars of STEM education. At that time it was noted that the disciplines of mathematics and science received more attention than did engineering or technology education (Beatty, 2011). The imbalances reflected the predominance of math and science within existing curriculums that were aligned with accountability procedures.

**The STEM Movement**

As previously stated, the inspiration for the STEM movement were disappointing national test score performances of math and science students coupled with the reports of workforce needs (DeJarnette, 2012). The global economy has dictated the need for professional workers in the STEM fields (DeJarnette, 2012). The workforce can be a terminal endpoint and therefore an important goal for education. The National Science Board (2015) has made the case that the workforce has a direct impact on national competitiveness, innovation and even immigration. The National Science Board summary also claims that although the term STEM workforce is referenced in law and documents, there is no consensus on how it is defined in terms of what fields are specifically identified as being STEM. Depending on the agency doing the counting, social science and health fields may or may not be included. What does remain clear is that the STEM workforce is seen as being critical to innovation and competitiveness, that there are multiple pathways to occupations and that assessing, enabling and strengthening pathways is essential to individual and national prosperity and competitiveness (Guzey, Hawell & Moore, 2014). Within the documentation of the National Science Board (2015) there is now a list of STEM occupations, of which the first listed is "Computer and Mathematical Scientists." While they were not initially



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included within STEM education, computer science professions are key components of the STEM workforce. Additionally, it is recognized that within the current STEM workforce there is a great deal of inequity and that women and minorities are underrepresented (Hill, Corbett & St. Rose, 2010). Regardless of whether you include computer science as a part of STEM, the largest gaps found within the workforce pipeline are in computer science (National Science Board, 2015).

Recognizing that the lack of consistency in the definition of what constitutes best practices in engineering the work of Moore, Glancy, Tank, Kersten and Smith (2014) looked at the development of a framework for describing what constitutes a quality engineering education in a K-12 setting. In this case they felt that engineering was a natural integrator for STEM and the parts of the framework included the process of design, engineering thinking, tools and techniques, ethics, and teamwork (Moore et al, 2014).

**STEM Education as a Model for Computer Science**

STEM education programs were hoped to be the solution to the workforce pipeline. Increasing student experience and interest in the STEM fields was seen as a way to increase the flow of students into higher education programs and ultimately into the workforce. Interestingly, one of the largest gaps within the workforce is within computer science careers (Rodger, Hayes, Lezin, Qin, Nelson & Tucker, 2009). The majority of the unfilled jobs are actually in information technology and these programs are not being addressed by current STEM initiatives. It is therefore logical that we need to look at bringing CS education to more students.

Looking to the STEM literature we can find important variables and factors that are also present in the challenges of computer science education. Sanders (2012)



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states that he feels the term STEM education has been worn out and yet there is still no agreement regarding its meaning.  Sanders outlines the importance of integrative programs as best practice for STEM (2012).  Intentionally integrating engineering design-based learning into the practices of math, science and even languages and social studies represent the best pedagogical approach (Sanders, 2012; Reimers et al., 2015).  Hansen and Gonzalez (2014) looked at student achievement in STEM and noted that STEM learning should integrate technology, reach across disciplines, relate to real world problems, and be project based. Madden et al. (2013) suggest through a curriculum mapped with a technology company that the skills needed for workers include communication, organization, work well with others and are creative lifelong learners. In keeping with these Wang et al. (2011) looked at STEM integration and at teacher perceptions necessitated by the movement away from the traditional silos to more integrated approaches. Within their work Wang et al. make a distinction between multidisciplinary and interdisciplinary approaches.  Using the metaphor of a pizza, multidisciplinary is when the parts come together to make a new whole, and interdisciplinary just has boundaries that are blurry between the ingredients (Wang et al., 2011).  There is research that supports an interdisciplinary approach especially when students begin with real-world problems and include critical thinking and problem solving skills (Wang et al., 2011). Indeed, most real-world problems cross through different disciplines with lines that are blurred between them (Valtorta & Berland, 2015). Likewise the connections for students can be explicit or implicit. In the case of explicit instruction connections, the material is present in multiple formats and disciplines. Implicit connections are those, which are not pointed out by the instructors (Valtorta &



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Berland, 2015). Curriculum integration results in knowledge of the real world because it has connected experiences with prior knowledge as a result of meaningful collaboration (Wang et al., 2011). Wang et al. also conclude that the best integrative approach includes problem-solving skills with inquiry-based instruction. Studies have indicated that there is a possibility that girls benefit from inquiry-based learning (Kim, 2015).

One of the trends that evolved from a desire to shift away from the traditional silo methods to integrated STEM education is the need to allow students to construct their own knowledge. In keeping with the theoretical framework DeJarnette (2012) notes that the most effective science education is one where students are allowed to construct their own knowledge and expertise through procedural and pedagogical methods that encourage and support inquiry. One of the best techniques to achieve this is problem-based learning (PBL) which has been known to keep or increase students interest in science careers (Asghar, Ellington, Rice, Johnson & Prime, 2012; Gibson & Chase, 2002). PBL has also been linked to growth in building self-efficacy (Hansen & Gonzalez, 2014). "Scientific problem-based activities promote critical thinking and engage students in science" (DeJarnette, 2012, p. 80). Increasing student engagement is facilitated by PBL that deals with real-life problems (Hansen & Gonzalez, 2014; Newman, Dantzler & Coleman, 2014). Another parallel to STEM from computer science is in challenge based or problem based instruction, which is the desire to break large tasks into smaller, easier challenges to be solved (Berland et al., 2013; Borrego & Henderson, 2014). This is similar to the large complex problems students are encouraged to solve using the engineering design process. Use of these methods has a parallel in computer science in that abstraction and problem deconstruction are



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among the most basic and important concepts for students to master (Meerbaum-Salant, Armoni, & Ben-Ari, 2011).

The STEM literature correlates to computer science in that there is a shortage of experienced engineering instructors (Newman et al., 2014; Reimers et al., 2015). Similarly, it has been reported that nationally 67% of physics and 61% of chemistry teachers were not certified in their field (Newman et al., 2014). One of the biggest challenges in STEM education is that there is not sufficient content knowledge or comfort with engineering concepts (Reimers et al., 2015). There are few programs where pre-service teachers are taught engineering concepts and there are few professional development programs for those currently employed (Reimers et al., 2015). Additionally, effective professional development needs to be prolonged and ongoing and allowing for continuous feedback and follow-up (Reimers et al., 2015; Wang et al., 2011). Ralston, Hieb and Rivoli (2013) indicate that building effective change will require the creation of a cohort of teachers who can adopt an engineering curriculum.

One of the most important aspects that STEM and computer science have in common is that both programs require critical thinking about real world problems (Wang et al., 2011). Computing and computational thinking have been growing and gaining significant attention so that resources can now be targeted to advancing these programs (Israel, Pearson, Tapia, Wherfel & Reese, 2015).

**Outreach and After School Programs**

In 2014, the National Research Council of the National Academies assembled the STEM Learning is Everywhere Convocation that took another look at problems in STEM education. This forum paid special attention to the ways that students receive



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STEM outside of school by participating in activities such as afterschool and summer programs, in organized activities and in programs at institutions such as museums and zoos (National Research Council, 2014). One of the invited speakers, Dr. Bruce Alberts (2014) declared that the ambitious goals of science education included enabling all children to acquire the problem-solving, thinking, and communication skills of scientists, as well as the need to cast the widest net possible to recruit science talent. This is extremely relevant to computer science education because up until Code.org began its initiatives in 1993, computer science education was mostly absent from K-8 education, and the majority of computer science education for K-8 students happened outside of the traditional classroom (Wilson et al., 2010).

One of the ways that schools have tried to address shortfalls of students in the STEM pipeline is through the creation of outreach programs. Programs that are not part of a school curriculum, but are created to supplement learning include extracurricular programs that can meet after school, during the weekends and summer camps. The most successful outreach programs are those that introduce hands-on learning to students at an early age (Ralston et al., 2013, Starrett, Doman, Garrison & Sleigh, 2015). Surprisingly, Ralston et al. (2013) note that there was no statistical significance in the self-efficacy of students who participated in outreach programs, and that the only programs that saw increases in student self-efficacy were rigorous semester long courses. Watermeyer (2010) noted a positive change in self-efficacy of secondary school aged girls that participated in an outreach program *Discover!* that was a collaborative mentored Saturday program in the U.K. Dubetz and Wilson (2013) also identified that teacher encouragement to participate in a hands-on middle school



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Saturday outreach program (GEMS) was more important than parent support.  A girls STEM conference exposure showed girls enjoyed computer science activities that were challenging and fun (Groover, 2009). A research based mentored after-school middle school robotics program found that students gained greater interest about careers in engineering and had a positive impact on the broader school culture (Blanchard, Judy, Muller, Crawford & Petrosino, 2015).  It is also reported by NCES that, "eighth grade students from all demographics who report doing science-related activities that are not for school score higher on national science assessments" (Barton et al., 2013, p. 72). There have been numerous introductions of coding using tools like Alice and Scratch in after school and camp programs that have been successful in building student interest in computer science (Rodger et al., 2009; Sontag, 2009; Werner, Campe & Denner, 2005).

**Results of Early Adoptions in School Programs**

One of the most successful engineering (STEM) curriculums we have seen implemented to date is Project Lead the Way (PLTW).  PLTW has shown to be adequate preparation for science and engineering courses in college (Ralston et al., 2013). While test scores have yielded mixed results for this program, it has been suggested that teacher comfort with the materials and their experiences with professional development has been both good and bad results in inconclusive testing (Valtorta & Berland, 2015). Research has also pointed out that deeper understanding occurs when students can identify a purpose for what they are learning (Valtorta & Berland, 2015) and that this idea is important when designing science and math curriculum.  When students can understand and make connections deeper learning is achieved.  PLTW is known for an integrated curriculum that focuses on real world



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problems, and while there are growing amounts of higher education institutions that are providing support, there are issues with teachers who are not trained in implementing a STEM curriculum (Nathan et al., 2011). Teachers' comfort level is key to determining if they will invest time into learning the methods and if they can be retained as STEM teachers (Stohlmann, Moore & Roehrig, 2012) because similarly to their students, teachers' comfort with the content knowledge has a large impact on their self-efficacy and longevity.

**Importance of Mentoring and Modeling**

Mentoring has been found to be a successful tool for STEM education especially in middle school settings (Nunez, Rodario, Vallejo & Gonzalez-Pienda, 2012; Stoeger et al., 2013;). Mentoring aimed at preventing dropout in math, science and engineering courses and majors has been a successful tool in postsecondary education (Larose et al., 2011). In a study of 11-18 year old females who were mentored by female college students majoring in STEM fields there were learning and achievement gains as well as an increased likelihood of taking more science courses (Stoeger et al., 2013). In addition, Stoeger et al. have confirmed that mentors of the same gender and mentors that are as close in age as possible to their mentees tend to be the most effective. Similarly, when an inquiry-based project was paired with online mentors who were scientists in their field, the researchers reported a break down in myths and misconceptions that middle school students had about scientists as well as increasing the students' confidence in their math and science ability (Qing et al., 2010). There were also gains to college students who mentored middles school students in an after school program through the development of empathy in the former, along with academic gains made by the latter (Carroll, 2014). Carroll looked at the importance of design



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thinking skills for building cognitive and social skills. The author provides evidence that early intervention may help in student perceptions. Another important aspect seems to be the introduction of within field mentors, although the studies that highlight the importance of mentoring are at the collegiate level (Larose et al., 2011).

Britner and Pajares (2005) predict that mentoring is important to middle school students because being told they have the ability to do well is an important key for female and minorities who may not as often see themselves as scientists. A study performed by Reisel, Jablonski, Munson and Hosseini (2014) found that mentoring for freshmen engineering and computer science students was effective in retention, but most effective in advanced math courses. Ing, Aschbacher and Tsai (2014) have shown that interest in science and engineering careers increases or is more persistent when a middle school student knows or has a relationship with an engineer or a scientist.

An interesting study by Buck, Plano Clark, Leslie-Pelecky, Lu and Cerda-Lizarraga (2008) determined that eighth grade girls identify with a role model if there are personal connections and their image of scientist helped them believe they could have a connection with a scientist. What was also interesting in this study was that the scientist mentors felt pressure to portray themselves as perfect scientists. The researchers noted changes in the images for both the students and mentors as the relationships developed between them.

Similar to mentoring, modeling activities provide a rich vehicle for introducing engineering education into the classroom. English and Mousoulides (2011) have shown that modeling can help students make sense of complex problems. Key features for



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models for students are to have sufficient criteria to self-assess if a model is effective, the ability to relate to and make sense of a problem, creation of representations, and generalizability to other related problems.

Mentoring has been shown to be a powerful tool to keeping students engaged. The supportive relationships which place a more experienced learner with a less experienced partner allows for a trust based relationship that can provide support. Mentoring programs that match like gendered individuals, or with mentors working in the industry have both proven to be successful (Larose et al., 2011). After school programs for middle school girls that have provided girls with an opportunity to create computer games in a collaborative setting have been shown to improve not just informational technology literacy but have improved informational technology fluency (Werner, Campe & Denner, 2005). Studies also suggest that girls are more successful learning programming when they are exposed through a guided discovery approach (Miller & Webb, 2015).

**Why CS is Different than STEM**

**Creating vs. Using.** One of the issues that set CS apart from STEM as a discipline is that many of the people responsible for making curriculum decisions do not understand what computer science is and what it is not. There is often confusion between using computers and program applications with creating them. When Fidoten and Spacco (2012) surveyed liberal arts faculty they determined that only a third of the faculty were able to correctly distinguish between computer science and information technology. Sadly, it is common to confuse working with computers and computer applications as computer science (Rodger et al, 2012). For example for many years computing in New Zealand schools was focused on teaching students how to use



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computers, and there was little opportunity for students to learn about programming and computer science as formal subjects (Bell, 2014). If the people that are in charge of creating educational opportunities such as administrators and school board members do not understand that the two things are different, then it is unlikely that they would implement changes in their schools.

## Computer Science Education

The issues that plague computer science education were first addressed by the *Running on Empty: The Failure to Teach K-12 Computer Science in the Digital Age* (Wilson et al, 2010) report. The report was corroborated in the analysis provided by Grover and Pea (2013) that focused on the lack of computer science standards, computer science courses, as well as the lower, disproportionate amount of women and minorities studying computer science throughout secondary school education. Of course, the low numbers of women studying computer science reflected the lower numbers of women in the computing workforce.

### Rationale for Computing in K-12

One of the first nations to address the need of K12 computer science education was the United Kingdom. After noting the declining enrollments the Computing At School (CAS) initiative was a grassroots effort to increase skills that combined teachers and lobbyists for the field (Brown et al., 2013). A significant survey project undertaken by Google and Gallup identified perceptions, access and barriers to K-12 computer science education. Overall, the surveys showed that there are many incorrect perceptions of the field, but there is overwhelming evidence that parents believe that computer science should be taught in the schools, while administrators falsely perceived that parent demand is low (Wang et al., 2016). While there is a desire to add



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computer science to K-12 education, there has not been much thought about the best way to teach children the concepts (Grover & Pea, 2013).

Another element to understanding the acceptance of computer science programs can be found in the research of Straub (2009), who states, "Technology adoption is complex, inherently social, developmental process; individuals construct unique yet malleable perceptions of technology that influence their adoption decisions" (p. 625). Straub goes on to define innovation as any new idea to a population that is important to consider as we look at the new tools that have been developed to teach computer science.

**Shrinking Education Pipeline**

The middle school years have been targeted as the point at which students begin to consider careers and think about courses for high school (Graham & Latulipe, 2003). If computer science is not an option in these early years they will eliminate themselves from advanced degree programs later in life (Weisgram & Bigler, 2007). Factors that contribute to low enrollments are that not all schools offer computer science, and many lack qualified computer science teachers (Rodger, Dalis, Gadwal, Hayes, Li & Liang, 2012). The middle school years have been identified as a key time for identity building and developing proclivities towards specific academic fields (Grover, Pea, & Cooper, 2014; Rodger et al., 2009). Therefore, any effort to broaden participation in a discipline must consider these years as critical.

Using longitudinal data Tai, Liu, Maltese and Fan (2006) showed that students who expressed a desire to have a career in science are more likely to graduate with a science degree. Additionally, high mathematics achievers that were determined by achievement scores with science interest held the highest rates of earning physical



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science or engineering degrees. This is significant because students who take advanced science and math courses in high school are correlated with successful outcomes in four-year postsecondary institutions (DeJarnette, 2012).

There is research that attempts to answer why a discrepancy begins in middle school (Rodger et al, 2012). The problem can be summarized as stemming from issues that are most often related to the experiences of the students. Prior research overwhelmingly reports that there is an incorrect understanding of the discipline as well as negative attitudes about computer science among students (Grover, Pea & Cooper, 2014; Grover, Rutstein & Snow, 2016). How science is taught can affect learner attitudes as self-efficacy correlates with science achievement, as well as affecting a learners' interest in science as a subject and career (Liu, Hsieh, Cho & Schallert, 2006). Yardi and Bruckman (2007) have provided evidence that students perceive computer science to be difficult, boring, lacking real world context and the experience of those who work in the field is that they work in isolation. When a class of college freshmen were asked to draw a picture of a computer scientist, all of the class drawings were of white males regardless of who drew them. The drawings support the notion that students are not identifying with the field and that they do not have a clear understanding of what is involved in the work (Martin, 2004), which is consistent with the data found this year (Wang, Hong, Ravitz & Moghadam, 2016). Guzey, Harwell and Moore (2014) confirmed that positive attitudes toward science lead students to pursue science. Although students use technology regularly, most do not have a clear understanding about technology careers (Craig & Horton, 2009). Many teenagers perceived computing to be boring, solitary and not relevant, however graduate students



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in the field identified the field as being exciting and having a positive social aspect on the world (Yardi & Bruckman, 2007). The research of Weisgram and Bigler (2007) showed that teaching about discrimination of women in science fields can lead to girls being more determined to make a difference and increase the desirability of a career in science.

Among college students, when it is time to choose a major they look to identify with a field for a chosen profession. If the students harbor preconceived notions about the field that are unfavorable, they will not choose to major in those fields (Cheryan, Plaut, Handron & Hudson, 2013).

**Middle School Career Choices**

Since middle school is important as students develop their career identity it is logical that we look to increase access to programs at this level (Grover et al., 2014). While the CSP curriculum will introduce more students to computer science at the high school level it may be too late to provide the long range forecast of women entering into computer science majors in college (Settle et al., 2012).

## Women in Computer Science

While today's education and employment gap for women is real, the lack of women in various computing fields has not always been the norm. Notably, the computer science field has a history of female pioneers. From Ada Lovelace to Grace Hopper, to the staff of the ENIAC project, to the women code breakers like Rock, Lever and Clarke of Bletchley Park during World War II the field was more evenly divided in terms of gender (Lee, 2001). What happened to computing that the shift has been so distinct since the 1960s? Among the possible answers the work of Bench, Lench, Liew, Miner and Flores (2015) suggests that the imbalance of individuals entering the field



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might have something to do with men overestimating their ability rather than women underestimating their abilities. This idea could explain some of the shift in which women do not see themselves as successful in the math and science courses and hence do not take them. This gender gap that is held by many women in that they do not believe they have the ability to learn difficult math (Brickhouse et al., 2000) is something that could explain why there are lower enrollments of females. The work of DeWitt, Archer and Osborne (2013) point out mismatches between student ideas about science and scientists that result in students finding science to be important, but not for them.

**Gender Bias**

Views about science that form in middle school support the context that it is important to participate in science education, but that being a scientist is undesirable (DeWitt, Archer & Osborne, 2013). This bias often surfaces during middle school and it affects significantly more females than males (Aschbacher, Ing, & Tsai, 2014; Kim, 2015). While this is an area that is important to development it has been shown that stereotypes are often situated as a result of the attitudes of teachers and parents (Shapiro & Williams, 2011). Typically middle school students view computer science as difficult to understand and that boys were better suited to pursue the field (Jones, Howe & Rua, 2000). The Anita Borg Institute (ABI) claims that early on, societal stereotypes and unconscious bias reinforce the perception that girls and minorities are not as good as white boys in STEM disciplines (Simard, 2009). This bias, which is most often unconscious, can be exhibited by parents, teachers, and even mainstream media and results in discouraging girls and minorities from pursuing computer-related activities (Kekelis, Ancheta & Heber, 2006).



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Regardless of past history, today's gender gap in both STEM and computer science is real. Potential causes have been examined by scholars and those that focus on self-efficacy have shown to have high correlations between student beliefs and choices. Britner and Pajares (2005) have identified student belief about their ability to be successful as the number one predictor of their self-efficacy. Overall, these authors found that students construct their self-efficacy through four main sources, previous experience, observing others, the judgments of others, and mood states that can be influenced by anxiety or stress. While middle school students depend more on previous experience, high school students were more sensitive to input from peers and adults. A case study of middle school students in an engineering enrichment program found that girls' belief in their own skills was more positive than the view that the boys' held about them (Redmond, Thomas, High, Scott, Jordan & Dockers, 2011). Similarly the work of Shapiro and Williams (2011) on the role of stereotype threats shows that stereotypes are often situated through self-affirmation tasks or the presence of role models.

An ethnographic study by Barton et al. (2012) looks at the creation of identities as being socially negotiated and focuses on how girls from non-dominant backgrounds identify with science over the course of their middle school years. The ethnography points to the importance of understanding the formative experiences of youth because career aspirations develop during middle school. If we are going to see a shift in middle school career aspirations we need to integrate computer science into the curriculum (Repenning, 2012). Aschbacher, Ing and Tsai (2014) took a look at how expectancy value theory affected perceptions. Expectancy value theory looks at motivation as it relates to a person's belief about how successful they can be at a task as well as how



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important the task is to them. They found a positive correlation in the relationship between science self-perceptions and career aspirations. Another possible cause for the lower presence of women in computer science could be attributed to the perception of computer science as hard and boring (Carter, 2006; Repenning, 2012). The work of Marcu et al. (2010), suggests that computer science and engineering courses for middle school girls should support flexibility, experimentation and play. It can also be that beliefs about stereotypes lend themselves to gender bias.

**Role of Stereotypes**

Studies among college students that have found that females and males have preconceived stereotypes of a computer science career as being menial, isolating, and technical (Beyer, Rynes, Chavez, Hay & Perrault, 2002; Clarke & Teague, 1996;). The stereotypes about the culture of the field including the type of work and the people that do it are what deter females (Cheryan, Master & Meltzoff, 2015). The research of Beyer (2014) confirms that positive experiences with computer science courses correlated to gender differences about the self-efficacy, interests, values, and interpersonal orientation. The work of Cooper (2006) pointed out the self-fulfilling prophecy of gender stereotypes because the general public believes that men and boys have greater interests and proficiency with computers than females.

The study by Crombie (1999) compared enrollments in Canada of all-female sections to co-ed sections of computer science courses and found that girls from the all-female classes held similar levels of confidence about their work, but girls from the co-ed classes were less confident and did not enjoy working with computers as much as their male counterparts. Twelve years later Stoilescu and McDougall (2011) declared



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that the influence of negative stereotypes among computer science education had become ubiquitous.

What accounts for women not choosing information technology (IT) careers has been studied and it is believed that women value different aspects of work than their male counterparts and "parental and family influences as well as social pressures may contribute to divergence in occupational patterns" (Rosenbloom, Ash, Dupont & Coder, 2007, p. 553). It may be that the incorrect perception of working alone or that the field is dominated by nerds lacking social skills that is responsible (Wang et al., 2016).

Another interesting study compared the attitudes of two groups of women where one group was exposed to media that supported the traditional stereotypes and found that the media had a significant impact on the resulting perceptions of the participants (Cheryan, Plaut, Handron & Hudson, 2013). The work of Cheryan, Plaut, Handron and Hudson (2013) has uncovered a number of stereotypes for science fields including the perception that computer scientists have strong interests in programming and electronics, that these interests result in the exclusion of being people oriented: that they lack interpersonal skills and are socially awkward, they are intelligent, male, and they are unattractive, pale, thin and wearing glasses.

**Benefits of Learning Computer Science**

One area that has not been fully investigated is the idea of computing as a medium for teaching other subjects. While the work of Papert (1980) began in this direction, and there are studies about modeling (Khine & Saleh, 2011) there is a distinct lack of empirical work about the problems faced by beginning programmers (Grover & Pea, 2013). Rogers et al. (2012), have suggested leveraging the availability of educational technologists to add to those available to teach computer science and



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computational thinking. It was their experience that the best way to integrate computing into middle school was through technology teachers by getting them to work with the other traditional disciplines like math, science, history and world languages.

With the work of Papert (1980) and the creation of LOGO, the development of Smalltalk and Apple's Hypercard we had the first small wave of teaching computer science in the 1980s (Grover & Pea, 2013). Prior to our understanding of the importance of computational thinking we had the idea of teaching and learning computational literacy. Computational literacy and later the term procedural literacy is evident in the literature of the 1980s (Grover & Pea, 2013).

When looking at programming skills in particular Armoni, Meerbaum-Salat & Ben-Ari (2015) have identified three categories including kinesthetic, visual programming environments and robotics of computer science activities for children. It has been pointed out that we now have tools to teach programming, but programming is still not taught in the majority of public middle schools (Repenning, 2012).

**Computational Thinking**

The most important writing in computational thinking was a Viewpoint piece that appeared in a peer reviewed journal by Wing (2006), which was determined to be the most cited reference with 1562 citations to date, and is foundational to computer science education studies. It is important to teach critical thinking skills and the programming tools available today like Scratch and Alice provide a model for integrating computer science into all academic disciplines (Rodger, Dalis, Gadwal, Hayes, Li, Wolfe & Liang, 2012). Alice has been successfully used as a tool to engage middle school students in camps, after-school programs and within traditional course work (Rodger et al., 2009).



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Along with the need for computer science education, the literature reveals the need for students develop computational thinking and critical thinking skills. The terms computational thinking and critical thinking have grown throughout the last decade since Wing's influential article (2006). There is a relationship between the two in that computational thinking is a problem solving method that synthesizes critical thinking and existing knowledge using computer science techniques to solve problems (Voskoglou & Buckley, 2012). It is also important to understand that programming requires more than just coding and that computational thinking is applicable to daily lives as was evidenced by a comprehensive review of 27 research articles (Lye & Koh, 2014). In 2014, Dr. Alberts was the keynote speaker at the National Research Council of the National Academies STEM Learning is Everywhere Convocation. Dr. Alberts encouraged students to acquire problem solving and thinking skills, because he was advocating for the inclusion of computational thinking into the curriculum. While this is a worthy goal, Cooper, Perez and Rainey (2010) worry that computational thinking is too confusing for many teachers because without being a computer scientist, the terms mathematical, algorithmic and quantitative reasoning are hard to differentiate. Therefore, they advocate that computational thinking be designated as computational learning that is a more iterative interactive process between a human and a computer (Cooper, Perez & Rainey, 2010).

Recognizing Wing's (2006) call to action about computational thinking and similar literature that points to the importance of teaching computer science along with computational thinking (Guzdial, 2008) the National Academy of Sciences held workshops to explore computational thinking and pedagogy (Grover & Pea,



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2013). Grover and Pea point out that much of the previous work focused on the tools for developing these skills and did not answer many of the questions educators possess in terms of the pedagogy and process of building computational thinking skills. This has led to a situation where there is a rush to introduce children to these concepts "without much thought of how children will best learn CS concepts" (Grover & Pea, 2013, p. 723).

## Successful CS Implementations

While there are not a lot of schools that currently offer computer programming to K12 students, there are some programs that have incorporated elements of programming within them. One such program that has evolved from the focus on STEM has been the maker movement (Loertscher, 2012). Initially maker consisted of a community of hobbyists who would come together to build and tinker where tinker is a term borrowed from the MIT Media Lab. The movement has expanded to library spaces and even some classrooms and it is also exposing more students to computer science (Martin, 2015). The combination of digital tools with an exploratory maker mindset have evolved into a growing trend that often incorporates many of the tools to learn computer programming with crafts, electronics and community support. Overall, the maker movement is a class of activities that center on building or repurposing materials for play or function that can utilize digital physical tools like 3D printers or programming tools like Scratch (Martin, 2015). Martin also shares characteristics of the maker mindset that include playfulness, growth orientation, failure is acceptable while learning and collaboration are all imperative to creating a knowledge building community (Martin, 2015). He also identifies one of the keys to Maker's success in schools will be that it will need to maintain the collaborative and growth mindset, and if it becomes tool



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centric, it will be destined to fail. While some versions of the maker movement are evident as extra-curricular events, some schools are beginning to incorporate maker labs into their academic settings. These implementations are an early success in bringing computer programming to the K12 student.

**Game Based Learning Using Computer Tools**

Another aspect of using the beginning programming tools like Scratch and Alice is that they allow students to play and make games (Rodger et al, 2012). Both gamification and game based learning are current topics in education. Another advantage of the beginner tools is that they are scalable, which has a broad appeal to students regardless of background (Gibson & Grasso, 2009). Scalable games are thought to be powerful tools to introduce and expose students to computer science (Basawapatna, Koh & Repenning, 2010). Repenning (2012) believes that the ability to create a working game is the most important ingredient in changing middle school student's perceptions about computer science.

One of the most promising studies about student engagement with computer science is that of Buffum et al. (2016) in which they implemented a middle school game based curriculum derived from the CS Principles course into a twenty session in school course. Survey results indicated that the program successfully improved student attitudes about computer science in students who were not predisposed to in their attitudes in a way that the enrichment programs had not. Another promising study by Carter, Blank and Walz (2012) implemented a middle school curriculum with computer science concepts that were designed and presented by graduate researchers in computer science. Their qualitative study focused on delivering the breadth of computer science with the specific goal of having students develop interest in the field that



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showed high engagement in students but the program was only evaluated anecdotally through student participation in voluntary games.

The work of Werner et al. (2014), developed a framework to identify the three dimensions that are acquired while programming that include knowledge, strategies and models. Their analysis of computer gaming programming suggests that creating games can be a good way to increase student interest and their framework can be used to assess computational thinking. Likewise the work of Buffum et al. points to the importance of measuring learning gains while creating games (2015). However, it is important to note that the work of Doran, Boyce, Findelstein and Barnes points out that students limited understanding of computer game creation leads them to have unrealistic expectations about what they can achieve in the classroom (2012).

Basawapatna et al. (2011) looked at computational thinking patterns in games and found that students were able to transfer their game learning to other situations or contexts. Students who had worked with visual programming environments also showed evidence of successful transfer of concepts (Basawapatna et al, 2011, Armoni, Meerbaum-Salant & Ben-Ari, 2015). One potential indicator is in the work of Miller and Webb (2015) in that students who were not able to create fully functioning games were unable to identify themselves as computer problem solvers and were less likely to see themselves as pursuing computer science classes. However, math ability has a high correlation with success in computer science (Grover, Roy & Pea, 22016).

Gender preferences have also been identified when creating computer games. Girls like games that were linked to math, and also preferred games that had the opportunity to create things rather than destroy them (Stewart-Gardiner et al., 2013). In



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the work of Webb and Rosson (2013) girls tended toward storytelling activities even when they were capable of far more complex computational concepts, but the most important aspect was providing scaffolding while learning computer science concepts.

### Robotics

One additional area that provides overlap between STEM and computer science is robotics. Educational robots are one of the best ways to get students excited about STEM and computer science (Kurkovsky, 2014). There are robotics tools that are providing an opportunity to teach concepts from several disciplines at all grade levels. Research projects involving robotics are always interdisciplinary and require the computational thinking and mastery that has been advocated by Wing and others.

## Challenges to Computer Science Adoption in K-12

### Teacher Shortages

Goals for future computer science education remain in teacher education. There are very few education programs that train teachers to teach computer science. Currently there are initiatives like CS10K that have been funded by the National Science Foundation (NSF) and maintained by the American Institutes for Research (AIR) that seeks to have 10,000 well-trained computer science teachers in 10,000 high schools across the United States (https://cs10kcommunity.org/). One of the goals listed by Code.org is to prepare new computer science teachers (https://code.org/about). There are some state initiatives such as Georgia Computes! that are attempting to rectify the situation (Guzdial, 2008). However, there are only a handful of states with programs such as these.

DeJarnette (2012) suggests that universities should reach out into their surrounding communities to provide training for veteran teachers and more should be



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done to encourage students to take rigorous academic courses. There has been work that has demonstrated the challenges that teachers face in new interdisciplinary STEM courses.  It should be noted by Rodger et al. (2012) that, “from our experience, the best way to integrate computing into middle school is through technology teachers, getting them to work with teachers in other disciplines” (p. 426).

Teacher professional development is exceedingly important no matter the field.  However, veteran teachers who are being asked to teach new content like computer science are facing in motivation and self-efficacy that are not unlike the challenges of their students (Albion, 2001).  Retention of these teachers can be increased if they are motivated and supported.  One of the ways to support them can be in the creation of communities of learning and practice both in person and online through a robust learning management system (Hardre et al., 2013).

**Computer Science Assessments**

One of the obstacles to bringing these tools to the classroom is that we are lacking in methods of assessment (Grover & Pea, 2013).  Judging the effectiveness of any tool is not possible without assessment and this is one of the next steps CSTA is taking by looking at this problem and making recommendations about assessment techniques (Yadav, Burkhart, Moix, Snow, Badura, & Clayborn, 2015). The Task Force led by Yadav et al., conducted some studies to evaluate the challenges teachers face in assessing students in computing concepts and explore assessment practices in computer science. For computer science to become more accepted within the curriculum there will have to be methods that can leverage support to the design and development of standards-aligned and performance-based assessments (Yadav et al., 2015).



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Integrated, design-based approaches that are common practice in computer science provide teachers with assessment challenges (Harwell, Moreno, Phillips, Guzey, Moore & Roehrig, 2015). In terms of the assessment issue, Werner, Denner and Campe (2012) have looked at ways to measure computational thinking in middle school classrooms. By utilizing paired programming techniques Werner et al. (2012), found that their model was motivating and showed marked progress in comprehension. Paired programming was found to have a significant positive effect on assessment scores and the longer students spent with a partner, regardless of initial ability, the higher they scored on individual assessment (Tabet, Gedawy, Alshikhabobark & Razak, 2016; Werner, et al., 2013). It also should be noted that partnering on difficult tasks could lead to higher zones of proximal development (Ruvalcaba, Werner & Denner, 2016). Additionally, their work indicated that latino students in paired programming used nonverbal communication more often than their non-latino classmates. Additionally their research highlighted benefits for stronger and weaker students even though some teachers indicated that they didn't think the stronger students would benefit. This is good news because the new AP course curriculum for Computer Science Principles (CSP) that is being piloted this year has been aligned with cooperative learning techniques. The College Board and National Science Foundation have been working to bring an introductory college course in computer science to the high school level. CSP is hoped to attract more students to computer science and focuses on its core of seven big ideas all of which are augmented and partnered with computational thinking skills (AP CS Principles, 2014). One of the CSP big ideas is Big Data. The work of Buffum, Martinez-Arocho, Frankosky, Rodriguez, Wiebe and Boyer



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that noted that students start making career choices in middle school led to the decision to introduce a Big Data unit into a middle school curriculum. (Riegel-Crumb, Moore, & Ramos-Wada, 2011). The introduction of the CSP curriculum is something that seems very logical to do in middle school, as it will help with many of the issues as presented.

## Conceptual Framework

### Learning Theory

The conceptual framework presented employs two theories. The first theory identifies how computer science learning takes place through the work done by Seymour Papert. Papert (1980) worked with Piaget at the Center for Genetic Epistemology in Geneva in the early 1960s where he learned first hand about constructivism. While he understood learning to be genetic, he ultimately believed that what is learned is dependent upon the models that an individual has available. Papert describes two fundamental themes about learning computer science in his book *Mindstorms*. The first theme is that it is possible to design computers so that learning to communicate with them is a natural process, and the second is that "learning to communicate with a computer may change the way learning takes place" (p. 6). An additional focus is on how to deploy technology to service education, which is a theory of instructional technology (Koschmann, 1997). These themes resonate with the work that has been done by Wing (2006) within her definition of computational thinking. Papert (1980) diverges in his interpretation of Piaget's theory in that he distinguishes between concrete and formal thinking. Papert believes formal thinking begins to develop at a later stage (around the age of twelve) and more importantly he is known for his belief in the importance of learning without curriculum. Although there was to be no curriculum, he believed that children should be supported as they "build their own



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intellectual structures with materials drawn from the surrounding culture” (p. 32). Hence, he is known as the father of constructionism. The tool that he designed while he was at MIT for children to learn about computers and programming, Logo was a language that utilized a turtle that a child could program by creating steps that the turtle would take on the screen. Later, Papert’s student, Mitchel Resnick, would go on to build Scratch (https://scratch.mit.edu/) a block based language that works by snapping traditional Lego blocks together where in this case they are blocks of code. This legacy of early tools, and even the newest tools are constructionist by design. Several of the articles about computer science education are centered on specific programming tools such as these. What all of the tools have in common is that they can be used to teach computer science through students constructing their own code by putting together building blocks to create games, models and simulations. Constructionism can be seen throughout the tools available right now including Google and MIT’s AppInventor (http://appinventor.mit.edu/explore/), Carnegie Mellon’s Alice (http://www.alice.org/index.php), University of Kent’s Greenfoot (http://www.greenfoot.org/door) and MIT’s Starlogo (http://www.slnova.org) that presents the user with the opportunity to manipulate screen output with turtles. Armoni, Meerbaum-Salant and Ben-Ari (2015) have indicated that middle school students experienced in these visual tools had higher cognitive levels of achievement and were more likely to enroll in computer science courses later on.

An additional consideration of these programming tools for Papert, and expanded upon by Resnick was that it was important for these tools be easy to learn (low floor) while having the ability to do a lot (high ceiling) (1980). This was a standard that was set



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by Papert and has been adopted by many of these newer products. These tools work within the framework of Vygotsky's Zone of Proximal Development (Meerbaum-Salant, Armoni & Ben-Ari, 2011; Repenning, 2012; Robinson, 2005). These tools do not require learning a pure language. Additionally, for many of the tools users are even encouraged to share their work with others and the open mindset encourages the use and reuse of code for one's own purposes leading into a new era where programming is socially constructed and shifting away from an isolated practice.

**Career Theory**

The second theory that is identified in the model involves the development of career theory. Career development theory has evolved since the work of Parsons in 1909 (Patton & McMahon, 2014). Today, the model is social constructivist and identifies the way individuals play a role in their own development (Patton & McMahon, 2014). The work of Super and Hall (1978) points to the importance of the adolescent considering possible future careers in stages that are tied to a young person's developing sense of self. One very important component to the framework is self-efficacy. As Bandura (1997) points out self-efficacy is a judgment about what a person can do based on their capabilities and is not based on their self-esteem or self-confidence. The social cognitive career theory of Lent is an extension of Bandura's theory (Lent, Brown & Hacket, 1994). Social cognitive career theory emphasizes the process that individuals go through focusing on interactions in the formation of career choices (Lent, Brown & Hacket, 1994). The factors that are the most influential in their theory are a dynamic sense of self-efficacy, personal beliefs about outcomes and one's own capabilities (i.e. "can I do this?"), as well as goal setting (Rogers & Creed, 2011). In



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terms of goal setting, like Bandura, they see the individual as playing an important role and not just a passive reactor to other factors (Lent, Brown & Hacket, 1994).

Dorn and Tew (2013) point out the importance of student beliefs as being a key factor to how they learn new information inside and outside of the classroom. Further, they feel it is “imperative that we understand how our educational practices impact the underlying perceptions students have about computer science” (p. 183).

### Summary

The best way to teach middle school science courses is to provide problem based learning of real world applications (Hansen & Gonzalez, 2014; Newman et al., 2014). Inviting scientists to the classroom (live or virtually) can provide models that increase students’ self-efficacy (Bittner & Pajares, 2005). The importance of positive messages is one of the necessary components in helping students see themselves as scientists and building self-efficacy. Another lesson from the literature is that we need to do what we can to help all students, but especially girls, learn to believe that they can be successful in math and science (Aschbacher, Ing, & Tsai, 2014). Along these lines it is important for curricular content to be relevant to lived experiences. Curriculum is less successful when students are told that content will be important to their future careers, but they cannot conceptualize it (Enright, 2012). If we tell students that STEM or computer science is important but they cannot imagine themselves as professionals in these fields then it will be difficult for them to make the connections that would motivate them to be successful in these courses (Papert, 1993). Even more relevant is the problem that middle school students don’t have a conception of what a computer scientist is or what they do and that makes it impossible to see themselves as future computer scientists (Grover, Pea & Cooper, 2014). There is evidence that students



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begin to identify their career interests as early as third grade (Ing et al., 2014) and establish strong notions about their discipline preferences in middle school. Middle school is known as a time for identity building (Grover et al., 2014). Participation in outreach and enrichment programs for girls during middle school has been positively correlated with taking STEM courses in high school (Rodger, 2013). This means that it is critical that we help middle school students understand the field and what is possible if we have any expectations that they will consider these careers for themselves. This reminds us that it is important to bring learning opportunities and provide support like mentoring and good models for middle school students to increase their future participation in computer science fields. The work of Bamberger (2014) acts as a cautionary tale, because in this study the female students that spent time with successful female engineers came away from their experience with the awareness that "We can, I can't" (p. 557).



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# CHAPTER 3
# INTERVENTION

The intervention included two phases that were presented to students. The first phase, Phase I, included a survey and lessons presented sequentially. The students had assignments within the lessons and were provided guiding rubrics for completion. Phase II of the intervention consisted of student interviews of professionals in the field of computer science. Interviews were all live, some with guests in the classroom and some via telecommunications media in accordance with mentor availability. Three of the interviews were recorded with presenter permission so that students could watch the interviews if they had been absent from school during the interviews and posted in the G Suite for Education, Learning Management System (LMS) for access. After the interviews, students were assigned homework questions via an online discussion board in the LMS that they were already using within all of their other courses. Another survey was administered at the completion of both phases after the final projects were due and submitted.

## Overview

The students took a pre-unit survey a week before the lessons commenced. The lessons took two and a half weeks to complete. These are outlined in Figure 3-1 and discussed in more detail later in this chapter. The post-unit survey was taken after all of the work concluded and was turned in. In the case where two students had been absent, they were allowed to take the final survey the next day upon their return after all the assignments had been completed and turned in. The intervention was developed to implement the logic model in Figure 3-2. The students, as individuals, already had preconceived notions of the field of computer science. The people that have influenced



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**Computer Science Intervention Unit**
**Lesson Plan/Lesson 1**

**Date:** tbd

**Subject / grade level:** Physical Science Grade 8

**Materials:** Students have access to personal iPads for research and note-taking

**Standards and Clarifying Objectives**
CSTA - Impacts of Computing – culture, social interactions

Florida

SC.68.CS-PC.1.1 Recognize and describe legal and ethical behaviors when using information and technology and describe the consequences of misuse.

SC.68.CS-PC.2.1 Analyze the positive and negative impacts of computing, social networking and web technologies on human culture.

SC.68.CS-PC.3.1 Answer research questions using digital information resources.

SC.68.CS-CS.6.1 Explain why some tasks can be accomplished more easily by computers.

SC.68.CS-CP.3.2 Create online content (e.g., webpage, blog, digital portfolio, multimedia), using advanced design tools

SC.68.CS-CC.1.3 Design, develop, and publish a collaborative digital product using a variety of digital tools and media-rich resources that demonstrate and communicate concepts to inform, persuade, and/or entertain.

**Lesson objective(s):**

Understand what computer science and programming are and obtain a working knowledge of the field.

The basic language and context will be provided through a Nearpod slide deck that introduces the terms, language and individuals who have made contributions to the field. Sample slide is included in diagram 3-1 below.

Students will learn about how technology can impact society. They will learn about he concepts of public and private date. They will also learn the concepts of symmetric and asymmetric communication as well as the importance of open and closed systems. Students should have a working knowledge of the vocabulary including: computer science, computer programmer, information technology, communication, open system, closed system, symmetric, asymmetric, public, private, social network

**ENGAGEMENT**

- Consider how technology has already advanced during your own life so far. What exists now that did not when you were born?
- Who created these technologies?
- Have they changed over time? Were changes quick or gradual?

**EXPLORATION**

- Students will be assigned an individual to research with a partner from a list randomly by number generated by a Scratch program created for the lesson.

**EXPLANATION**

- There are many basic terms students need to use in the unit and those will be introduced here including computer science, computer programming, and information technology.
- Students will examine the work and contributions of various computer programmers.

Figure 3-1. Lesson 1 of the Computer Science Intervention Unit



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**Computer Science Intervention Unit**
**Lesson Plan/Lesson 1**

**ELABORATION**

- Create a database entry about the person assigned.
- Review the entries of other students.

**EVALUATION**

- Students will deliver an entry that they create to a class database of the contributions of different programmers. The entry includes
  1. Name
  2. DOB
  3. Companies worked for/with
  4. Contribution to the field
  5. Interesting facts found

**Rubric**

Criteria

1. Document contains name. – 5 pts
2. Document contains dob. – 5 pts
3. Document contains employment information or perhaps education. – 5 pts
4. Document contains contributions to the field. – 5 pts
5. Document contains interesting factoids. – 5 pts

Figure 3-1. Continued

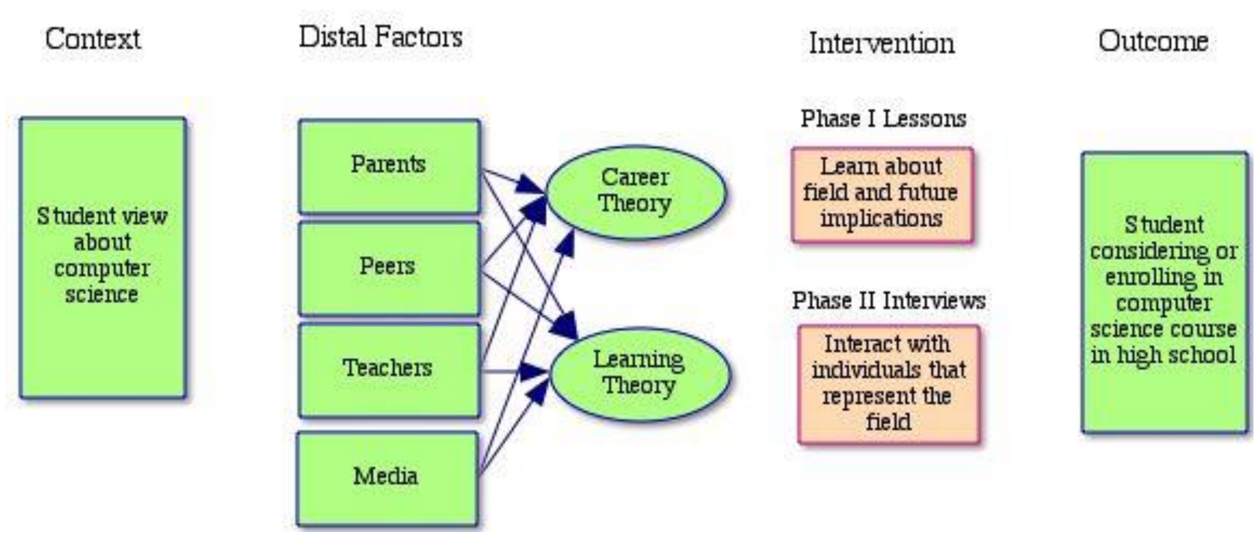


Figure 3-2. Logic Model



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their views to this point were predominantly their parents, peers, and teachers. All of the students in the study are taking part in an iPad program and bring their devices to school daily. Because the students are participating in this one-to-one program they have a high level of media exposure for students of their age group. Many of their ideas about computer science come from comedy shows like The Big Bang Theory and dramas like NCIS that have created and perpetuated the stereotypes that are prevalent in society (Cooper, 2006). These distal factors intersect with student-constructed views at a point when they may also be beginning to develop interests about career possibilities for their future. The logic model in Figure 3-2 illustrates the factors of the influences of their parents, peers, teachers and the media in concert with how they learn and how they think about their careers. The phases of the intervention were designed to have the students develop their own ideas about computer science careers that did not reinforce the dominant societal stereotypes with a focus on the global impact of computing.

**Why this Intervention?**

I began my teaching career twenty-two years ago with the idea that I wanted to get students, especially girls, excited about computer programming. As a former programmer, I enjoyed the nuances of the field and found the projects engaging. The transition to teaching came about because of family needs and concerns. From my earliest days teaching, I was struck by how few women were interested in computer science. Over the years I have worked to increase enrollment in my high school programming courses. I have attended workshops to investigate methods on how to increase enrollment. I have tried to implement the strategies recommended to increase enrollment, regardless, female participation in computer science courses at our high



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school remain low. This past year's female enrollment was ten percent. All of the previous interventions have been at the high school level and they have not resulted in increased enrollment. One of our latest ideas about growing the program was to try to increase interest among the middle school students to begin to develop a program to increase the high school enrollment.

Chapter two identified moderate success in interesting girls in the field through after-school and enrichment programs. A few years ago I volunteered at Girls Inc., teaching computer programming using Scratch and spreadsheet skills to girls ages seven to fourteen. The girls were eager to learn, excited about the material and none of them had access to computer programming at the schools they attended. During this experience I brought one of my students ("Brittany") in to mentor the girls. Their reaction was quite impressive in that they asked about my student every time that I returned. Several remarked they wanted to pursue computer science "just like Brittany." This left an impression on me that the role of mentoring for girls at this age could be life changing which is supported within the literature (Brickhouse, Lowery, & Schultz, 2000; Britner & Pajares, 2005). Therefore, I felt that the inclusion of the interviews with mentors in industry would be an integral component of this intervention.

**Lessons**

The lesson plans show the implementation of the CSP unit and how it has been scaled to meet the needs of the eighth grade classroom. The original CSP lessons were developed by UTeach Computer Science at the The UTeach Institute at The University of Texas at Austin supported by the National Science Foundation (grant #1543014).



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The lessons were presented sequentially and some of the student work took place in class and some was carried over and assigned as homework.  The class periods were not equally divided and length of class varied by day so it was important to allow the same amount of time for students so lessons were presented in the same sequence, but not necessarily on the same days.

**Lesson 1**

Lesson one was an introduction to the field.  Students were introduced to the field via a slide deck in the Nearpod app (https://nearpod.com/) that allowed for student interactivity.  Introductory materials including definitions were provided.  Students had the opportunity to interact on some of the slides by voting to identify programmers and to look at Department of Labor job information and statistics in general and the specific information about computer science fields.

Two sample slides from the Nearpod presentation for the introduction appear in Figures 3-3 and 3-4.  All of the images obtained for these lessons were mined through the advanced Google search with usage right criteria of free to use or share, even commercially through the Creative Commons. The accompanying task was to ask students to identify the computer programmers from the eight individuals pictured.

After students voted in Nearpod it was revealed that all eight of the individuals pictured are very successful programmers. Students were always surprised to discover that all eight are computer programmers and usually identified only the stereotype of the male working alone to be a programmer.

After the introductory slides the students were asked to consider a technology from yesterday such as the telegraph and were asked to think about how it impacted society.  An analogy was made to the newer technologies of today. They were asked to



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Figure 3-3. Which of these are programmers?

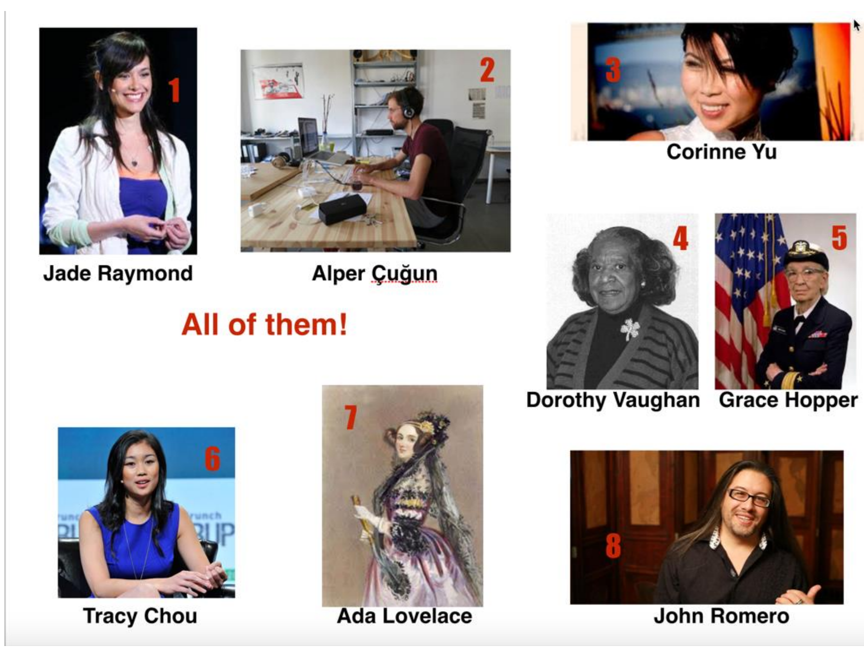


Figure 3-4. Named Computer Programmers



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consider social interactions and how technologies can change things and they were specifically asked to consider financial implications and the dissemination of news. The next point covered was the differences between private and public communication, asymmetric and symmetric communication as well as open and closed platforms as appear in Figure 3-5 (UTeach CS Principles, 2017).

| Service | Public/Private | Symmetric/Asymmetric | Open/Closed |
|---|---|---|---|
| Email | Private | Asymmetric | open |
| Facebook | Private | Symmetric | closed |
| Twitter | Public | Asymmetric | closed |

Figure 3-5. Examples of Communication

The lesson also asked students to consider technologies that they found important. They were asked who created them and why. As an exercise for this unit the students were assigned a programmer to research. The students chose a random name out of a bowl that they were responsible to look up. Originally, the list of individuals was both male and female, but on the morning of the assignment, it was decided to only put female names in the bowl. This was a deliberate change based upon observations and reflection about the assignments through the practice of maintaining a weblog. The student’s reports contained some really interesting facts such as Mae Jemison the astronaut was afraid of heights. The list of women for which biographies were written included: Nancy Grace Roman, Mae Jemison, Francis Spence, Marlyn Meltzer, Sandra Kurtzig, Jean Bartik, Susan Kare, Margaret Hamilton, Adele Goldstein, Elizabeth Feinler, Grace Hopper, Maria Klawe, Evelyn Granville, Ruth Teitelbaum, Janese Swanson, Ada Lovelace, Betty Holberton, Kathleen Antonelli, Adele Goldberg, Adele Goldstine, Evelyn Granville, Jean Sammet, Mary Kenneth Keller, Mary Shaw, Sandra Kurtzig, Janese Swanson, Susan Kare, Frances E. Allen, Anita Borg,



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Marissa Mayer, Ruchi Sanghvi, Shafi Goldwasser, and Hedy Lamarr.  The turned in entries were combined for the class to review as a whole. A detailed student rubric for the assignment can be found in Appendix B.

The students then continued with the lesson and were given a document to read from the CSP curriculum about future technologies.  They were given a homework assignment to ask a parent, grandparent or neighbor the following questions.

- What kinds of social activities did you engage in?
- How often did you socially interact with others?
- Who did you interact with socially?
- How far away from you did they live?
- Do you still have contact with them today?
- What tools or technology, if any, did you use to interact with others?
- What have been the biggest technological changes in social interaction that you have seen since you were younger?
- How would you have done things differently if today's social media tools were available when you were younger?

They were then asked to write a short summary of the things learned from the conversations that included the following items.

- Identify five aspects of social interaction that have fundamentally changed since they were your age.
- Identify five aspects of social interaction that are more or less the same as when they were your age.
- Describe the most surprising thing that you learned about social interaction in the past and explain why it was so surprising.
- Identify one way that you think social interaction might change between now and the next generation (i.e., in 20–30 years).



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**Lesson 2**

The focus of the second lesson was on how technology can revolutionize life as an extension of the first unit lesson. The background information for this lesson was derived from the book *The Victorian Internet* by Standage (1998). The lesson portrayed a series of statements, after which the students were asked what technology was being referenced. When played out in classes, the first section believed it was the Internet; the second felt it was a particular form of social media like Facebook or Instagram. They were both surprised to discover that it was the telegraph. The discussion which followed included the transformation that the telegraph had on society in many aspects, some expected and some unexpected, as well as some positive and some negative impacts. Students also engaged in a discussion of whether or not the telegraph was a utility or a luxury. They were asked to consider if when invented, does a technology start out as a luxury and mutate into a utility? The students were asked to think about this and then asked to invent a new technology of their own with a partner. There were two deliverables for this unit and the first was a two-minute elevator speech to introduce the class to their invention followed up with a chose media deck with details about their invention. Details of this lesson are contained in Figure 3-6. They finally were asked to decide if their own invention qualified as a utility or a luxury. The second assignment for this unit was a written document that describes in greater details the specifics of the invention.

A detailed student rubric for both the elevator speech and the written assignment can be found in Appendix B.



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**Lesson 3**

The third lesson asked the students to identify a field they would be considering for their future careers. If they claimed not to have one, they were asked to indicate any

| |
|---|
| **Computer Science Intervention Unit**<br>**Lesson Plan/Lesson 2** |
| **Date:** tbd |
| **Subject / grade level:** Physical Science Grade 8 |
| **Materials:** Students have access to personal iPads for research and note-taking |
| **Standards and Clarifying Objectives**<br>CSTA - Impacts of Computing – culture, social interactions<br>Florida<br>SC.68.CS-PC.1.1 Recognize and describe legal and ethical behaviors when using information and technology and describe the consequences of misuse.<br>SC.68.CS-PC.2.1 Analyze the positive and negative impacts of computing, social networking and web technologies on human culture.<br>SC.68.CS-PC.3.1 Answer research questions using digital information resources.<br>SC.68.CS-CS.6.1 Explain why some tasks can be accomplished more easily by computers.<br>SC.68.CS-CP.3.2 Create online content (e.g., webpage, blog, digital portfolio, multimedia), using advanced design tools<br>SC.68.CS-CC.1.3 Design, develop, and publish a collaborative digital product using a variety of digital tools and media-rich resources that demonstrate and communicate concepts to inform, persuade, and/or entertain.<br>**Lesson Source**: - UTeach CSPrinciples gitbook resource |
| **Lesson objective(s):** Design a technological innovation that could revolutionize and enhance everyday life. The final guiding question will be is their technology a utility or a luxury? The following excerpt from the UTeach CS Principles course will guide the lesson:<br>Technological advances are made *by* people *for* people. Scientists, inventors, and developers all work hard to innovate new ideas and create new products that directly or indirectly affect the rest of us. In most cases, the impact we experience is a positive one as the technology improves or enhances our lives in some meaningful way (e.g., email correspondence, productivity software). Other times, technological advances also have an equally powerful down side (e.g., spam, computer viruses).<br>Working in pairs, your task is to invent a new technological product or service that might be possible within your lifetime. This is your opportunity to be as creative and imaginative as you would like as you and your partner conjure up the next new innovation to potentially revolutionize our digital world.<br>To begin your collaboration on this project, you and your partner should work together to identify recent technological trends and use those trends to imagine what might very well come next.<br>For starters, consider how technology has already advanced during your own life so far. What products, services, or technologies do you now rely on every day that did not exist when you were born? How have those technologies changed over time? Has the change occurred practically overnight or has it evolved gradually? How will these technologies continue to change in the near future? What do they allow you to do today that you could not do in the past? What can you still not do today that you hope to maybe do in the future? |

Figure 3-6. Lesson 2 of the Computer Science Intervention Unit



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| Computer Science Intervention Unit<br>Lesson Plan/Lesson 2 |
|---|
| **ENGAGEMENT**<br>• Consider how technology has already advanced during your own life so far. What exists now that did not when you were born?<br>• Have they changed over time? Were changes quick or gradual? |
| **EXPLORATION**<br>• Students design a technological innovation that could someday revolutionize and enhance everyday life. |
| **EXPLANATION**<br>• Innovations come from creative thought and imagination. Many innovative ideas rely on advances in technology.<br>• Couldn't have FB without TCP/IP and hardware etc. |
| **ELABORATION**<br>• Identify a problem that a technological advance might solve.<br>• Invent a technological solution to that problem.<br>• Identify the key features of your solutions.<br>• Identify how this advance relates to computing<br>• Identify potential risks and benefits on individuals and communities<br>• Identify challenges to be overcome |
| **EVALUATION**<br>**Part 1**<br>• Students will deliver a 2 minute elevator pitch to demonstrate ideas to the class.<br>**Part 2**<br>• A written report in the form of a blog post, wiki entry or media presentation should include:<br>1. Purpose<br>2. Description<br>3. Features<br>4. Risks<br>5. Benefits<br>6. Technological Resources<br>7. Technological Challenges<br><br>**RUBRIC**<br>Criteria<br>• Detailed description of the innovation, including key features and use cases. – 5 pts<br>• Detailed assessment of the risks and benefits of the innovation to society. – 5 pts<br>• Detailed assessment of the technological resources the innovation will use and the challenges it must overcome. – 5 pts<br>• A mock-up of the innovation depicting its use and/or functionality. – 5 pts<br>• An "elevator-pitch" that describes the innovation and its impact on society. – 5 pts |

Figure 3-6. Continued

of their interests or passions. For example, if a student claimed not to have any ideas, but was on the basketball team, they were asked to do this assignment as a professional basketball player.



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The deliverable for this lesson involved an analysis of what was required to work in the chosen career. Students were expected to do some research to find out what the educational and training requirements were for the field. The next part of the analysis required of the students to indicate how important computer science and technology are to this chosen field. Finally, they identified the long-term future impacts of computer science and technology on the chosen field. Students were provided with samples of a couple of fields as examples to think about, such as the case of a hardware store owner. How has technology impacted this type of business? There were obvious things like inventory and sales data tracking, but students could dig deeper and consider other things that have changed. Such as in the past, mixing colors of paint was previously done by hand, today a computer measures and delivers the amount of pigment so that there are exact measurements each time and the color can be reliably created over and over again. A yoga studio used to rely on clients signing up in advance for classes on paper or via a receptionist. Today, class reservations are maintained on an app and the music in the studio is played via Spotify, where in the past it may have played from a DVD. The students were required to create a Keynote presentation that contained a minimum of 6 slides that answered the questions in the rubric in Figure 3-7. Several students asked if this would be a class presentation and they were told it would not be shared with their classmates.

**Lesson 4**

The fourth lesson was the most organic of the lessons as it was dependent on the amount of mentors that could be recruited to answer student questions. Attempts were made to find potential mentors from numerous sources including inquiries through the Grace Hopper Facebook group and Million Women Mentors as well as parents and



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**Computer Science Intervention Unit**
**Lesson Plan/Lesson 3**

**Date:** tbd

**Subject / grade level:** Physical Science Grade 8

**Materials:** Students have access to personal iPads for research and note-taking

**Standards and Clarifying Objectives**

CSTA - Impacts of Computing – culture, social interactions

Florida

SC.68.CS-PC.2.1 Analyze the positive and negative impacts of computing, social networking and web technologies on human culture.

SC.68.CS-PC.3.1 Answer research questions using digital information resources.

SC.68.CS-CS.6.1 Explain why some tasks can be accomplished more easily by computers.

SC.68.CS-CP.3.2 Create online content (e.g., webpage, blog, digital portfolio, multimedia), using advanced design tools

SC.68.CS-CC.1.3 Design, develop, and publish a collaborative digital product using a variety of digital tools and media-rich resources that demonstrate and communicate concepts to inform, persuade, and/or entertain.

**Lesson objective(s):** Students make connections between a possible career field and computer science. Students learn that computer science has far-reaching impacts to many careers.

**ENGAGEMENT**

- Students will identify field of interest.
- Students will research the field and create a presentation (Keynote) about the field and how it intersects with computer science and technology.

**EXPLORATION**

- Students identify the educational requirements for the field
- Students identify special training that may be required for the field
- Students must determine if computer science and technology has impacts on their chosen field.
- What impacts has it had in the past?
- What impacts might it have in the future?

**EXPLANATION**

- Students will be presented with two examples
  1. An owner of a hardware store and how he sells (mixes) paint.
  2. An owner of a yoga studio – how classes are booked and paid for.

**ELABORATION**

- How might changes in technology influence either of these examples in the future?
- How can someone be successful in this field?

Figure 3-7. Lesson 3 of the Computer Science Intervention Unit



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**Computer Science Intervention Unit**
**Lesson Plan/Lesson 3**

**EVALUATION**

- Students will create a brief presentation about their chosen field
- The presentation must reflect thought and research about what is already happening in the field and how advances in technology will impact the field in the future.

**RUBRIC**

Criteria

1. Detailed description of the field, including key features and educational requirements. – 5 pts
2. Detailed assessment of how one becomes successful in the field. – 5 pts
3. Detailed assessment of how technological resources impact the field – 5 pts
4. An assessment of how computer science intersects and affects the field. – 5 pts
5. The presentation has a good balance of text, information and images. – 5 pts

Figure 3-7. Continued

former graduates of the school. The goal was for each class to have at least two female individuals serving as models for the interviews. Both sections of the grade wound up having four mentor interview sessions.

Lesson four required students to think about careers and people who were currently working in the field of computer science. They were asked to write potential interview questions about things they wanted to learn about from the experience as a homework assignment. Many of the questions that the students submitted were similar so they were combined into one overall set that was used for all of the interviews. The questions were provided to the guests in advance for the live and electronic sessions (Facetime, Google Hangout) with the students. The question set provided the vehicle for discussion for the first part of all of the interviews, and students were allowed to ask additional ad hoc questions during the sessions. Both classes had the same number of interviews, although the people were not always the same as they were restrictions on time, such as one section did not meet in the mornings, and the interview was with an individual in Hong Kong so the time difference made it impossible for her to speak with



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both classes. Upon completion of all of the live interviews students were assigned a homework assignment to participate in an online discussion board about the process for follow-up. The discussion board was chosen because it has been found in my classes that all students would participate, whereas in a classroom discussion, certain students tend to dominate conversations while others remain reticent to participate. The discussion assignment was set up so that students were required to post their own to answer one or more of the questions before they were allowed to see the discussion posts of their peers. The text to the discussion assignment follows:

> By this point you have all had the opportunity to interview someone, as well as group interview some guests. Please think about the experience and consider these questions:
>
> - What did you learn about the field that you did not already know?
> - What surprised you the most about your interview/s?
> - Does the interviewee seem like what you thought a technology professional would be like?
> - What have you learned about the global impact of technology?
>
> Please respond to this discussion in a productive way.

Students were not given a specific number of times that they had to participate in the discussion beyond their first original posting. They were verbally encouraged in class to participate as little or as often as they felt like answering. Details of the fourth lesson can be found below in Figure 3-8.

## Summary

This chapter detailed the logic model and the lessons for this study. It was hoped that the lessons and experiences would have an impact on the perceptions of the learners. The effect of the intervention could be negative by confirming student views



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|---|
| **Computer Science Intervention Unit**<br>**Lesson Plan/Lesson 4** |
| **Date:** tbd |
| **Subject / grade level:** Physical Science Grade 8 |
| **Materials:** Students have access to personal iPads for research and note-taking |
| **Standards and Clarifying Objectives**<br>CSTA - Impacts of Computing – culture, social interactions<br>Florida<br>SC.68.CS-PC.2.1 Analyze the positive and negative impacts of computing, social networking and web technologies on human culture.<br>SC.68.CS-PC.3.1 Answer research questions using digital information resources.<br>SC.68.CS-CS.6.1 Explain why some tasks can be accomplished more easily by computers.<br>SC.68.CS-CP.3.2 Create online content (e.g., webpage, blog, digital portfolio, multimedia), using advanced design tools<br>SC.68.CS-CC.1.3 Design, develop, and publish a collaborative digital product using a variety of digital tools and media-rich resources that demonstrate and communicate concepts to inform, persuade, and/or entertain. |
| **Lesson objective(s):** Students interact with computer science professionals and develop accurate perceptions of those who work in the field of computer science. |
| **ENGAGEMENT**<br>• Students will be asked to write questions of interest to be presented to those being interviewed.<br>• Students will participate in an online discussion board to answer the following questions:<br>1. What did you learn about the field that you did not already know?<br>2. What surprised you the most about your interview?<br>3. Does the interviewee seem like what you thought a programmer would be like? |
| **EXPLORATION**<br>• Students will participate in live interviews. |
| **EXPLANATION**<br>• Students will be presented with the credentials of the visitor.<br>• Students will be asked to think about what they would like to learn about the field as well as asked to make connections about what the visitor does and its impact on society as whole as well as their contribution to their individual fields. |
| **ELABORATION**<br>• Students will have the opportunity to understand the field of computer science with an accurate mental model of what a computer programmer is and what they do. |

Figure 3-8. Lesson Plan 4



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| Computer Science Intervention Unit<br>Lesson Plan/Lesson 4 |
|---|
| **EVALUATION**<br>• Students will create a list of questions from which the teacher will choose a selection for the person to be interviewed<br>• Students will write their reflections in the online discussion after the interviews occur as a homework assignment.<br>**RUBRIC**<br>Criteria<br>1. Students submit interview questions. – 5 pts<br>2. Students present logical and thoughtful questions. – 5 pts<br>3. Students answer at least one of the three questions in their response. – 10 pts<br>4. Students optionally respond respectfully to a minimum of three other students about the interviews. |

Figure 3-8. Continued

that they are not suited for the field. Positive effects could have resulted from student views that were favorable to the field or that had been neutral and had no effect. Past students at our school have had exposure to Scratch and programming, but that exposure alone has not resulted in an increase to computer science enrollment at the high school level. The elements of these lessons that have not been addressed previously have been the bias and stereotypes that are the common misconceptions of middle school students. I have suspected that these stereotypes have perpetuated the status quo, and hence there have not been increases in enrollment. I hoped that the combination of these lessons would help students form different ideas contrary to held stereotypes as they begin to consider their career options that are developmentally appropriate within their age group. Career theory points to the possible importance of providing alternative constructions at the point where students are building their career expectations, hence the implementation of this study.



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# CHAPTER 4
# METHODOLOGY

The purpose of this study was to implement an intervention to change middle school student perceptions, with the hope of persuading more girls to study computer science courses in our high school. Like falling dominos, if more girls were to become interested in computer programming at the middle school level, this could potentially lead to more girls studying computer science in high school and then continuing on to higher education. If the status quo persists “every day we risk losing the talents of women as contributors to science, technology, and the arts because the advantages that technology provide are being conveyed disproportionately to men” while disadvantaging women (Cooper, 2006, p.320). Changing the outlook of the gender diversity among professionals can begin by changing the diversity within the classrooms that prepare those seeking entry to the field.

The intervention followed differentiation practices by having different types of assignments and challenges for students to accommodate their needs and learning styles (Benjamin, 2002). Bransford et al. (2000) recommends students have an opportunity to develop factual knowledge in a framework to facilitate efficient learning. Therefore the unit was designed to target instruction to help students best understand the field and current practices with various kinds of assignments and group and individual work. Before the middle school students took part in the intervention, they expressed their attitudes in a pre-unit survey that was not a part of their graded work. Likewise, they completed a post-unit survey that was also not part of their graded work. The students participated in the intervention as part of their science curriculum and were asked to think about and identify their current fields of career interest. Having



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students choose their fields follows the recommendations of Bransford et al. (2000) in using a metacognitive approach to helping students take control of their learning. The students were also assigned a project with a guiding rubric to present the impacts of computer science on a current field of interest for their future careers. Additionally, students had the opportunity to interview computer science professionals about their jobs drawing upon the importance of mentoring (Aschbacher et al., 2014; Beede et al., 2011; Buck et al., 2008). Ideally the interview process resulted in debunking the prevalent stereotypes and myths about careers in computer science that were identified in the literature review. This research study was guided by the following questions:

How can exposure to an intervention that incorporates some CSP materials, specifically the global impact unit, lead to a more authentic perception of the professional field of computer science among an eighth grade student population?

How can exposure to a CSP unit about the field of computer science and what computer scientists actually do, result in positive changes to student views about the profession of computer science, especially among female students?

## Research Design

This project followed the mixed method exploratory design as outlined by Creswell (2014). The research began and ended with quantitative components in the form of a survey assessment. The survey was intended to be a diagnostic to identify preconceptions held by students (Keeley, 2015). There were graded formative assessments that were based upon rubrics presented to the students as the lessons unfolded. The formative assessments through the intervention helped identify students' prior knowledge and determined the extent to which the student perceptions were moving forward in their understanding of concepts (Keeley, 2015). While I graded the



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majority of the project artifacts the co-teacher also independently graded some of the artifacts for corroboration, as is our practice throughout the year. The artifacts reflected the students understanding of the lesson objectives as outlined in the lesson plans. The artifacts that were collected during the intervention were assessed and used as part of the student's grade calculations for the quarter. The artifacts were also used for purposeful sampling of the students to help inform the decision of which students were interviewed at the conclusion of the unit. In the second phase of the unit the students had the opportunity to interview and interact with potential mentors in person or in live teleconference sessions depending on availability of the mentors and the timing of the interviews. For example, if the unit coincided with graduates visiting the area then that would be preferred to a teleconference interviews.

The teacher inquiry methods of Dana and Yendol-Hoppey (2014) were implemented in the form of a weblog using Adobe Spark cloud service that was updated daily. The process allowed me the opportunity of deeper reflection as I captured data and comments from students. Many of the things captured in the weblog were fleeting thoughts or student comments that I may not have remembered days or weeks later. As is recommended by Dana and Yendol-Hoppey, I recorded field notes with a focus on the same daily prompts:

1. What did I learn about student views of CS today?
2. What observations do I have about the lessons and how they presented?

This line of inquiry method helped me reveal any potential questions or areas of focus and clarification for students. I was able to mark down anecdotes about student interactions that were useful to identify strengths and weaknesses of the lessons. The



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methods of teacher inquiry put forth by Dana and Yendol-Hoppey (2014) express the importance of differentiated instruction in terms of “providing students with multiple options for taking in information and making sense of ideas” (p. 15) which was addressed through the varied lesson types and assignments that included a mini speech, question writing, brief written reports, online discussions and multimedia presentations. Providing lessons utilizing different methods has been shown to allow for deeper learning and the transfer of knowledge (Pellegrino & Hilton, 2012). The pre-survey was intended to measure preconceptions and the assessments throughout were intended to measure changes (Bransford et al., 2000). In keeping with these methods, the student perceptions were corroborated in the pre-survey and were always a primary focus of the research. Finally, students retook the initial survey at the conclusion of the unit. The field notes and artifacts acted as a resource to select a purposeful sample of students to interview for the project. Student experiences had the potential of being negative, positive or neutral. Selection was an organic process that was revealed by the artifacts collected and a result of the field notes being reviewed and processed. Those selected for interviews were representative of the breadth and depth of the student experiences as a result of the intervention. The data that emerged from the interviews was transcribed and coded as qualitative components of the study. The open-ended survey questions and artifacts were also coded to reveal themes, trends and anomalies (Clarke & Braun, 2017; Maykut & Morehouse, 1994). I attempted to approach the coding as a deliberate, reflective and thorough exercise as is commensurate with thematic analysis (Braun & Clarke, 2014).



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## Participants

A total of sixty-one students (out of a class of 71) students voluntarily returned signed permission slips over a two-week period prior to the launch of the project. Demographic information was not collected because the samples were too small; such as there were only three Asian students and one Native American. On the day that the survey launched there were 57 participants taking the pre-survey. Students were absent due to illness or sporting obligations. There was an extremely high incidence of absence throughout the three-week period as illness and flu spread through the sixth and eighth grades during the time of this intervention. There was an average of eight students out per day. The post-survey had 59 participants. There were a total of 61 students out of 71 that participated and had signed forms. However there were three participants in the pre-survey that were absent during the final. There were also two participants in the post-survey that were absent during the pre-survey. This left a total population $N = 56$ that participated in all aspects of the intervention. There were students who were absent during the interviews of mentors as well. Three of the interviews were recorded with the presenter's permission and posted in the student Learning Management System (LMS). Absent students were encouraged to watch any of the interviews that they missed when they were not in class. Although there is no way to know for certain that the students watched the interviews, all of them attended at least two of them regardless, so some exposure to professionals was available to all of the students in the population.

## Research Tradition and Rationale

The students involved in this study have previous experience with computer programming. The school had a five-year history of introducing the middle school



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students to Scratch programming as part of the math curriculum. Students participated in a project during the sixth or seventh grade year depending on the student's math achievement level. This project has provided an opportunity for the students to be exposed to the block based language in the form of game creation for a period that averaged two to three weeks in length. Chapter two revealed research literature that focused on trying to interest women to pursue computer science through exposure to specially designed programs that specifically introduced programming. There was limited literature that looked at computer science as a career path, although the majority of the articles referenced the need in our society for women and minorities to pursue computer science careers. For this reason this study shifted from the programming tools of the field to a focus on the importance of the field itself. Bransford et al. (2000) have suggested that if students' initial understanding of a new concept is not engaging then they can revert to their preconceptions. They also focus on the importance of metacognitive processes of building knowledge. It was hoped that the lessons were varied and engaging to help students learn about the field. The conceptual framework of career theory was identified because of its relevance to the importance of being the starting point for middle school students developing career aspirations (Lent, Brown & Hackett, 1992; Patton & McMahon, 2014). Maykut and Morehouse (1994) indicate that using qualitative methods can help in identifying connections between the teaching and learning from the experience with the mentors from the student responses. Thematic analysis of qualitative data provided a framework for finding patterns and implications of the coded data (Clarke & Braun, 2017).



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**Researcher Role and Reactivity**

The students selected to participate in this intervention were the four sections of eighth grade science classes. I served the dual role of being their science co-teacher and the main researcher in the study. Significantly, I was a former computer programmer and I had the potential to act as a mentor to the field as well as being in the teaching role. It was important that I did not guide the students in a way that they believed their input on the surveys would reflect the views and preferences that they thought I would want as their teacher. The students needed to feel empowered to answer as openly and truthfully as possible. In addition, students were informed that survey participation would not be reflected in any of the grades for the science course. The only part of the intervention that was graded were the assigned artifacts including homework assignments, reports and speeches that were graded according to rubrics students received in advance. Because of my dual role careful consideration was made in deciding the selection of students to be interviewed. A conscious decision was made to select students at both continuums on the attitude scale from the pre and post-surveys. It was also important to recognize that student beliefs may also shift in a negative direction as a result of the intervention. One student was chosen for an interview to meet this criterion. There was no guarantee that the lessons and interviews would have a positive impact on the career formations that the adolescents acquired during the research period.

**Planned Study Methods**

The first phase of the project implemented a survey of student attitudes about computer science and computer science careers. The survey consisted of free format and multiple-choice format Likert scaled items administered through Google Forms as



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part of the G Suite for Education that is utilized by the school. The students' participation in the iPad program has created a high level of proficiency and comfort in using the Suite. The form is available for review in Appendix A. The survey contains questions that represent the findings of other research, specifically it identified if students perceived computer science to be an isolating field and if they subscribed to the nerdy stereotypes. The survey was administered before the students experienced any of the planned lessons in the intervention.

The lessons that served as the intervention were derived from the CS Principles course curriculum designed by the UTeach Institute at the University of Texas at Austin. Unit 6 Innovative Technologies "aims to broaden students' awareness of the computing tools they use and rely on every day and to encourage them to start thinking about the decisions and processes that go into the creation of these technologies" (UTeach CS Principles Gitbook, 2016). The first lesson helped students understand the field and set up basic vocabulary. Later lessons explored the roles that technology played in their lives, which should lead to a conclusion that students rely on the Internet and the technologies such as their iPads and phones. Students then examined protocols and the ideas of innovations being evolutionary or revolutionary. The CS Principles College Board website (http://www.csprinciples.org/home/resources/lessons) has a similar lesson labeled Impact on Computing. The College Board assignment allotted a week for students to create a group presentation that gave various areas / industries / fields where computer science has impacted society in the way business is done and created new jobs. Students identified a field of interest that they could see themselves doing in the future. Examples could include medicine, movie production or cooking. Once



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identified, the students were asked to identify an advance in technology that had an influence on their chosen field. This modification was hoped to make students begin to construct new connections between their chosen field of interest and computer science that they previously had not held.

Once IRB approval was obtained, the process began to find mentors for the second phase of the intervention in which students would interview adults working in the technology field. Guests were solicited via organizations that are working to increase women in technology. Million Women Mentors failed to respond to the inquiry. Three alums that have successful careers in technology and remain in contact with me were invited to participate. A parent who had previously asked to speak to the students who is a former Silicon Valley executive and now entrepreneur with her own software startup was invited and accepted. A message was posted on Facebook for the closed group of Grace Hopper Scholars inviting women to be interviewed. The message stated:

> Research help needed! Hi everyone. I was a scholar in 2015, I am a graduate student at UF nearing the end of my program and I am also a computer science classroom teacher. I am looking for females who are working in the technology field to be interviewed by my students (8th graders) via skype/facetime for about ten minutes to let them ask questions about what you do. I will provide the questions ahead of time. I am doing some research on how we can change student preconceived stereotypes about the cs field. If you are willing to help I would be very grateful.

As a result, eleven women responded and six of those resulted in mentor interviews with the students.

For homework students were asked to write at least two questions that they would like to know about the potential guests who were computer science professionals. The questions were then compiled and merged into a comprehensive list of twenty. The interviewees received the questions in advance to prepare. The literature review



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pointed out the importance of both mentoring and modeling for females in STEM, so it was important to select women in a further attempt to break the stereotypes for all of the students (Brickhouse, Lowery, & Schultz, 2000; Britner & Pajares, 2005). Hopefully, these interviews gave the students an opportunity to relate to the professionals in the field. Students were asked to participate in a discussion board as a homework assignment about the mentor interviews. The reflections in concert with the scores on the artifacts and the musings in the field notes assisted in the identification of students selected to participate in interviews. The weblog was posted daily, and ideas that were noted resulted in small tweaks to the lessons as they unfolded between both groups.

Originally it was thought that the students would rotate participation between the technology unit and a non-related unit from the chemistry curriculum. As it turned out, once IRB approval had been secured, the needs of the seventh grade curriculum resulted in a staffing shortage so it benefited the school to combine the eighth grade classes for the entirety of the intervention. Therefore, the entire eighth grade experienced the unit simultaneously, in two sections divided almost equally. The two sections followed their normal rotations, one met Monday, Tuesday, Wednesday, and Friday. The other met Monday, Wednesday, Thursday and Friday.

At the conclusion of the lessons and after the students presented their projects, they retook the same survey assessment that they took at the start of the unit. Records were joined, gender was added and then the file was anonymized to secure the identities of the minors involved. The data was analyzed to quantify any changes in student perceptions. It is recognized that the intervention could have resulted in the changing attitudes in a positive or negative direction.



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**Instrument Development and Content Validity**

Early on, a validated survey instrument *Is Science Me?* developed by Aschbacher, Ing & Tsai (2014) was identified as a potential survey instrument. After corresponding with Aschbacher and Ing, permission to use and modify the instrument was granted. The authors were kind enough to supply their student interview protocol as well as their survey instrument. During the previous school year, the *Is Science Me?* Instrument was administered at the first week and the second to last day of the school year. The students had been introduced to programming in as gender neutral a fashion as possible within the math curriculum. Although all the students participated in three different coding projects during the school year, none indicated that they had programmed during the school year on this instrument. The students' lack of understanding of computer science as a field was evident in their lack of awareness that they had already engaged in computer science activities. This shortfall was part of the inspiration for this research project because one of the goals became to help students make connections between what programming is and what programmers do rather than on the actual coding portions of the CSP curriculum.

While this instrument was an inspiration, the goals for this research could not be met through this survey. The Aschbacher, Ing & Tsai survey contained many items that were not relevant, such as collecting information on student and family intentions to attend college since the school in the study is a college preparatory institution this information is already known. The *Is Science Me?* survey is nine pages long and took the students an entire class period to complete. The students taking the survey last year started to grow tired of it while they were taking it because it was so lengthy and the researcher feared they would "Christmas tree" the form and not fully read items and



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just fill in ovals.  Therefore, one of the goals of the present survey was to keep it short and straightforward.

An exhaustive search was made for validated surveys that could be used about computer science.   The work of Elliott Tew, Dorn and Schneider (2012) contained a potential instrument that was a modification of The Colorado Learning Attitudes about Science Survey (CLASS) that has been successfully used to measure attitudes about chemistry, biology and physics.  However, this instrument was validated with college students enrolled in computer science courses.  As such, the questions assumed that the participants were involved in a much higher level of computer programming than that of the eighth graders. For example “When I am working on a computer science program, I try to decide what reasonable output values would be” would not be relevant with these students (Elliott Tew, Dorn & Schneider, 2012, p. 137).  Because no pre-existing instrument could be found, one was designed for this study.

The survey itself underwent many revisions.  It was decided that the survey items that were of the Likert type would scaled between one and four.  According to survey research it is reasonable to force the students to make either a positive or negative choice rather than allowing them to remain neutral (Dillman, Smyth & Christian, 2009). There was an attempt at consistency among the items in that the questions were all in a positive tone and the items were ranked with the one as the low or negative value and the four as the high and positive reaction value. The majority of the questions used the scale of strongly agree, agree, disagree and strongly disagree.  The questions about future intentions use the scale of definitely I will, possibily I will, not likely and definitely I will not.



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Only three of the final version of the questions needed to be reverse coded to accommodate things like negative perceptions of the stereotype of a nerd. Again, the decision to rate the items on a scale of four to force the students to commit to either a positive or negative reaction with the neutral option purposefully being left out according to the survey techniques set forth by Dillman et al, (2009) in their text on designing Internet surveys was intentional. The survey questions are presented in Appendix A.

The research committee provided important guidance in the critique of the initial versions of the survey. Several iterations were created and when the final version was written, it was tested on several seventh grade students. Six seventh grade students were recruited from an afternoon study hall to review the survey in its current form. They reviewed it directly in Google Forms to simulate the experience of the live surveys. First, two students read the questions aloud to the researcher and they were asked if they understood the question and if they felt confident they would know how to answer them (Ericcson & Simon, 1993). This resulted in two minor revisions to the questions and word choices. The students identified a typographic error in the strongly agree box for one question. One student had a question about the word ethnicity because she was unsure of the meaning. As a result, the wording for that question was changed to include the phrase (or my family's culture) next to the word ethnicity. Next, three students volunteered and took the actual survey to also test the web address, and their data was removed from the dataset. Since the survey is provided to the students in Google Forms, summary statistics are automatically generated for the student responses. The two surveys were combined and the data were exported as a CSV file that was loaded into SPSS for advanced statistical analysis. It was important to



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determine if the effect of the measured attribute is reflected on the survey scores (Borsboom, Mellenbergh, & van Heerden, 2004).

The other artifacts that were collected throughout the unit were also reviewed and graded. The rubrics were designed to measure how the students meet or do not meet the standards that have been set within the lesson plans and originally were presented through the work of the CSP curriculum. The graded artifacts also served to determine student understanding and mastery of the subjects and requirements.

**Data Collection**

Data collection was in multiple forms. The pre and post-unit survey assessments were in Google Forms associated with the student G Suite accounts. The artifacts for the future computer science assignment were uploaded as a file attachment in the Canvas student accounts that acts as the LMS for the students in the course. The file uploads included text files, PowerPoint and Keynote options. The daily notes that students take on their iPads can be in any application that the student prefers. Students may be asked to share those occasionally as part of their science course methods, and students know to expect to be ready to be asked to do so. However, students were not asked to do so during the unit.

Daily reflections were posted to a weblog according to the methods of Dana and Yendol-Hoppey (2014). This was an effort to utilize the sense making, interpretation, and implication-drawing methods as outlined by Dana & Yendol-Hoppey (2014). Student questions for the interviews of professionals were collected electronically through a Canvas submission as a homework assignment. Upon review, I adjusted and combined the questions into a concise list that was provided to the prospective guests.



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Data collection proceeded according to the data collection and analysis plan details presented in Table 4-1. The unit lessons were delivered over a two and a half

Table 4-1. Data Collection and Analysis

| DATA | COLLECTION | ANALYSIS |
|---|---|---|
| Weblog | Daily reflection to two main questions plus any other relevant musings related to unit. | Reviewed to find trends and ideas that could help find bias, suggestions for improvement, overall record of exactly what was done. Results of class conversations and interactions will be noted and reviewed |
| Guardian Permission Form | Paper handed in before unit to teacher as homework assignment | Must be completed to participate in surveys. |
| Pre-Survey | Google Quiz Before Unit | Summary descriptive statistics |
| Post-Survey | Google Quiz After Unit | Summary descriptive and inferential statistics Records merged with pre document, names purged then downloaded as CSV file for SPSS for descriptive data and tested according to t test. |
| Assignment – Programmer Bio | Graded according to rubric | Overall student grade and evaluated as marker of students understanding field |
| Assignment – Elevator Speech | Graded according to rubric | Overall student grade and evaluated as marker of students understanding field |
| Assignment – Future Invention | Graded according to rubric | Overall student grade and evaluated as marker of students understanding field |
| Assignment – questions for interviews | Checked for completion for part of student grade | Questions combined and used to develop professional interviews |
| Assignment – online discussion board homework as follow-up to interviews | Checked for completion for part of student grade | Coded and reviewed by Thematic analysis. Used to identify students to be interviewed |
| Student Interviews | Recorded by interviewer | Coded (pre and emergent) and reviewed for common phrases and the analysis techniques of qualitative interviews looking for themes, topics, ideas, concepts, terms, phrases and keywords. |
| Student grades on unit | Performance measures | Indicator of students completing and understanding materials within intervention required student evaluation of performance |



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week (eight classes, four of 45 minute, two of 50 minutes and two of 75 minutes) period. Artifact collection was presented with due dates, however, it was within the class rules and expectations to accept late submissions without penalty depending on the conditions such as requests for extra time due to absence or illness. The interviews commenced after the initial lesson and prior to the delivery of the final career project. The professional interviews happened at the convenience of the guests so those varied for the classes. One group had the parent interview on a Wednesday morning while the group had it the following afternoon. All of the professional chats took place within the time frame of the unit. The post-survey did not commence until the second phase of professional chats and all of the lessons and deliverables had been completed. Two students who were absent took the survey three days later once they had made up the other work.

Students needed parental consent before being included in survey or interview protocols. All students took part in all of the lessons because they are being included as part of the regular course curriculum for the eighth grade year. However, only students with parental permission were included within any of the analysis of surveys. Students were selected for interviews based on the field notes, survey responses and viewpoints expressed within the artifacts. Students were purposely identified through positive, negative and neutral attitudes for interviews. Three students were interviewed. Opportunities to understand the development of the attitudes were the advantage of including the qualitative portion of the study design. Student interviews about the unit and student interpretations took place at the conclusion of the lessons. Students were given the opportunity to review their interview transcripts for accuracy.



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**Data Analysis and Interpretation**

Preliminary data analysis of the quantitative questions of the survey assessment was automatically compiled in real time through the Google Forms application within the G Suite. Further analysis of survey items was conducted through the SPSS software. This included the descriptive statistics, frequencies and paired T tests. The majority of the quantitative statistical analysis came from the analysis of the data collected from the pre and post-surveys. The surveys are identical and they were completed as a class in about fifteen minutes. Because the data was collected via Google forms within the G Suite for Education, the data was available to download as a spreadsheet that could be easily manipulated. The form contains three open-ended free response items for students identifying what do computer professionals do in their jobs. The inclusion of these open items allowed for pre and post comparison of what the students have learned about the field. It is possible that there is variation depending on the nature of the jobs of the individuals that our professionals chatted about and their experiences could have had impacted these answers. The data was converted to numeric values, and the names removed prior to loading into SPSS. The dependent t-tests determined if any changes between the pre and post data sets were significant with a set *p*-level value of .05 and the Cronbach's alpha test was run to determine the reliability of the scale.

Student artifacts were graded in accordance with a project rubric provided to students as the tasks were assigned. Both teachers reviewed and graded the finished projects. Student performance on the artifacts provided the required course assessments and also served as a measure of student learning.



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Interviews of students were electronically recorded and transcribed. Interviews were scripted and the format was adhered to in an attempt for me to not lead the interviewees and provide them the opportunity to answer without bias to the extent possible (Creswell, 2014). The questions for the interview can be found in Table 4-2 below. As previously stated, the students had the opportunity to read and validate the transcription. It was intended that the validity of the findings would be supported by the convergence of the various data sources. The weblog provided an opportunity to systematically and intentionally review my practice. I believed that my participation in this exercise challenged me and presented opportunities for my growth as an educator.

The intervention CSP unit will follow the plan for data analysis contained in the Dana and Yendol-Hoppey (2014) resource. Steps outlined above reflect the steps in this guide, and include action plans and a specific intervention to be followed by an outcome assessment. The first data to be analyzed were the artifacts turned in by students throughout the unit. The next step involved the evaluation of the survey quantitative data followed by the coding of the qualitative date. The last data to be coded were the following interviews at the conclusion of the intervention. The final summative assessment of description, sense-making, interpretation and implication drawing was followed through in the review of the data (Dana & Yendol-Hoppey, 2014).

It is also possible to categorize some of the items on the survey. The item categorization includes items of extrinsic factors, like they know someone, their family views or their peers views can be compared. Intrinsic factors that relate to the



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Table 4-2. Student Interview Questions

| Interview Questions |
| --- |

1. Have you changed your opinion about what computer professionals do in their jobs since we started this unit?
    a. (If yes) – how has your opinion about what computer professionals do in their jobs changed?
    b. (If no) – Does participating in this unit (and interviews) of professionals confirm what you believed prior to this unit?
2. So, what exactly is your impression of what computer professionals do in their jobs?
3. What field are you most interested in pursuing some day?
4. What types of job are you interested in doing some day when you enter the work force?
5. In what ways do technology and programming impact this field?
6. Do you think it is important for students to study computer programming? (Why or why not?)
7. Do you have any interest in pursuing a career in computer science? (Why or why not?)
8. Do you have any interest in taking a computer science class in high school?
9. Did you have any interest in taking a computer science class in high school before we studied this unit?
10. If the answers for 9 and 10 are different, why do you think this is the case?
11. Do you have any interest in taking computer science courses in college?
12. What did you think is one of the most important things you learned about computer science from our last unit?
13. Has anything that you have learned surprised you? Or was anything that you learned really different from your expectations before we started?
14. Do you think that computer science is a field you can see yourself pursuing some day?
15. What if any aspects of computer science do you find the most interesting?
16. What do you think are the traits of a computer scientist?
17. Do you think that you need to be a male to be successful in science?
18. Do you think that it is easier to be successful in computer science if you are a male?
19. Do you think that to be a successful computer scientist you have to work on programs all of the time?



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stereotype of working alone, or geeks or nerds or job is boring can be compared. Career goals like a love of puzzles or solving problems were compared. Finally, the data set was divided into scores between males and females to check for evidence of consistency (or a lack of it) within the items.

Coding of the open-ended surveys, artifacts and interviews followed the process of Thematic Analysis (TA) as described by Braun and Clarke (2014; 2017). While there are many methods for analyzing qualitative data, the method that may best suit the diversity of the artifacts is Thematic Analysis (Braun & Clarke, 2012). Theming data "is appropriate for virtually all qualitative studies, and especially for metasynthesis and metasummary studies" (Saldaña, 2009, p.140). As is recommended, the data required inductive and deductive methods to determine the commonalities (Saldaña, 2009). After familiarizing and rereading the student responses analysis progressed to identifying initial codes that form initial labels (Punch, 2014). Initial codes can be interpretive or summative (Braun & Clarke, 2012). The next phase identified emergent themes (Braun & Clarke, 2012) followed by a review and redrawing of the themes to the final definition, renaming and reporting of themes. The multiple passes resulted in the identification of similarities, differences, frequencies, sequences, relationships and causation (Hatch, 2002). Multiple passes of the data brought order by finding patterns, categories and descriptive units to aid in the interpretation of the data (Patton, 1987). For example, one pass of the data resulted in identifying redundancies in words that were the restatement of the questions. For example the question item *what does a programmer do* will result in the words 'a programmer' because it is the restatement of the question and not providing new data. Additional passes of the data helped to



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identify key phrases and provided opportunities making connections through the analysis that resulted in conceptual diagrams.

The student work and assignments that were presented in the lessons were graded similarly to the other units the students had throughout the year. The students were assessed by quizzes online, homework completion, participation grades, lab reports and projects through rubrics throughout the year. The assessments within this unit were consistent with the whole course grading practices. Student achievement was assessed by performance as represented through the final unit grade. The final unit grade was averaged with the other grades the students received throughout the quarter, semester and year for the final yearlong grade computation. This unit was weighted similarly to all other units.

The questions that were asked of the students for the career project were designed to determine their interests from the aspects of learning theory and career theory. The questions in the interviews were designed to best determine what learning theory has provided in terms of how the students have constructed their ideas of the field. In addition, the questions provided insights about what students are thinking for their potential future careers. Within the high school, students are advised to take courses that will lead to particular pathways in terms of college acceptances. For example, if someone is interested in medicine they will be advised to pursue honors and AP science courses and to take electives like Anatomy I and II. Our school, as a college preparatory school, puts emphasis on advising and college advising beginning in the eighth grade. Student's courses of study are planned with the oversight of college counselors each year. The college counselors begin their own interventions



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with students and parents and have group meetings beginning in grade seven and private meetings beginning in the ninth grade. Students are encouraged to begin to think about potential careers because this will assist college counseling with the process of planning their course of study and application strategies. Both learning theory and career theory will provide a lens for the interpretation of the data that was compiled throughout the study.

**Trustworthiness Plans and Ethical Considerations**

The ability to have my co-teacher to corroborate student grades on student artifacts helped eliminate grade inflation for students as well as eliminating potential bias in attempting to meet my research goals. All of the coded interviews were run through an analysis to be sure that frequently occurring words and emerging themes were coded and analyzed. Statistical analysis of the closed response items was done in accordance with social science significance thresholds (Cohen, 2008). Finally, the daily blog provided an overview of the entire process.

As stated previously, the ability to transfer the outcome of the study is limited in that it can only apply to a similar population of students of a co-educational college-preparatory independent school. Even though the population is specialized, it was interesting to have the opportunity to watch the students interact with models and mentors that are atypical to the student views and expectations. This factor alone was worth analyzing because career theory points to the importance of this element in the creation of the adolescent expectations about career choices. Any movement, positive or negative that was obtained as a result of the mentor interactions is an important factor to obtain a concrete measure for the field.



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While the interviews had the potential for bias since they were self-reported it is possible that a different experience with a different interviewer could have different results. The triangulation of the interview data via independent cohort review and participant review is hoped to bring a level of dependability to the data analyses of the study.

It has to be acknowledged that there is always the possibility that the interviewer and interviewee will influence each other. I made all attempts to not lead students during their interviews. Entries about my experiences in the interviews were posted in my daily blog. I felt it was important to follow a pre-established question base prior to the interviews, and I did not depart from the script.

The study complies with all of the policies and procedures of the University of Florida IRB. Participants were all eighth grade class members and under the age of fifteen. Parent permission to participate was obtained prior to students beginning work on the unit. Students had to have signed permission slips to participate in surveys, and in addition, students were told that their participation was strictly voluntary. The students had the option to not answer any questions or withdraw from participation at any time without fear of any penalty. Participants who were interviewed had the opportunity to review the transcripts of their sessions for validation. All students are referenced according to pseudonyms throughout the study. Survey data does not contain names, and the CSV sheets that are moved to SPSS had all login identifiers removed.

All participant interview files and transcriptions were and will be kept on a password-protected computer. When the analysis was completed the names were purged from the records. Only the dissertation committee will have access to the score



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sheets for the artifacts and survey SPSS results. The data will be maintained securely for the number of years required by the University of Florida and will then be destroyed.

**Methods Summary**

Once IRB approval was secured, parent permission slips were distributed and sent home for signatures and returned. The forms were collected over a two-week period prior to the start of the unit. Students were reminded via email to bring in forms, but were not assigned, nor were any grades given for participation or non-participation. Once signed and returned, the initial survey assessment was given to students in their science class so that the attitudes can be evaluated before any of the intervention steps began. Once this formative assessment data was obtained it was used in a summative fashion (Harlen & James, 1997). The data analysis from each step of the intervention informed the next step. Students received a lecture on the field and participated in lessons about computer science and its potential impacts on society in the near-term and far-term future. The first lesson included photos and documentation about current and past programmers and is modified from the lessons available for CSUnplugged Women@SCS Roadshow curriculum posted online at https://www.women.cs.cmu.edu/What/Outreach/Roadshow/. Students were presented with multiple images of programmers that represent diversity and are encouraged to understand that there are programmers that look like them in the world. Part of this early step was to help students see themselves as potential members of this professional community. The next lessons had the students working on a future of computer science assignment related to a field that is the field they most closely identified with professionally at the start of the unit. The next phase involved interviewing and virtually meeting female mentors participating in the profession. At the



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conclusion of the unit the students took a post-unit survey assessment identical to the pre-test to determine any shifts in their thinking in any direction. Depending on student feedback and grading of student artifacts, students were selected to interview to dig as deeply as possible into the thinking and concerns that the adolescents have related to the field.

I created and updated a daily weblog throughout the entire project for mandatory reflection. It was important that the reflection be kept with pseudonyms to protect student identities. I found the weblog to be useful in helping me to remember details and in helping me make sense of the experience in accordance with the *Reflective Educator's Guide to Classroom Research* by Dana and Yendol-Hoppey (2014). The Finding your Findings chapter of the resource provides the methods and steps that have been enlisted and followed as a guide throughout the research study. The action plan set forth in this document was followed in the hope that the intervention led to an outcome assessment that will verify taking the time to help adolescents make career connections as a valuable step in social cognitive career theory development.



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CHAPTER 5
RESULTS/FINDINGS

This study examined the perceptions held about the field of computer science by eighth graders in a science class both before and after they experienced an intervention about the global impacts of the field. The surveys measured student attitudes with four point Likert scales where the high score of four was assigned to strongly agree, three to agree, two to disagree and one to strongly disagree. Details for the scales appear in Table 5-1. Overall, students obtained the highest grade point average for this unit. All of the students earned grades in the B or higher range. Student engagement throughout the unit was consistently high and rewarding to experience as a teacher. The weblog included many positive comments that students made throughout the unit.

This chapter will summarize each instrument including the pre and post-surveys as well as looking at the student artifacts and student interviews that were collected during and after the project. This study was guided by two main research questions including:

- **RQ1:** How can exposure to an intervention that incorporates some CSP materials, specifically the global impact unit, lead to a more authentic perception of the professional field of computer science among an eighth grade student population?
- **RQ2:** How can exposure to a CSP unit about the field of computer science and what computer scientists actually do, result in positive changes to student views about the profession of computer science, especially among female students?

The data collected moves between both questions, so it will be presented as quantitative and qualitative data chronologically. The quantitative data collected is confined to portions of the pre and post-surveys the students completed on Google Forms within each student's G Suite account. The qualitative data for the surveys



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appears in the coded open response section. The analysis of the qualitative data of artifacts and student interviews follow.

## Surveys

The survey consisted of 18 questions. Questions one, 17 and 18 were open responses and the remaining questions were closed responses. Of the fifteen closed responses, fourteen were Likert four point scales (Dillman et al., 2009) and one was a binary yes or no response. The Likert scales had four options with the most positive having the value of four to the lowest of one as listed in Table 5-1.

Table 5-1. Likert scale labels for survey items

| | | | |
|---|---|---|---|
| 4 Strongly Agree | Always | Definitely I will | Completely understand |
| 3 Agree | Almost Always | Possibly I will | Somewhat sure |
| 3 Disagree | Almost Never | Not Likely | Somewhat unsure |
| 1 Strongly Disagree | Never | Definitely I will not | Do not understand |

## Closed Responses

The survey was tested with Cronbach's alpa (fourteen items; α = .831) to determine internal consistency. This Cronbach's alpha value exceeded 0.8, and the overall survey internal consistency reliability was α = 0.831 showing a high level of reliability of the closed response items. Analysis of the survey items is summarized in Table 5-2.

The first group of questions that look at student perceptions of the field show a significant changes of their views. Item two asks students if they *understand what computer scientists do in their jobs* shows a large change with a $t(55) = 10.053$, $p < .001$. Clearly students felt more strongly that they understood the field upon completion of the intervention. The graph in Figure 5-1 shows the shift in student beliefs in their confidence about understanding what CS professionals do in their jobs.



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Table 5-2. Analysis of Closed Survey Responses

| | PRE | | | POST | | | Paired T test | |
|---|---|---|---|---|---|---|---|---|
| Theme/Item Number | N | M | SD | N | M | SD | t-value | p-value |
| Stereotype/2: I understand what computer science professionals do in their jobs. | 58 | 2.24 | .904 | 59 | 3.32 | .655 | 10.053 | <.001 |
| Stereotype/4: I think that computer science professionals have jobs that are boring. | 58 | 2.76 | .733 | 59 | 3.10 | .687 | -3.800 | <.001 |
| Stereotype/5: I think that programming a computer is boring. | 58 | 2.59 | .879 | 59 | 2.92 | .877 | -3.203 | .002 |
| Stereotype/6: Most people who work as cs professionals are geeks or nerds. | 58 | 3.22 | .594 | 59 | 3.29 | .720 | -1.150 | .255 |
| Stereotype/7: Most computer science professionals spend their time working alone at their computer. | 58 | 2.74 | .579 | 59 | 3.02 | .682 | -3.033 | .004 |
| Profession/8: Computer science professionals spend most of their time working with people to solve real world problems. | 58 | 3.03 | .591 | 59 | 3.20 | .714 | -1.944 | .057 |
| Family Influence/9: My family thinks it is important for me to learn about computer science and how to program a computer. | 58 | 2.47 | .941 | 59 | 2.53 | .953 | -0.362 | .719 |
| Peer Influence/10: My friends think cs is cool. | 58 | 2.26 | .739 | 59 | 2.53 | .796 | -2.974 | .004 |
| Gender/11: People who share my gender are well represented in the field of cs. | 58 | 2.47 | .883 | 59 | 2.46 | 1.039 | .645 | .521 |
| Ethnicity/12: People who share my ethnicity (or my family's culture) are well represented in the field of computer science. | 57 | 2.70 | .886 | 59 | 2.90 | .845 | -2.058 | .044 |
| Persistence/13: I enjoy working with puzzles and do not give up on them easily even when they are difficult. | 58 | 2.78 | .992 | 59 | 2.88 | .911 | -1.293 | .201 |
| Career/14: It is important to me that my future career will allow me to work with people. | 58 | 3.28 | .720 | 59 | 3.41 | .591 | -1.308 | .196 |
| Career/15: Do you think you will take a computer science course in high school? | 58 | 2.21 | .874 | 59 | 2.56 | .896 | -4.153 | <.001 |
| Career/16: Would you want to someday work as a computer science professional? | 58 | 1.98 | .761 | 59 | 2.19 | .861 | -1.699 | .095 |



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Table 5-3. Analysis of Survey Items by Gender

| Independent Samples T-Test for Pre-Survey and Post-Survey by Gender | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Gender | *N* | *M* | *SD* | *t-value* | *p-value* |
| Stereotype/2: I understand what computer science professionals do in their jobs. | Pre | m | 24 | 2.460 | 1.021 | 1.554 | .126 |
| | Pre | f | 34 | 2.090 | .793 | | |
| | Post | m | 26 | 3.420 | .643 | 1.053 | .297 |
| | Post | f | 33 | 3.240 | .663 | | |
| Stereotype/4: I think that cs professionals have jobs that are boring. | Pre | m | 24 | 2.880 | .680 | 1.016 | .314 |
| | Pre | f | 34 | 2.680 | .768 | | |
| | Post | m | 26 | 3.270 | .604 | 1.689 | .097 |
| | Post | f | 33 | 2.970 | .728 | | |
| Stereotype/5: I think that programming a computer is boring. | Pre | m | 24 | 2.830 | .761 | 1.835 | .072 |
| | Pre | f | 34 | 2.410 | .925 | | |
| | Post | m | 26 | 3.080 | .796 | 1.264 | .211 |
| | Post | f | 33 | 2.790 | .927 | | |
| Stereotype/6: Most people who work as computer science professionals are geeks or nerds. | Pre | m | 24 | 3.170 | .565 | -.616 | .540 |
| | Pre | f | 34 | 3.260 | .618 | | |
| | Post | m | 26 | 3.270 | .724 | -.177 | .860 |
| | Post | f | 33 | 3.300 | .728 | | |
| Stereotype/7: Most computer science professionals spend their time working alone at their computer. | Pre | m | 24 | 2.710 | .550 | -.362 | .719 |
| | Pre | f | 34 | 2.760 | .606 | | |
| | Post | m | 26 | 2.960 | .824 | -.551 | .584 |
| | Post | f | 33 | 3.060 | .556 | | |
| Profession/8: CS professionals spend most of their time working with people to solve real world problems. | Pre | m | 24 | 3.080 | .654 | .525 | .601 |
| | Pre | f | 34 | 3.000 | .550 | | |
| | Post | m | 26 | 3.230 | .765 | .259 | .796 |
| | Post | f | 33 | 3.180 | .683 | | |
| Family Influence/9: My family thinks it is important for me to learn about cs and how to program a computer. | Pre | m | 24 | 2.790 | .833 | 2.301 | .025 |
| | Pre | f | 34 | 2.240 | .955 | | |
| | Post | m | 26 | 2.770 | .863 | 1.776 | .081 |
| | Post | f | 33 | 2.330 | .990 | | |
| Peers/10: My friends think computer science is cool. | Pre | m | 24 | 2.330 | .868 | .644 | .522 |
| | Pre | f | 34 | 2.210 | .641 | | |
| | Post | m | 26 | 2.540 | .859 | .111 | .912 |
| | Post | f | 33 | 2.520 | .755 | | |
| Gender/11: People who share my gender are well represented in the field of cs. | Pre | m | 24 | 2.920 | .776 | 3.595 | .001 |
| | Pre | f | 34 | 2.150 | .821 | | |
| | Post | m | 26 | 3.190 | .849 | 6.171 | <.001 |
| | Post | f | 33 | 1.880 | .781 | | |
| Ethnicity/12: People who share my ethnicity (or my family's culture) are well represented in the field of cs. | Pre | m | 24 | 2.700 | 1.020 | -.042 | .966 |
| | Pre | f | 34 | 2.710 | .799 | | |
| | Post | m | 26 | 2.850 | .834 | -.418 | .678 |
| | Post | f | 33 | 2.940 | .864 | | |
| Persistence/13: I enjoy working with puzzles and do not give up on them easily even when they are difficult. | Pre | m | 24 | 2.710 | .999 | -.432 | .667 |
| | Pre | f | 34 | 2.820 | .999 | | |
| | Post | m | 26 | 2.810 | .849 | -.548 | .586 |
| | Post | f | 33 | 2.940 | .966 | | |
| Career/14: It is important to me that my future career will allow me to work with people. | Pre | m | 24 | 3.080 | .830 | -1.740 | .087 |
| | Pre | f | 34 | 3.410 | .609 | | |
| | Post | m | 26 | 3.380 | .637 | -.254 | .801 |
| | Post | f | 33 | 3.420 | .561 | | |



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Table 5-3. Continued

| Independent Samples T-Test for Gender | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Gender | *N* | *M* | *SD* | *t-value* | *p-value* |
| Career/15: Do you think you will take a computer science course in high school? | Pre | m | 24 | 2.460 | .932 | 1.882 | .065 |
| | Pre | f | 34 | 2.030 | .797 | | |
| | Post | m | 26 | 2.880 | .864 | 2.595 | .012 |
| | Post | f | 33 | 2.300 | .847 | | |
| Career/16: Would you want to someday work as a computer science professional? | Pre | m | 24 | 2.210 | .779 | 1.943 | .057 |
| | Pre | f | 34 | 1.820 | .716 | | |
| | Post | m | 26 | 2.420 | .857 | 1.918 | .060 |
| | Post | f | 33 | 2.000 | .829 | | |

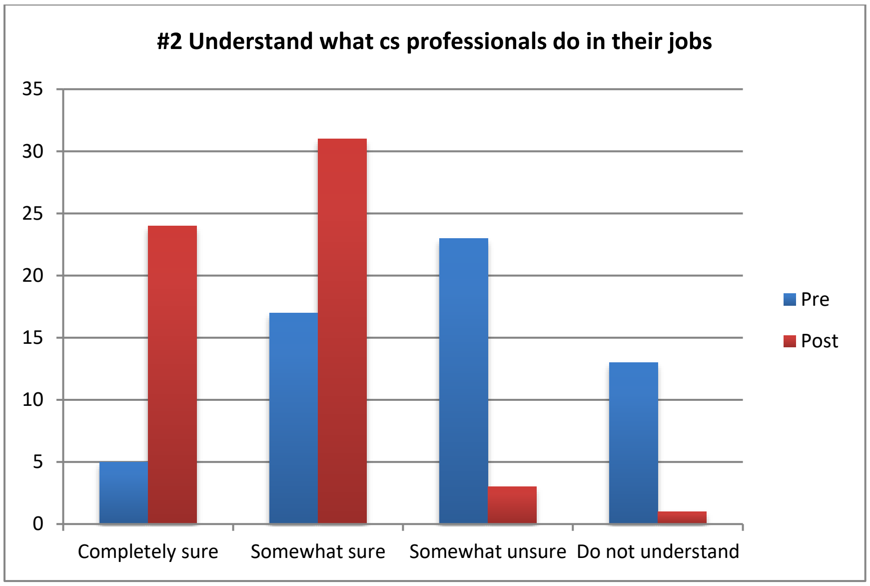


Figure 5-1. Analysis of Closed Survey Responses

The first two items related to stereotypes, that *computer science is boring* and the *jobs are boring* also saw significant shifts. The *jobs are boring* evaluated to *t*(55) = 3.8, *p* < .001 and the *programming is boring* question evaluated to *t*(55) = -3.203, *p* = .002 shows large shifts of perceptions. Also, part of the stereotype is the notion that *computer scientists work alone at their computers*, and this *t*(55) = -3.033, *p* = .004 was also a significant change in perception. Item ten, *my friends think that computer science is cool* looking at student beliefs is also a significant *t*(55) = -2.974, *p* = .004 change in perception.



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Item nine; the question related to family views did not yield any information other than the distributions being identical for the pre and post-surveys. In both cases it was an almost even split between agreement and disagreement. However for this item a statistical test by gender was significant at $p$ =.025. Here the males moved from $M$ = 2.79 ($SD$ = .833) to $M$ = 2.77 ($SD$ = .863) and the females moved from $M$ = 2.24 ($SD$ = .955) to $M$ = 2.33 ($SD$ = .990). Similarly, item eleven, *people who share my gender are well represented in the field of computer science* showed a $t(56)$ = 3.595, $p$ = .001. Males feeling that they were represented moved from a $M$ = 2.92 ($SD$ = .776) to post $M$ = 3.19 ($SD$ = .849) while females moved from $M$ = 2.15 ($SD$ = .821) to post $M$ = 1.88 ($SD$ = .781).

Less significant, but present nonetheless, was a shift in the understanding of the student's ethnicity being represented in the field. Item twelve about *people who share my ethnicity are represented in the field* evaluated to $t(55)$= -2.058, $p$ = .044 which indicates that a change occurred in their beliefs that their ethnicity was represented. Without corroborating demographic information, however, this is not really valid data. We can only say here that the perceptions changed, but we cannot corroborate whether the student belonged to an under-represented demographic.

Finally, the last significant change of perception was identified in the question that looked at the future intentions of students when asked if they *would consider taking a computer science course in high school*, $t(55)$ = -4.153, $p < .001$, a $M$ = 2.21 ($SD$ = .874) to post $M$ = 2.56 ($SD$ = .896). Table 5-4 shows the distribution, and the amount choosing to definitely take a course doubled.



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Table 5-4. Distribution of those choosing to take courses in HS

| | Pre M | Pre F | Pre Total | Post M | Post F | Post Total |
|---|---|---|---|---|---|---|
| Definitely I will | 3 | 1 | 4 | 7 | 2 | 9 |
| Possibly I will | 9 | 8 | 17 | 10 | 12 | 22 |
| Not Likely | 8 | 16 | 24 | 8 | 13 | 21 |
| Definitely will not | 4 | 9 | 13 | 1 | 6 | 7 |

The third question on the survey asked if the respondent knew a computer professional. This question was intended to measure the distal factor for the career theory of whether or not the individual had first-hand knowledge of someone in the profession. Item three asked if they *know someone who is a computer science professional*. The pre-survey numbers were 21 yes and 36 no. This shifted on the post-survey to 43 yes and 16 no. A chi-square test of independence was performed to examine the relationship between knowing someone in the field before and after the intervention. The relation between these variables approached being significant, $X^2$ (2, $N$ = 61) = 10.852, $p$ =.028.

## Coded Open Response Data

### What Computer Professionals Do

The first open question to be examined, item one, was the question that asked students what computer professionals do in their jobs. The student responses were analyzed and coded to identify trends and themes. All of the closed survey responses were coded according to the Thematic Analysis method (Braun & Clarke, 2012). For item number one, the amount of words students wrote had a pre $M$ =15.23 ($SD$ = 10.598) and post $M$=15.72 ($SD$ = 10.668). While the amount that the students wrote did not change in any significant way, coding provided a clear change in the views that they represented. In the pre-survey the responses; seventy-one percent contained the key words help, fix, code, or program. A typical response was "I think computer



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professionals code and do programming." The thematic map is presented in Figure 5-2. The thematic graphic in Figure 5-2 shows the key terms with the word code representing either repairing and/or creating.

What professionals do on the post intervention survey again resulted in the most frequently used words to be help, fix, code or program. Again, the majority had targeted phrases like "codes to solve" where the end word could be problems, issues or world problems. However, the post option showed more words in more sophisticated phrases like "make lives easier" or "helping people" than what was present in the pre-survey. In the post-survey fifty-five percent of the students indicated "solving real world problems"

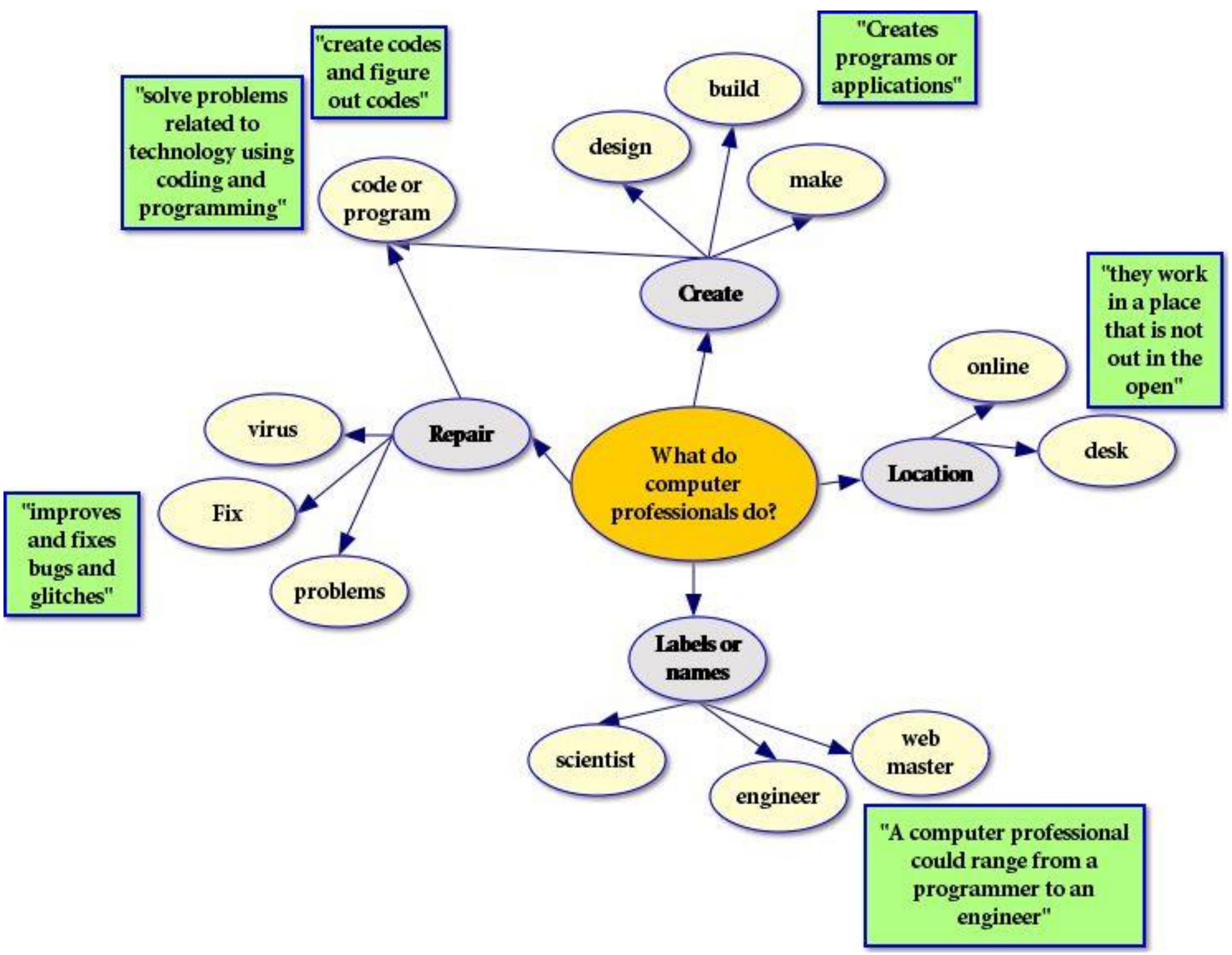


Figure 5-2. TA for pre-survey Item 1



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or “help the world” compared to just nine percent in the pre-survey. The coding of this item in the post-survey indicated a clear shift in perceptions. Respondents began to include a worldview that was not present in the pre-survey. In the post-survey, there are references to repairs and creating, but they are tied into a worldview. Statements have a new depth that is not present in the pre-survey in comments with additional themes such as those represented in Figure 5-3. Examples of the depth are found in statements like “create things to save lives” and “create programs that can help in a lot of different fields.” Additionally, the world view theme shows overlap with creation, repair, and a new theme of research that emerges within statements such as “research, code, and work with various programs to try to fix a problem to change the way the world works.”

**Biggest Challenges for Computer Professionals.** The second open-ended question, item 17, is “What do you think are the biggest challenges for computer science professionals?” For item 17 on the pre-survey the amount of words students wrote had a $M$ =18.72 ($SD$ = 15.28) and on the post-survey there was a $M$ = 20.41 ($SD$ = 16.974). This showed that students wrote slightly more on the post-survey.

The pre-survey thematic analysis for this item appears in Figure 5-4 and the post-survey thematic analysis appears in Figure 5-5. The thematic coding found that half of the responses related some sort of finding or fixing problems identified as being related to coding and/or time. An example is “finding bugs in an application and fixing the problem.” Time was also related to the rate of changing technology. An example by one student stated, “the biggest challenge is keeping up with the latest technology.”



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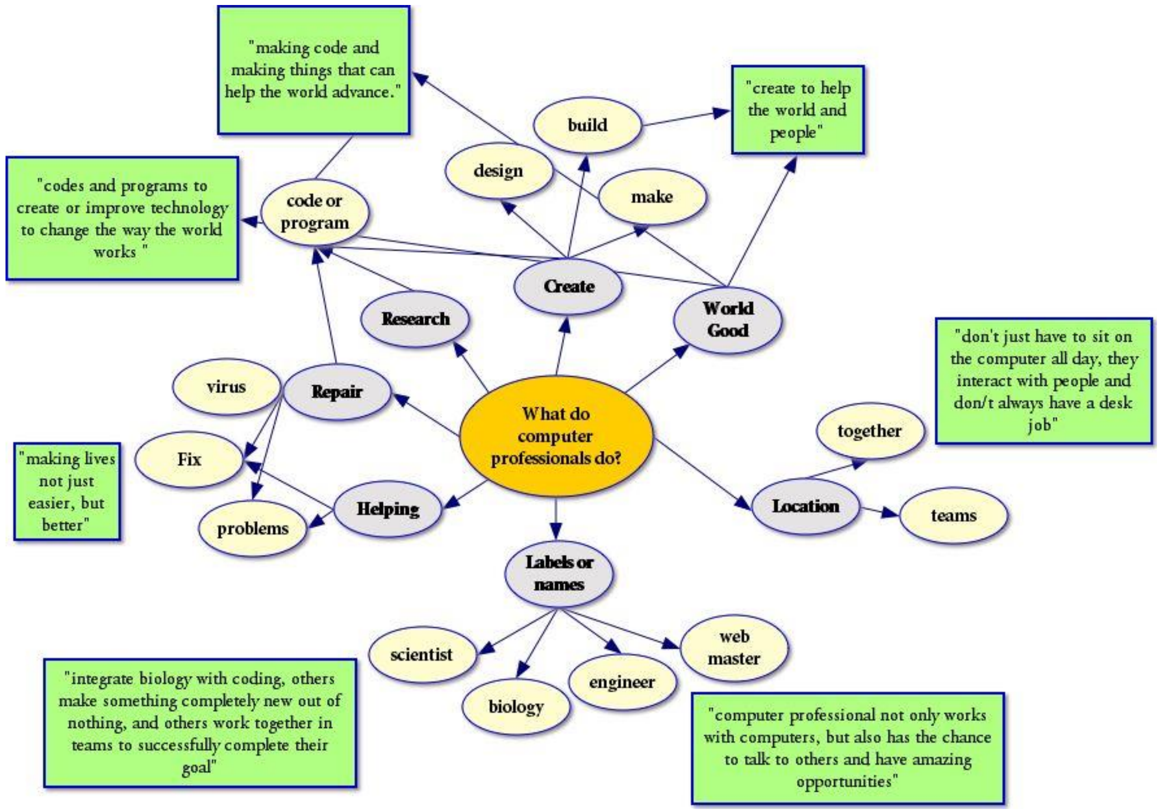


Figure 5-3. TA for post-survey item 1

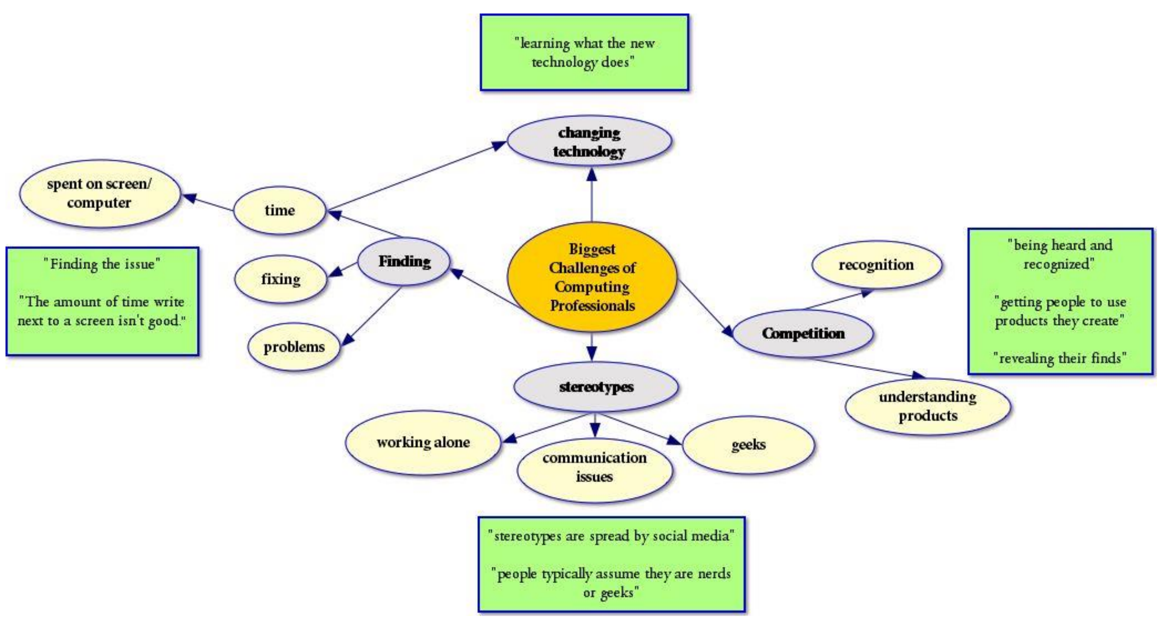


Figure 5-4. TA for pre-survey Item 17



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Twenty percent of students identified problems in either being heard, recognized or overcoming factors related to the stereotypes of nerds such as “stereotypes are spread by social media.”  In the pre-survey nine students listed items that reflected the stereotypes including nerds, time alone, and in front of screens. This shifted in the post-survey. In the post-survey twenty-five percent of the students identified gender as an

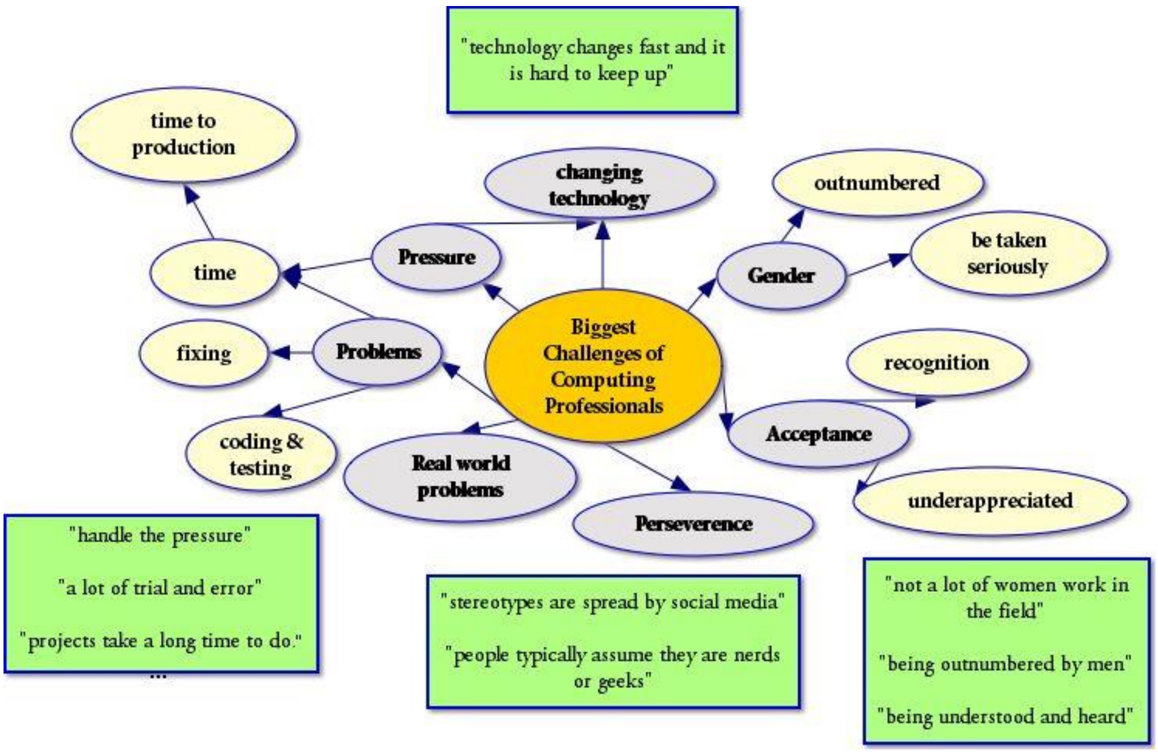


Figure 5-5. TA for post-survey Item 17

Issue it was noted that women had a hard time because men dominated the field or that men did not take them seriously. Where half the respondents in the pre-survey identified fixing problems, only four of them noted this in the post-survey. Instead, there were more specific references in the post-survey that did not exist in the pre-survey to “working through challenges” or “not giving up.” Also emerging in the post-survey for the first time was that it was a goal to overcome fears and to “get yourself known.”



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There was also a convergence of codes that related to the importance of keeping up with new technology as well as learning new things.

**Typical Goals of CS Professionals.** The third open-ended item, question 18, asked "What do you think are the typical goals of someone who works as a computer science professional?" For item 18 on the pre-survey the amount of words students wrote had a *M* =17.00 (*SD* = 14.52) and on the post-survey there was a *M* = 16.79 (*SD* = 14.81). This showed that students wrote just slightly less on the post-survey. The pre-survey thematic analysis for this item appears in Figure 5-6 and the post-survey thematic analysis appears in Figure 5-7.

Within the pre-survey coding the responses showed that answers centered on fixing, solving or improving, with twenty-five percent of the comments listing one of these exact words within phrases. There were six instances of the word create, two instances of gender, six references to the world, and three instances of each to discovering, inventing and creating. There was a single reference to "wanting more females to work with technology" and "encourage more women or people of color." One student stated, "to work for a big company like Apple." While another student stated "to be like steve jobs and create their own technology so they can be famous."

Within the post-survey, the third open-ended question addressing typical goals there is shift in the responses. The coding revealed the themes dropped by twenty-five percent, so the remaining seventy-five percent saw more overlap. For example phrases of fixing or coding now included phrases like "to fix real world problems." Likewise, eighteen students used the word world. These, in combination with phrases like "help people" or "make things easier for people" occurred for another twenty percent of the



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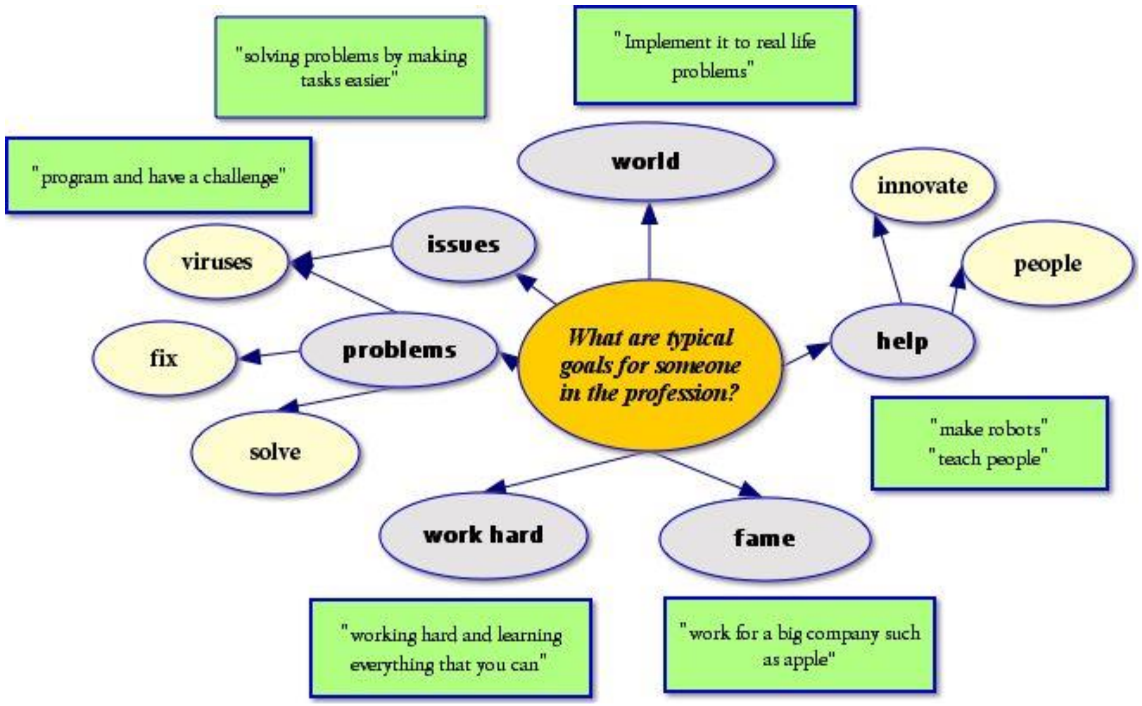


Figure 5-6. TA for pre-survey Item 18

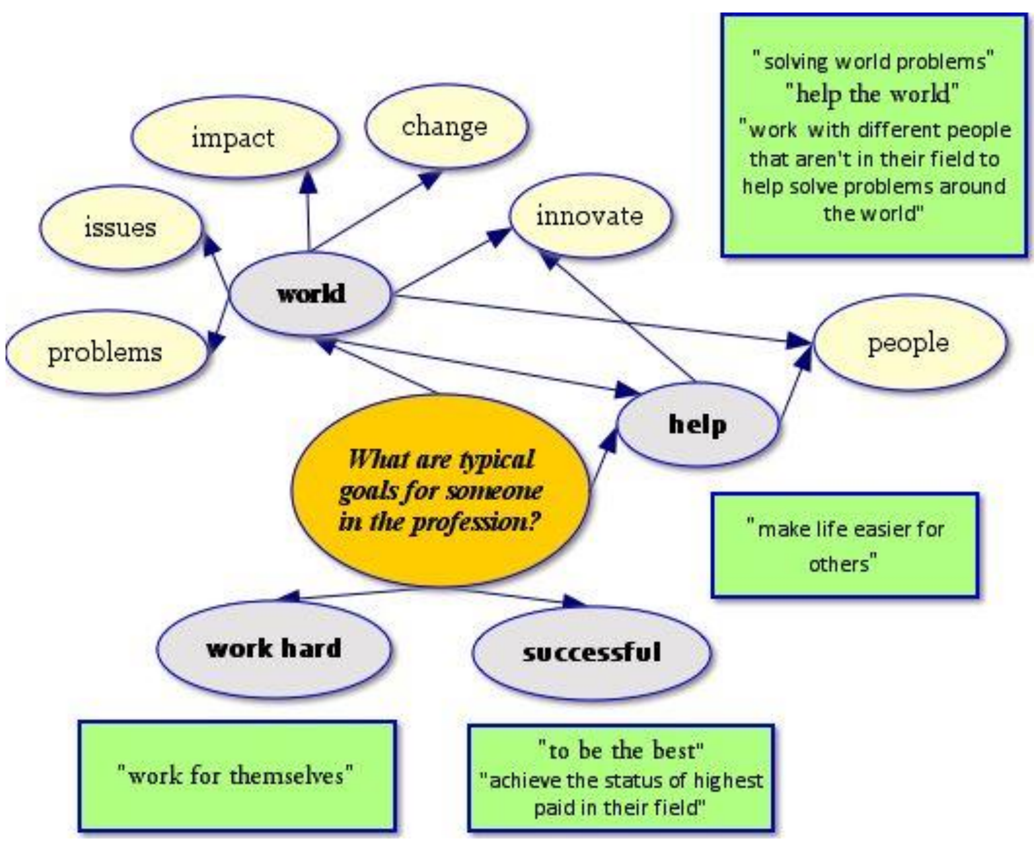


Figure 5-7. TA for post-survey Item 18



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responses. Appearing for the first time are phrases like "defeat the unbeatable" and "make their company known" and "become their own boss."

## Lesson Artifacts

### Lesson one.

**Biographies.** Lesson one required students to write a biographical piece. This lesson was designed to help students begin to understand the nature of the field and to give them a historical perspective that included information about the history of women in the computer science field.

**Yesterday's Homework Assignment.** The homework assignment from lesson one that required students to interview someone older than them provided an opportunity to code their perceptions about the changes in technology over time. The majority (95%) of the students interviewed a parent. Four interviewed both parents. The three that did not interview parents chose a grandfather, an aunt and an uncle, and an older brother (age 26) who is working as a computer programmer. Reviewing the weblog, there are notes about two student comments about this being interesting and fun to ask these questions. Likewise, there are notes in the weblog during parent conferences because this was assigned the night before parent conferences. Three of the parents that attended the parent conferences commented that they enjoyed doing this assignment with their children. One parent referenced that it was a conversation starter and allowed her to "have a conversation about safety" with her son. Many times the parent involvement at our school for this age group is to check on whether or not students have done their homework, and one commented that they were pleased to have an assignment that provided a chance to have an interesting conversation with their child and that it "spilled over to dinner."



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**Identifying things that have changed.**

Overall, the assignments referenced many of the obvious changes that included notable and expected communications advances such as cell phones, information and news resources online, texting, and email. Over ninety percent of the students indicated social media in some form as being one of the biggest changes. Some interviews resulted in students writing a directly quoted personal anecdote while others generalized or contextualized their answers. An example of a contextualized answer relating to *how much social interactions have not changed* follows:

> I think technology has completely re shaped how we live, and I was expecting to have little to no similarities. But the basics of hanging out with friends and having fun is still the same. I think there are some qualities of friendship that will never disappear no matter how much differently the interactions are made. Whether we make friends over the social media or someone we meet at school, they are a friend, and you should stand up and have fun with them. Friends will always be there for you when times are down, no matter how they are made.

Themes and samples of things that had changed that were identified included dating apps, Apple pay, applying and finding employment, digital photography, online shopping or ride services like Uber. Some noted changes of things that were no longer popular or allowed, like walking to see friends on their own or sending letters via the mail or even going to a library for research. One assignment noted that children were now much busier, in terms of obligations and things they were scheduled for had greatly increased.

**Identifying things that have remained the same.**

Among the things that hadn't changed that were most noted by the students were relationships with friends ("hanging out with friends" or "going to the movies") and participation on sports teams ("played on school baseball team"). They also noted



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family gatherings like dinners, ("having dinner together as a family"), watching shows ("family time watching TV") and taking vacations ("People still take vacations") had remained the same.

**Identifying things that were surprising.**

The question inviting students to indicate what they found surprising contained many varied responses. Seven of the students noted that long distance telephone service was expensive at one time. Ten mentioned that that children used to be able to walk to many places on their own. Two specifically did not realize that the World Wide Web (though they would say Internet interchangeably) was not around for the people they interviewed when they were their age.

Among one of the notable changes identified by a male student who is a twin (note this does not give identity away because there are three sets of twins in this class) stated in his interview with his father:

> The most surprising thing that I learned about social interaction in the past was that everyone my dad talked to was within walking distance from his house. This is surprising because I do not have any friends that live walking distance from my house, but it is still easy to get to their house with a car.

Related to this another male student stated:

> I was surprised to learn that in the past it seemed it was a much safer world for kids to hang out with their friends, walk to the store, without having to worry about bad people kidnaping you or hurting you. What was surprising was that it was all still happened back then. But without social media is was not out there for everyone to hear and know about it.

Another female student revealed from her interview with her mother that she was unaware that one of the surprising changes was that bullying often occurred online in her statement:



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> One of the most surprising things that I have learned about social interaction is the amount of negative and bad comments said on social media. Especially when it is targeted to one single person or idea, it can definitely hurt one another mentally, and can cause them to become upset about their ways.

While another noted:

> My mom says that she wished that she had video chatting when she was younger, because her father lived in a different part of the world, and she would have liked to see and talked to him more. It is surprising that before the internet was created, there was a social chat room, called Dial Up, which would dial into another person's chat site and they could talk. I think that this was surprising because in Dial Up, you did not know who you were talking to until you asked. Now, you can easily go into your contacts and text a person of your choice.

Most of the assignments were extremely well written as was evidenced by the (*M* = 96) grade for the science class. Figure 5-8 has been provided to exemplify the different approaches that students took in completing this assignment. One memorable quote is the following: "I'm surprised that they had absolutely no internet at all, because without internet, I don't think that I could live." While one of the interesting predictions made by a student was that "the idea that physical school would become less commonplace or perhaps not even needed in the future."

**Lesson two**

This assignment had students work in groups selected between the two class sections to design a future technology product. The projects were shared with the class in an elevator speech not to exceed two minutes as well as a written component to be completed by the entire group and turned in electronically upon completion.

**Elevator Speeches.** All but one elevator speech was delivered in under the two minute timed requirement. Students picked their own groups with the exception of students who had been absent who were grouped together when they returned to



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1. Identify five aspects of social interaction that have fundamentally changed since they were your age.
   1. The ability to instantly contact anyone (via. phone, email, etc.)
   2. Uber (the ability to get a ride without having any money)
   3. Apple Pay (the ability to pay for things without cash, just phone)
   4. The ability to share pictures
   5. The ability to know the location of people instantly
   6. The ability to travel and book tickets for flights easily on technology
   7. Just the fact that most things now are shared and done with technology
2. Identify five aspects of social interaction that are more or less the same as when they were your age.
   1. Can still call people on the phone (even though it is much easier now)
   2. Can still sit down and have a nice coffee with them
   3. People still take vacations
   4. People still date and get married, even though it is easier now that there are dating websites
   5. Travel is still the same, it is just easier with technology now
3. Describe the most surprising thing that you learned about social interaction in the past and explain why it was so surprising.
   1. It took a lot longer for information to be spread
   2. Dating was much different in the 1900s
   3. Cell phones weren't even a thing in 1970
   4. The updating in technology and the new inventions have changed.
4. Identify one way that you think social interaction might change between now and the next generation (i.e., in 20-30 years).
   1. In 1970, when my dad was a child, it was inconceivable that technology could change and expand and update in such little time, so when I think about what technology will be in 20 to 30 years, I can't even imagine it. I think that social interaction will change by cars. After reading lots about it, I believe that cars will be able to drive themselves in 30 years.

Identify five aspects of social interaction that have fundamentally changed since they were your age.

Many aspects of social interaction have changed since my mom was my age. Typically, my mom hung out with her friends. She would talk, sing, dance, and go rollerskating with her friends. These activities are not as common. Now, kids hang out at the mall and are always texting and checking social media, not always directly interacting with each other. My mom hung out with her friends everyday afterschool and on the weekends, which isn't the same as today. Kids today are busier with lots of homework, hobbies, and clubs, which doesn't always allow lots of hangout time. My mom hung out with people her own age, which is mostly how kids are today. Some kids, however, interact with strangers on the internet who may be older than they say they are. In the past, telephones, fax machines, letters were used to communicate with friends and family. Today, we use wireless smartphones and computers to email, text, call, FaceTime, etc. people everywhere. To find information for school, my mom would use a textbook to find limited information. Nowadays, we have the entire internet at the touch of our fingers with a wide variety of sources.

Identify five aspects of social interaction that are more or less the same as when they were your age.

Some aspects of social interaction stayed the same between generations. When my mom was younger, she would hang out with her friends at the movies and the beach, which are still popular hangouts. My mom hung out with people her own age, which is mostly how kids are today. There were many trends and fads that spread despite the lack of social media. My mom was always listening to music with her friends, which many kids do today. There are always the iconic singers that everyone knew and loved. My mom also still has contact with her friends from her past, which will most likely happen to us in the future.

Describe the most surprising thing that you learned about social interaction in the past and explain why it was so surprising.

I found it strange that my mother would walk 3-5 miles to hang out with a friend. Nowadays, we are so used to driving and other forms of transportation that walking almost becomes foreign. Every quarter or so, we dread running the mile in PE. Imagining walking 3-5 miles almost everyday makes running the mile seem like a trivial problem.

Figure 5-8. Yesterday's Assignment Sample Artifacts



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school. The groups were crossed between both classes so that the students had not had the opportunity to work together prior to this assignment. The products they invented showed variation that that they designed home objects, health objects, sport objects and even hobby objects such as a fishing lure that had special technology embedded within it.

The observations of the students on the weblog noted that the students were highly engaged in this activity. When the teaching partner and I circulated among the rooms the students were focused, on task, and deep in conversation about their ideas and the benefits that would result.

In summary, the speeches were rehearsed during the classes and one group presented as though they were a commercial for their product. Some groups elected one person to speak while the majority had all of the group members speak from the front of the classroom. All of the groups received full credit for this part of the assignment except for one group that lost two points for going over the time limit during their presentation. A third of the groups used prompts or slides from their iPads for the speeches. Their products were representative of a wide range of subjects for example they included a solution for coral bleaching, a jet pack backpack, contact lenses for Diabetes, ear pieces for language translation, magic bullets for the military, breathalyzers for car ignitions, a self-tuning violin, a bracelet to record heart rhythms that would automatically dial 911, as well as tools to help with cleaning and laundry in the home. One group sought to create lenses to correct color blindness. The content for this project is in the media presentation slides.



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**Future technology project presentation**

The technology project slide shows were worked on as a group in class. All but six of the groups ran out of time and were unable to complete the assignment in class because the mentor interviews took out four class days. Therefore, the majority of the groups worked via Skype or Facetime to finish up their assignments in the evening or during study hall according to the group member preferences. One student from each group uploaded the project. Overall the grades were high (*M* = 97). The slide deck components that were required included purpose, description, features, risks, benefits, technological resources and technological challenges. A group sample appears in Figure 5-9. Student inventions included interesting ideas such as LiFi (permanent internet access), Anti Crash Car, Hand Held Skin Healers, Allergreen (removes all allergy ingredients from food), and Smart Traffic Lights (dynamically change according to traffic flow on roads). The groups were allowed to determine the format for their submission and final projects were distributed as Keynote (5), pdf (4), Slides (10), PowerPoint (1) and Adobe Spark (2). The file choices meant some could work simultaneously on the same slides, but the majority divided up the load and individual students took responsibility for individual parts and collated them back together making it impossible to identify how much of the project was completed by each student.

**Lesson 3 – Future Career Project.** There was a homework assignment that students had to fill in "I think I might like to be a _________ when I am an adult." The Future Career Project asked students to do some research about the careers that interested them. Once again, they could choose their own presentation tool and individually were to create a presentation that identified their field, the requirements, and provide assessment of success in the field, the impact of computer science and the



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importance of technology. The student career projects were the final piece students worked on interspersed with watching interviews through the last remaining classes. The majority of this assignment was done as a homework assignment.

- Isn't it annoying to have the struggle of finding an outfit for the day
- Not knowing what you are going to wear, leading you to throw on the first two things you see?
- Well that won't be a problem anymore with our idea
- All you have to do is press a button and then boom, you have an outfit
- Here's how it works:
    - When you download the app, you will be asked to take a survey
    - This survey will determine your personal style and will give you options that you're guaranteed to love
    - There will be an ipad on your wall, next to your closet
    - On the iPad, there will be an app that knows what clothes you have in your closet
    - You will be able to use that app to find an outfit for the day
    - Just press the shuffle button and the app will mix and match w/ the clothes you currently have in your closet
    - It will then give you 3 different outfits to choose from
    - All you have to do is choose one for that day
- This benefits people who struggle to find an outfit in the morning
- You know that one thing in your closet that you never wear
- Because it does not look good with anything?
- Well our app can help with that
- It will give links to clothes that will look good with that one piece
- And then you could go buy it to complete your outfit
- So go buy our app on the appstore for less struggle




Figure 5-9. Example of Future Technology Product Artifact

All of the students successfully chose a field and they ranged from Air Force pilots, detective, professional athletes, film makers, broadcaster, authors, teachers, engineers, business owners, journalist, computer professionals, interior designers, marine biologist, medical professionals such as pediatricians, neurosurgeons, nutritionist, dermatologists, veterinarians, anesthesiologist, and orthodontists. The distribution can be seen in Table 5-5. A sample, from the medical field because it was the largest category, used with student permission, can be found in Appendix C.



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**Lesson 4/Phase 2 – Mentor Interview Experiences.** The mentor interviews took place over a week and a half. The live interview in the classroom for both sections was the same person but took place on different days. Similarly, both sections had a Skype session with Brittany, but they were on different days to accommodate the class schedule. All of the interviews were in the format of the students volunteering to read the list of questions to the mentors.

Table 5-5. Distribution of Chosen Careers

| | |
|---|---|
| Medicine | 22 |
| Author/Journalist | 5 |
| Computer Science | 7 |
| Politician | 1 |
| Military | 4 |
| Detective | 3 |
| Forensic Psychology | 1 |
| Lawyer | 1 |
| Actor | 2 |
| Engineer | 11 |
| Entrepreneur/Business Owner | 4 |
| Marine Biologist | 1 |
| Teacher | 2 |
| Veterinarian | 2 |
| Designer | 1 |
| Filmmaker | 2 |
| Firefighter | 1 |
| Athlete | 6 |

The information that the students learned were that the career paths were all different as the mentors were different ages and were in different industries. One moved from a successful company in Silicon Valley designing software to worrying about the automation of pizza delivery for a large national pizza franchise. She explained how she turned this into an opportunity by creating geolocation programs for which she holds two patents and has two more pending.



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The questions were slightly adapted for the younger mentors that are still students in school. Of the three students, one is working as a teaching assistant while finishing a doctorate. Another is headed to medical school (she was accepted as a college sophomore and graduates two weeks after the interviews concluded). The third is a senior and has had an internship with Google last year and has another this summer with Microsoft.

All of the mentors shared their time and their opinions and were met with interested and polite students. At least three of the mentors brought up the significance of how technology is constantly changing. The fact that the field is rapidly changing and advancing makes it difficult for anyone in these fields to project their goals for more than two years. All mentors indicated that a decade was a long time either because they were themselves young or that relative to a changing field this was too far out to predict. All of the mentors also commented on the fact that the field is rapidly changing, and that they were constantly learning new things, and they felt that they had to keep learning in order to stay relevant in their fields. Keri pointed out "one of the exciting aspects of my job is that I have completely changed what I am working on over the course of my career, and I like that."

In terms of advice offered, all were explicit and encouraged the students to take computer science regardless of their long-term goals. Brittany was especially complementary of the opportunities that the students had at their school, and that "you should take advantage of the fact that you can take computer science in the upper school even though you might not want to major in it because it's so important." On the other hand, Keri and Meriem both indicated that even if students didn't elect to take



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courses in programming, they should take courses that would prepare them for using technology in other ways similar to what their unit looking at fields in computer science was providing.

**Discussion board about mentor interviews**

The online discussion board was assigned as the follow-up activity to the mentor interviews via the LMS. The students were asked to post at least one time, and they had to post one comment of their own before they could read their peers responses. They were required to make one posting, but they were verbally invited to participate and to comment as much as they wanted with no imposed limits. The students were given four writing prompts and asked to respond to at least one that included:

- What did you learn about the field that you did not already know?
- What surprised you the most about your interview/s?
- Does the interviewee seem like what you thought a technology professional would be like?
- What have you learned about the global impact of technology?

A summary of some of the results has been compiled with the names, date, and time stamps removed and appears as Appendix D. The discussion board responses were varied and they were carefully reviewed and coded in their entirety. Once again Thematic coding was applied (Braun & Clarke, 2012). The coding was an important exercise to derive trends and ultimately themes and required the multiple passes as prescribed in the Thematic Analysis method. There were a total of 118 responses and the frequencies of the total postings are detailed in Table 5-6. It is important to note that frequencies do not represent quality. For example, one student with one response



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posted three paragraphs of outstanding content and another student with three responses added together would only add up to a few sentences with little content.

Table 5-6. Total Student Contributions to Discussion Board

| Responses | Students |
|---|---|
| 0 | 10 |
| 1 | 39 |
| 2 | 14 |
| 3 | 9 |
| 4 | 1 |
| 5 | 5 |

The student answers varied in length with some answering a single question while others answered multiples and still others posed new questions to the group. The conversations among the students are identified by theme and are shown in Table 5-7. The first phase of reading the discussion involved reviewing the discussion posts to provide a grade for students achieving familiarization as recommended by Braun & Clarke (2012). The second phase generated the initial codes and key words, which were then used to search for themes. The final phase involved a review of the potential themes and collapsing them to identify what emerged and is discussed as stereotype busting, gender imbalance, and impacts of the field. For example, the word time was identified in phase one and two. In phase three, themes associated with the word time were identified within fifty-one phrases. From those phrases, time was condensed to the themes of hours spent coding, choosing hours, changing goals, and changing technology, which would be summarized into the final impacts category.



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Table 5-7. Codes to Thematic Codes (Phase 2 – 3)

| Initial Codes | Thematic Codes | Example |
|---|---|---|
| time | In coding – longer to create than expected<br>Goals changing<br>Hours spent<br>Technology changing quickly | “can choose their own hours” |
| sit | Time at a computer | “don’t just sit behind a desk all day and code” |
| changing | Technology evolving<br>Speed of changes | “technology always changing”<br>“changing as fast as it is” |
| jobs | Different than thought<br>More kinds<br>More than coding<br>More opportunities<br>Impact daily lives<br>Impacts all fields | “almost every job you can think of has technology”<br>“there are different jobs”<br>“every job is different” |
| goals | Change over time | “what surprised me was hearing what each person had originally thought what they were going to be when they grew up” |
| stereotype | Social skills<br>Solitary<br>Boring | “people would lack social skills because of their long amounts of time spend on the computer, but my assumptions were proven wrong”<br>“some do alone some do not”<br>“learned the jobs are not boring” |
| view | Proven wrong/changing | “global impact of technology changed the world forever” |
| universal | Can impact lives | “no matter how big or small can impact lives” |
| global | Real world connections<br>Connects more people | “they go into the real world” |
| team | Work with others | “learned that development was done with teams interacting person to person was some what surprising to me” |
| opportunities | To change the world help others in many fields | “all the interviews were different” |
| coding | More than just coding solving real world problems and making life easier | “harder than they thought”<br>“CS is more than coding”<br>“use skills other than coding” |
| gender | Male dominated<br>More opportunities<br>outnumbered | “because of male dominance, or the mindset of CS being a man’s job”<br>“small amount of women” |
| Personalities<br>Inspiration | Confident, humble, accomplished, enthusiastic | “I was very inspired by these women” |
| Perspective | Changed over time | “I never realized how much computer science impacts in in our daily lives” |
| creativity | Opportunities | “learned there is a lot more creativity involved in computer sciences” |
| impacts | Impact daily lives<br>Impacts all fields | “impact of technology is everywhere” |
| Computer science | Not what thought | “The problem is that most [people] don’t know how it works.” |



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**Stereotype Busting**

The first major theme to emerge was that more than half of the students mentioned in some way that computer professionals don't just sit alone all day at their computers and code. The phrase "sit all day" appeared in over 25 comments. This was exceedingly noteworthy because this was not something specifically mentioned in class, nor was it mentioned by any of the mentors. The mentors spoke to what they did but did not talk about sitting alone and coding. The only previous reference that they students had to this description was in the pre-survey. This would point to the confirmation that students did have a pre-existing stereotype of computer scientists. This was often linked to other comments that computer science was more than just coding and that computer science was different from what they thought it would be. Codes like "proven wrong" and "not what I thought" emerged and converged to indicate student attitudes had changed from the interviews. An example of this is shown in this student response in a thread:

> I also thought that computer science would be completely different than what it actually is. I thought it would mostly be a desk job where you have to program and code, but it's not that at all!

Two thirds of the population stated in some way that their perspective about computer science had changed as a result of what they learned in the interviews.

**Gender Imbalance**

Another major theme that emerged from the coding included references to the field being male dominated and that women were often outnumbered professionally and in their educational experiences. Gender differences in both the profession and in the higher education classrooms were noted and commented upon. A student posted "their classes are extremely male dominated." The survey data did not show that students



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recognized a gender imbalance prior to the unit. Here, within this discussion the gender imbalance was a popular topic because there were more than ten references to the field being male dominated and eleven to women being outnumbered, all totaled, half of the respondents noted the gender division in some way. One respondent did extra research and posted it to the discussion. The summary by one student that:

> overall, the women did not look like what I though a technology professional looked like and I think this is unfortunate because young people should be taught what they can accomplish in the world of computer science no matter their age, gender, or ethnicity.

There were twelve instances of phrases that coded as “male dominated” and seven instances of the word “outnumbered.”

**Impacts of the Field**

Several students indicated that computer science impacts many jobs within many fields. Along these lines the theme that computer science had a global impact converged among the student comments. In alignment with the teaching of the global impacts unit, the students as evidenced in comments like ‘technology no matter how big or small can impact lives and technology connects more people than I ever thought possible” now understood a clear correlation. Another theme to emerge was that technology is evolving and changing quickly and this, too, had impacts on all fields. Comments that including phrases like “more to computer programming than just coding” extended the general phrase to have a global, real world or daily impact. Another example indicated that the “global impact of technology changed the world forever.” The codes of real world, global, daily lives, had so much overlap it made converging and counting instances extremely challenging. The variations of this were evidenced in



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terms that included different words, but conveyed a similar meaning such as real world and benefits lives.

**Changed Perspectives**

The question for the discussion specifically asked students what they found surprising.  There were twenty-four posts that identified that the students felt their perspective about computer science had changed in some way.  Phrases of computer science “being different than what I thought it would be” were common to ten of them, and there were at least eleven students that stated they had been “proven wrong” in some way.  The migration of their original definitions from the early pre-survey that identified computer scientists as people who code show evolution of ideas with further refinement provided in definitions of people who code to create or to change the world or impact the world or daily lives.  Additionally, there were comments that reference changes in technology, and that it reflected changes for those in the field and opportunities for them to be creative, and to need to develop a sense of perseverance to be successful in the field.

The themes listed above were all of the ones that were common to more than half of the population.  Examples how perspectives had changed included the previously seen comment in the survey of “how programmers didn’t just sit and program” now new words emerged to describe the field such as creativity, opportunities, persistence and teams.  Similarly the discussion of gender imbalance led to comments about how creative and positive the mentors were in their dealing with being outnumbered.  Other things that were noted were the benefits of the flexible schedule and salaries that can be found in the field.



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There were comments by students about how all but one of the mentors did not set out to become computer professionals, and how the mentors goals and aspirations were continuously evolving. There were also 25 comments in the discussion that referenced how young the mentors were and that they felt that they were all well spoken, confident and accomplished in what they were doing.

An example of a good summative statement was “I learned that almost every field uses technology and it has a huge impact on some fields.” Another supporting student quote “I learned that the jobs are not boring they are actually interesting and they really help everyone in every job globally.”

This post quoted below represents some of the richness that emerged and is one that supports that the mentor interviews were a positive experience stating:

> Personally I have never really had an interest in technological jobs. I always assumed that I did not like the subject and would just avoid the topic, however, thats not the case. The truth is technology is all around us and you can't avoid it. I never really noticed this until the guest speakers came in. As they talked more and more, I realized that no matter what job I get, technology will still have an affect. I thought that technology was just its own subject, but boy was I wrong. Technology was not just its own category but it had branches that stretched into other subjects like space, marine biology, civil engineering, interior designing, zoology, ecology, mathematics, and so many more jobs. Thats when I realized I couldn't avoid it, instead I had to learn about it and embrace it. Even though I disliked the topic I still had to learn, which was actually a good thing. I learned that technology affects so many things from the smallest bacteria on the planet to research and collecting data in space. Without technology the world would be lost and other subjects like marine biology, engineering, construction, and space, would be so much more difficult to research and conduct experiments. I have also learned over the course of many weeks that technology is the largest way to reach out to people. Think about it, we use technology to follow the news and receive information that we need to know for jobs and school. Overall I have learned so much about technology throughout these past few weeks. Technology is all around us and you can not stop that. Without technology our world would be so different and our jobs would be so much harder.

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**Student Interviews**

Three students were selected for an interview about their experiences during the intervention according to the question in Appendix E. The purpose of the interviews was to dig deeper into the perceptions and to look for any information that had not been revealed in the surveys or artifacts. One student was chosen because of the quality of her work and her apparent change of heart about technology as was evidenced through her survey. Another was chosen more as a matter of convenience because she is in an advanced math class and has some of the prerequisites for computer science, but has not indicated interest within her survey data. The final student was selected because her perceptions moved in a more negative direction over the course of the unit, where in the pre-survey she stated she might not take a course in high school at the conclusion she stated she definitely would not take a course in high school. All of the interviews took place on the same day and the students were interviewed during study hall, break and before school. The interviews took place two weeks after the unit had ended because the school's spring break immediately followed the conclusion of the unit. This was advantageous for corroborating evidence because the interviews were two weeks after the students had completed the post-unit survey (Table 5-8).

The student interviews provided a high degree of corroboration with the data that was previously collected through the student surveys and artifacts. In all three cases the student replies were consistent with their previous responses. Some of the questions in the script were actually identical to questions in the assignments. The questions about taking classes, consider working in the field, and their future pursuits all matched their previous answers.



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Table 5-8. Thematic Results of Student Interviews

| | |
|---|---|
| Changed opinions | Yes (3) noted they did more and were more independent than they knew |
| impression | They change the world, the effect all fields, they are making lives easier and sometimes harder |
| Intersection with chosen field<br>Pursue CS | Yes (3)<br>No (2) Maybe (1) comments of "it seems cool but I don't know yet" or "right now I have other things I am more interested in but I am not sure and the interviews told me that they all changed their minds so I guess it is possible" |
| Take classes in HS | Yes (1) No (1) Maybe (1) noted by the one maybe that everyone should study some aspect of it |
| Important thing learned | "it's part of everything"<br>"it's important to all fields so I need to consider it" |
| surprises | "it can help the world"<br>"there are so many different languages to code in"<br>"that it impacts daily lives" |
| Most interesting | "fun creating codes when we made drawings in Processing earlier this year"<br>"enjoyed the history of it and how it came to be"<br>"the interviews were all really interesting" |
| Traits for success<br>gender | "focused" "determined" "type A"<br>Women can be successful (3) but "you will face bias" (3) (1) "you can make this work to your advantage if you do it right" |
| Time coding | No (3) |
| Learned from interviews | "learned more about coding and what it takes"<br>"learned what the field really is and how it effects all of us"<br>"was inspired that what you can do with a comprehensive understanding of coding" |

Additional coding of the interviews provided very little new insights. This is not surprising because I had reviewed the student documents and graded them prior to their participation in the interviews. Therefore some of the answers to the interview questions were already known, because in one case this was the reason for her selection. However, the question was asked as to why she would not consider taking a



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class in high school. What emerged from the discussion was that she revealed she didn't care for the coding that was done earlier in the school year, so she knew she didn't like it. She added that she thought it was important, but that it didn't appeal to her. When the details of the CSP course, and it not being coding intensive were explained then she expressed that she might consider taking something like that in the future. Overall, there were references to having learned about the global nature and the importance of computer technology that was coded and highlighted within the discussion posts. Again, there was consistent emergence in the revelation that computer science was more than just the coding and working alone on a computer. The best thing shared by all of the interviewed students was that they came away with a new appreciation for the breadth and depth of the impacts of technology. Also one student specifically mentioned that she had enjoyed the unit very much because 'technology was omnipresent' and that "it would be unimaginable to have a world without technology."

The discussion of the imbalance of gender within the field was also addressed. The students indicated that in two out of three cases they were aware of the imbalance, but one student attributed it to the fact that she thought computer science was boring and therefore it was a logical conclusion to her that girls would not want to work with computers. This was the student that was targeted for an interview because her surveys had gone from 'probably would not' to 'definitely would not' take a computer course in high school. She also revealed that at the start of the unit she thought that computer scientists only sat and programmed video games that mostly boys would enjoy. She felt that her view had changed a great deal because she now understood



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computer science to be global and that it was part of any and all fields. However, even with her view about the field changing she was more sure now that she would not take a CS class in high school, and when asked why she indicated that she did "not like how long it took to get little details correct in a program for it to run properly." The overall results of the student interviews confirmed saturation with the previous data in the surveys and artifacts.

**Summary**

Overall the SPSS analysis results indicated that the surveys had good internal consistency. Because the survey was home grown, and not previously validated this was supportive of the survey. The closed survey items were analyzed individually in terms of their effect with Paired Samples T tests, which provided better significance than the Independent Samples T tests grouped on gender. Many student artifacts were independently graded twice, once by myself and once by the co-teacher to be sure that they met the standards set forth in the rubrics. Three students were selected for final interviews at the completion of the unit. One selection was based on a decline in attitude about future courses as indicated on the surveys. One student was selected due to convenience and her strong math skills, but unwillingness to pursue computer science as evidenced in her artifacts. The final student was selected because she indicated her pleasure in the unit by doing extra work during the biography project and her responses in the discussion artifact. The final piece of data for the intervention is that fourteen of the students have pre-registered for the Introduction to Computer Programming next year as ninth graders. While this number may change over time, because one quarter of the ninth graders do not have any electives because they are



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already obligated to continue with their fine arts selections. This number is considerably higher than the three students who enrolled the previous year.



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# CHAPTER 6
# DISCUSSION

Lack of exposure to computer science in the K-12 environment has been identified as one of the key reasons as to why many students are not pursuing the field (Rodger et al., 2012). Computer science programs have continuously been identified as having lower enrollments and much of the research has focused on the continued gender divide and lack of diversity that have plagued the pathways (Hoegh & Moskal, 2009; Wang et al., 2016). Reasons have included negative associations with the nerd stereotypes, male bias in software, confidence issues, lack of role models, and knowledge of the subject matter (Anderson, Lankshear, Timms & Courtney, 2007). The intervention in this study was designed to challenge those prior assertions. It was hoped that changing perceptions could result in more students enrolling in computer science in high school. The survey data was intended to measure student perceptions before and after the intervention. The reliability of the items and relative significance of the items have documented the changes in student perceptions. The student artifacts and interviews corroborated that the students did undergo changes in perceptions that were identified through the assignments and experiences in the classroom. The research questions restated here will guide the discussion that follows.

- **RQ1:** How can exposure to an intervention that incorporates some CSP materials, specifically the global impact unit, lead to a more authentic perception of the professional field of computer science among an eighth grade student population?
- **RQ2:** How can exposure to a CSP unit about the field of computer science and what computer scientists actually do, result in positive changes to student views about the profession of computer science, especially among female students?



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## Research Question 1

### Busting Stereotypes

The first research questions looks at how student perceptions about the field could become more authentic and move away from the persistent stereotypes held by teens. The traditional stereotype that needed to be challenged was that computer science is boring and that computer professionals work alone, and lack real-world contexts for their work (Cheryan, Plaut, Handron & Hudson, 2013; Grover, Pea & Cooper, 2014; Yardi & Bruckman, 2007). The entire intervention was designed around the global impacts unit from the CSP course with the intent of introducing the field of computer science and the global nature of the field to correct prior research indicating students do not understand the field (Wang et al., 2016).

A statistically significant change that was revealed for the students was their understanding of what computer scientists do in a move away from the preconceived stereotypes (Cheryan et al., 2013). This was important, because it showed that one of the main objectives to increase student overall understanding of the lesson was attained. The students gained a richer understanding of the profession and what the professionals do and the impacts of their jobs. Survey item number two looked for alignment with the statement *I understand what computer science professionals do in their jobs*. The survey indicated that the students more clearly understood the field in the ways that they articulated what professionals do in the open responses. In addition the coding of the qualitative data showed students shifting their beliefs from statements that were simplified as "sit and code" to more robust descriptions that included "code to create programs to impact the world."



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Additional survey questions that saw statistically significant effects included the questions about computer science being boring and that computer professionals were isolated because they spent the majority of their time alone with their computers (Graham & Latulipe. 2003; Yardi & Bruckman, 2007). These shifts confirmed a change of attitude away from stereotypes in the field that programming wasn't necessarily boring and that these professionals did more than just sit and code as was their perception in the pre-unit survey (Anderson et al., 2006; Cheryan et al., 2013; Meelissen & Drent, 2008).

Survey questions four, five and six chipped away at the issue of the pre-existing stereotypes with four and five focusing on the boring reputation and six on the geek or nerd label (Cheryan et al., 2013; Wang et al., 2016). Both of the questions related to boredom were statistically significant and confirmed a high likelihood that the shift in student views was not accidental but truly related to their experiences in the intervention. There was not a strong shift for the question about nerds, but it was surprising to learn that not many of the students initially held this view in the pre-survey as was predicted within the literature (Grover et al., 2016). The sample as a whole had no members that "strongly agreed" with the sentiment that people who work as computer science professionals were geeks or nerds, and only two males and three females even "agreed" with the statement in the pre-survey. Therefore it is not surprising that the shift for this question was not significant. A student that shifted her attitude from "disagree" to "agree" was chosen for an interview. What was uncovered during the interview was that the student had taken on a positive connotation for the word nerd, and saw it as a compliment. She specifically recalled a comment made by



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one mentor about her high school friends and their use of the term as more of an endearment. Since the early literature indicated that association with this negative stereotype was problematic for girls enrollment in courses this was an interesting outcome (Grover et al., 2016; Heersink & Moskal, 2010; Hoegh & Moskal, 2009).

Changed perceptions were corroborated in the discussion board, and interviews. Indeed, the discussion board contained commentary that clearly indicated a shift in perspective away from the stereotypical phrases. The discussion board had half of the students state some reference indicating the computer professionals don't just sit all day and code. Here, too, there was evidence of student growth in the sophistication of the phrases and word choices of the students. Specifically they moved from general words like program and code to more sophisticated word choices like research and solves world problems (Wang et al., 2016).

Survey item ten about whether their friends found computer science to be cool had a result that aligns with the idea that their perceptions have changed. The shift here was most notably toward agreement and that it was perceived as being cool, which contradicted the literature (Cheryan et al., 2013; Hoegh & Moskal, 2009).

**Understanding the Profession**

Item one from the survey allowed for a free response description by the students of what computer professionals do and provides evidence of students modifying their computer science perceptions. The first read through of the data was for identifying code words through the frequencies of their usage. Further coding showed that most of the more frequent words recorded were words that were within the question itself. This is understandable because students at the school are taught to answer questions by repeating or incorporating part of the question into their answers. If we remove those



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words we could see a shift from descriptions of words like code and program in the pre-survey to words like creativity, opportunity and team in the post-survey. The open-ended questions moved from simple phrases that repeated the words contained in the question indicating professionals “program, code or fix” computers to more higher ordered phrases like “more than coding” with a global or social good perspective that were reminiscent of the things that the students heard in the mentor interviews.

Question eight from the survey asked if computer scientists *spent most of their times solving real world problems*. Pre and post there were about the same very small number (nine and six respectively) of students that felt this was not true. However, there was an interesting change that emerged in the data after the intervention, and that was that the students who felt strongly that this was true doubled. This was corroborated in the discussion and interview data. Over two thirds of the students talked about the global nature of technology in their posts. One student even stated, “technology no matter how big or small can impact lives.” Some of the students who were interviewed also related the idea that all students should study computer science because of the global nature of technology. This unit helped them understand the ubiquitous nature and showed clear evidence of the students of the students understanding the impact outside of their classrooms (Grover et al., 2016).

The third open-ended question identifying typical goals of a computer professional also revealed evidence of shifts in perceptions. Students in the pre-survey targeted goals of creating and developing, but there was only a single instance of a student mentioning implement real life problems. On the other hand, the post-survey saw more than half of the students identifying the importance of making or changing the



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world while helping people as the goal for professionals (Graham & Latulipe, 2003). It was clear from coding the responses that there was a decided shift from thinking about an individual to thinking about changes to be made with real world impacts. This was very satisfying because one of the overriding goals of the intervention was to help students understand the importance of computer science in terms of global impacts, as was implied in the designation as one of the 'Big Ideas 'of the course delineated by the College Board with the resulting curriculum from UTexas.

**Gender**

The survey questions about their view about computer scientists being their same gender and ethnicity were interesting to interpret. For the females, the idea that professionals looked like them decreased while for the males it increased. What was learned here and was confirmed during the coding of the discussion comments was that the students did not have a clear perception of the gender differences that exist in the classroom and the professional world (Wang et al., 2016). Many of the mentor interviews resulted in making them aware of a problem that they previously did not know existed. It can be argued that perhaps it was not a good idea to teach the students that there is a gender imbalance if they were not aware of one, because learning this could result in an opposite effect of letting them know there are barriers. However, the work of Weisgram and Bigler (2007) shows that knowledge of barriers can result in students increasing determination to succeed. All of the mentors interviewed talked in some way about their struggles with being a minority in the classroom or within their practice. In fact, they all volunteered because they connected with wanting to help girls pursue computing careers. Even if the specific gender question had been removed from the script, it was often cited when the mentors were asked general questions about what



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were the biggest challenges they had to overcome. Giving the students the role models was an important key to their understanding the field (Bamberger, 2014). At the same time, it made them aware that there was a problem. This was certainly a conundrum that had not been addressed while creating the questionnaires and surveys. Regardless, the students came to the understanding that the imbalance exists. Fortunately, all of the volunteers that came forward were extremely successful in their fields and made no mention to the idea of a glass ceiling! Since the mentors were all volunteers it is logical that they are successful, and that they would possess self-confidence. It would be illogical to think that someone with low self-efficacy would volunteer in this capacity. Rather, it was found that all of the mentor responses were extremely positive and supportive to the idea that anyone can be successful in their fields (Liu et al., 2006). In addition, the discussion data noted that the students felt the mentors were very humble. The fact that their humility was noticeable speaks volumes to the idea that they did not volunteer to champion their own successes, rather they volunteered because they genuinely wanted to inspire students – females especially – to pursue computer science or wherever their passions led them.

**Puzzles and Sociability**

A question was posed in the survey about students liking to solve puzzles. This question was inspired by the research that related frustration and motivation in robotics activities (Kaloti-Hallak, Armoni & Ben-Ari, 2015). Student attitudes remained consistent about this from the pre-survey to the post-survey, which was what was predicted. In an attempt to move away from the notion that computer science is an isolating field this question about wanting to work with people was intended to measure how important social contact was to the students (Yardi & Bruckman, 2007). The



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question about social interaction also retained a consistent distribution pre and post, but it is interesting to note that almost all of the students agreed with this as being a priority to their future professions.

**Future Enrollments**

Finally, one of the most important motives behind the research was to see if the intervention could result in an increase in student enrollment in computer science courses for our high school. This survey question provided evidence of a change in the amount of students who shifted to declare their intentions to definitely take a course in computer science in high school. The final question relative to joining the profession also experienced a change, but the result was not enough to indicate that the null hypothesis for this question could be rejected. This question remained exactly the same for those with strong opinions before the intervention aligning with their post intervention responses. The only movement here was 12 students shifted from not likely to possibly, which can be interpreted as possibly adding to enrollments in the future. Students indicating a more positive shift show that the intervention could have had merit.

**Global Impacts**

While the surveys provided evidence of changes in student perceptions the work within the artifacts reflected changes as well. Reading through the weblog the notation from the first lessons resonated. One of the early lectures had the students solve a mystery by picking out a technology that had criteria relevant to global changes in society. All the students guessed incorrectly that it was some form of the Internet or social media and when they were told that the technology in question was the telegraph the students were all shocked. The weblog recorded that one student actually blurted



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out that her mind was blown. Perhaps more shocking to the teacher was that a fair number of students did not know what a telegraph is! Regardless, the point is that the students really began to think in terms of global impacts past, present and future. Connecting the profession to the global changes was one of the key elements in helping them to make change their perceptions. Comments within the online discussion corroborate this with posted phrases such as "global impact of technology changed the world forever," and "anyone can do anything in the technology world."

The coding of the online discussion about the mentor interviews proved to be a valuable tool for looking at student perceptions. Many things of interest were shared. There were major themes that converged during the coding of the transcript. The first theme to emerge was the global impacts of technology. Additionally, when asked about what surprised them, the most impactful was that they no longer thought of computer professionals as sitting alone at their computers. They now appreciated other nuances of the field, including things like it takes a lot longer to complete many projects than they would have thought and that many of the projects were creative and required the efforts of a larger team. The indication that there was teamwork involved directly contradicted the stereotype of a lonely profession (Yardi & Bruckman, 2007). One student even posted that technology professionals have a huge stereotype that they have to overcome to enter the field.

The artifacts for the future careers project corroborated the idea that computer science and technology impact most jobs and fields. The students were challenged during Kristan's presentation to name a field that did not use some form of technology. The only one not to be shot down by the other members of the class were choices



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made by people who held religious beliefs that impacted their use of technology. In general the posts revealed there was a strong consensus that all jobs and professions were impacted by technology (Grover et al., 2016). Another theme to emerge was that there were real world connections because it is used by so many. Similarly there were many instances of students indicating that technology impacts our daily lives in many ways. There was an insightful post that noted that everyone used technology but many people do not understand it (Fidoten & Spacco, 2012). This notion was corroborated in the student interviews when the students spoke of how they felt it was important for all students to have the opportunity to learn about computer science in some form.

Another discussion post identified one of the biggest changes for society was that social media was increasing social interactions. Social media was also identified as a common theme for altering today's social interactions among the yesterday's technology artifacts that the students submitted. These artifacts almost all identified how dramatically social media had changed society. Many of these artifacts also pointed to changes within society from mobile phones and Internet access as well. The student comments on these artifacts identified global impacts of technology in general, so it is not surprising that much of these sentiments were echoed when the students created their final career presentations and entered their discussion posts a few weeks later.

Continuing with the evidence in the discussion board the student statement as to "what surprised me the most about these interviews were how different everyone was" confirms that the students expected all programmers to have similar backgrounds and goals which was not supported by the mentor interviews and served to further debunk



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the stereotypes held by students. The mentor interviews allowed students to make real world connections with specific fields including defense, transportation and medicine. One student summed it up by writing “technology is making a massive impact to the current world.”

In terms of the implications for the future, one student stated on the discussion board “one day, I hope to expand and inspire the community with computer science.” Overall, what was clear in the discussion board posts about the interviews was summarized nicely when a student posted that the mentors “were all very inspirational women.”

**Research Question 2**

One of the important components for this intervention was to help girls make real world connections. The work of Graham and Latulipe (2003) indicated some initial success at altering stereotypes working with girls in grades nine and ten. Their research showed that girls wanted to work on things that would benefit people and that they did not want to just spend time sitting alone in front of a computer. The student responses reported that they no longer felt that computer science was just sitting alone in front of a computer worked to dispel this myth among the students and show a change in perceptions.

The work of Cheryan et al. (2013) identified part of the stereotype of computer scientists was that they are obsessed with computers and programming to the point that it did not allow for any other interests and that computer scientists were socially awkward. The evidence that best debunks this is the overwhelming number of students that commented in the discussion board about their surprise at how well spoken and confident the women mentors were in the interviews, and that they were equally as



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surprised at the diversity of their interests. The research of Meelissen and Drent (2008) pointed out the importance of role models, and more specifically female role models as having an impact on the attitudes of females. Having the experiences with the female mentors resulted in only positive comments about the mentors. The students made specific references that they found the mentors to be successful, poised and inspirational as part of their highlights of the interviews.

**Shifts in Perceptions**

Reviewing the survey data and the differences observed between male and female students that was represented in the question of *did you think it was important to your family for you to study computer science* had a noticeable variance with more males believing this to be the case. This aligns with the research findings that the field is generally viewed as more acceptable for males (Webb & Miller, 2015). The question of whether or not you would take a computer course in high school had a larger variance between males and females in the pre-survey. The final question about pursuing a career had the greatest variance in the pre-survey. Overall it appeared that there were shifts in attitudes for the girls as a result of the intervention, but that the shift was parallel for the boys. Upon further reflection, since all of the students experienced the same things, it is logical that their impressions moved in similar patterns. Leading more students to understand the importance of the field with the hopes of enticing them to courses worked for both sexes. However, this did not solve the long-term problem of the imbalance!

**The Influence of the Opinions of Peers**

One possible factor for the declining enrollment that was not identified in the literature review was the importance of the opinions of peers to middle school aged



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students. This evolved more as a gut instinct after working with this age group for over twenty years. For this reason a question was added to the survey (item ten) to discover how important the students felt their friend's views were of the field. This resulted in a shift for males and females that was similar to their impression of their friends' views of computer science.  What was interesting here was that initially none of the girls strongly agreed with this, but after the interviews three indicated they did with a sizable movement of seven of them away from seeing it as a negative at all.

**Evidence of Changes from Open Responses**

The second-open ended survey question about the challenges that professionals face exemplified a decisive shift.  The students moved from phrases about fixing programs or learning languages to a focus on the need for computer professionals to have persistence. They indicated that coding would often result in programs that would not work.  These were a reality in the life of a programmer, but that it was okay, you had to have the persistence to keep at them to make them better.  The other gender related perception to emerge that was not present in the pre-survey was an awareness of the fact that men dominate the field.  Less than three percent of the students noted any disparity in the initial documentation, and after experiencing the interviews over half of the students indicated that the lack of gender diversity in the field to be one of the biggest challenges.

Finally, one promising change was a shift for some students that had previously indicated no interest in taking computer science courses in high school had moved to considering or possibly taking the courses in the future.  This shift was awesome because it was one of the goals of the unit in terms of looking for ways to increase student participation and encouragement for girls to take computer science courses in



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our high school. Results showed that more girls indicated in the post-survey that they would now consider taking a course in high school, which supported the research question.

**Unintended Consequences**

One of the unintended consequences of the mentor interviews was that many students learned for the first time that men dominated the field. There were at least twenty-five coded instances of it in the student surveys, and it was referenced by more than half of the students in one way or another in the discussion transcript. It surprised me that many of the students had no idea prior to the unit that this was the current distribution. One student took it upon herself to do her own research for her discussion post and noted that

> I also did not know the gender difference in this field. I knew that there was not many people in computer science or did coding but I did not know that the woman to men ratio was so vase. According to readwrite, 70% of Apple, Twitter, Facebook, and Google employs are male. This mean less than *half* of their employees are female.

This issue has been part of the fabric of my professional career for so long that it was shocking to find out that many of the students did not realize the gender divide prior to the lessons (Barton et al., 2013). One could wonder if advising them about the imbalance to the gender distribution would backfire, and perhaps students would become more reticent to study or work in the field. If a student were female and introverted, would this kind of knowledge dissuade her from pursuing the field? Overall, I preferred to hope that understanding the imbalance would be used as a benefit. These students did not experience the shock that mentors expressed when they explained being the only or only one of a few females in their college computer science courses. It seems possible that students having an awareness of the imbalance before



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being blind-sided by it may help retention. Guided by research that indicates that middle school students should be introduced to coding for them to absorb it into a vision for their future supports the concept that they should be made aware (Grover et al., 2015). Although if the research becomes truly successful, we can hope that more students that represent society's diversity will enroll and change the make-up of the pipeline helping to negate the original imbalances in the education pipeline and in the field. The research of Weisgram & Bigler (2007) specifically looking at the effects of learning about gender discrimination and they found a positive relationship between teaching about discrimination and student attitudes. In their research only the girls that learned about gender discrimination showed increases in self-efficacy and beliefs about the importance of science (Weisgram & Bigler, 2007).

**Student Interviews.** The student interviews provided a high level of corroboration with the data that was extracted from the surveys and coded from the artifacts and discussion. All of the interviewed students provided answers that were matched up with their prior answers. The student that had moved to a more negative attitude about the possibility of taking a computer science in high school revealed that she really enjoyed the unit and now had a more global understanding that computer science impacted all fields. However, with her increased appreciation she had confirmed her belief that coding was not for her because she really did not like the need to be so persistent with details to get programs to run. At this point, I asked if she was aware that there was a non-coding AP CS course called CSP and that CSP was intended for non-computer science majors. I also told her that the unit she completed was directly from that curriculum and asked her if she would consider taking that



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course.  She responded that she was not aware of the course and that she liked the unit so there was probably a chance she would take it in high school.

Another one of the students indicated in the interviews that she enjoyed the unit and that she felt that all students could benefit from learning what she learned. She succinctly summed it up be saying that she felt that it was important for all students to study CS because "all students should have a comprehensive understanding of it because it is an integral part of daily life in the modern world." This is evidence that her perceptions had shifted to a more realistic understanding and supported both of the research questions.

Overall, the three interviews supported and confirmed that student's experiences in the intervention correlated with changes in their perceptions.  The students that were chosen corroborated their pre-existing attitudes that confirmed to negative stereotypes and indicated that they had changed their perspective of the field. Even the student that was sure she didn't want to take a course in high school indicated that she had greatly enjoyed the unit and that it was coding that she was confident that she didn't like.  Her potential willingness to consider the CSP course showed that she did appreciate the field.

## Implications for Practice

The November 2016 computer science K-12 standards make a case that the key to achieving diversity in filling future jobs is to provide equal educational opportunities to all students (The K-12 Computer Science Framework, 2016).  While this is true, this work has shown that for this student population, an understanding of the field is an integral part of the education that the students receive exposure to if the intent is to increase student understanding and ultimately enrolments.



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**Benefits of the Yesterday's Interview Assignment**

The written artifacts that the students provided for the yesterday's interview assignment provided some valuable information. While we may typically think of the positive aspects of technology changing, the students had the opportunity to reflect on both positive and negative aspects. For example they indicated a great deal of surprise at phone calls having been very expensive, some did not realize there was no texting and that the Internet was not a common resource. What needs to be noted here is that these students are all part of an iPad program. Initially the movement to an iPad program was grounded in the desire to lighten the load of student backpacks. It was hoped that the students could use their iPads for textbooks and that we could eliminate some of the physical textbooks. It seemed ironic that only two students out of 71 mentioned changes in the use of eBooks and eReaders. Arguably one of the biggest changes to their daily routine the iPads have allowed is for the immediate research and ability to quickly answer any questions the student have, yet this was barely noted. The interviewees did note the important change of having instant news and many resources for news. There was, however, a student that noted that having to rely on notes only on paper would stress her out. She felt that having electronic access and the multiple copies of her work as being tantamount to her success as a student. An implication for practice is that a key to understanding the past when it comes to technology can be found very easily at home. A simple assignment that encourages a productive and interesting conversation at home can be beneficial for many middle school children and their families. Assignments that encourage adults to share their history with teens can mutually benefit both cohorts, and technology can give another topic for discussion.



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**Benefits of the Elevator Speech Assignment**

The most difficult part of this assignment was getting the students to understand it. They understood and were deeply engaged in conversations with partners in thinking up future products that they wanted to invent. They also had no trouble doing the slide shows for their products. These were typical to the kinds of assignments they get in many classes. For this speech, the students had to work as a group and agree what on relevant points in a concise way to present their product to the audience in less than two minutes. The students were shocked that they would have a grade penalty if their speeches went over the time limit, and this was something they never experienced. This assignment resulted in more student questions than any of the others. During the presentations all but one group was able to meet the time restriction. This was definitely a new skill for them, and one that has value in terms of computational thinking, in that they had to extract the most relevant points and present them coherently (Grover & Pea, 2013; Yadav et al., 2016). This is one assignment that we will keep in our curriculum because it really challenged the students to think computationally.

**Benefits of Mentor Interviews**

In general, the students reacted overwhelmingly positively for the experience of the interviews. When asked, they relayed both verbally and in writing that they enjoyed them. This was clear in their behavior in class during the interviews. They were extremely attentive and always polite. They thanked the volunteers on every occasion and took turns reading the scripted questions beautifully. The stands out interviews to the students were Kristan and Brittany, and that is easy to understand because they had more personal connections with them. In the case of Brittany she is legendary and our very own celebrity due to her international successes. Having opportunities to see



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mentors such as these will always be a unique and memorable learning opportunity for students. Three of the interviews were recorded and posted to YouTube and it will be nice to have the opportunity to use them again. Informal conversations in the weblog indicated that the students were receptive to the mentor interviews, and the student interviews confirmed that these were their highlight of the unit. I believe that the mentor interviews provided powerful role models that the students connected with as was evidenced in their comments and engagement, which makes this an important component in helping to guide student perceptions about the field. It is conceivable that some teachers might not be able to find mentors themselves. There are repositories that are being developed that teachers can call upon. While it was not used in this project, the work of Career Girls can be a useful resource to create a similar kind of lesson plan because this site incorporates videos and information about many careers. The information at https://www.careergirls.org/careers/search/all can be incorporated to help students to better understand careers. Additionally, within the last two months a feature has been added to the Code.org site to request volunteers to mentor either in person or through conferencing with requesting teachers. Although we cannot generalize beyond the population in this study, the overwhelming positive response from the students as well as their perspective changes hold potential for others to explore.

Two of the mentors spoke specifically about the difficulty of being a minority within their classes that echoed the work of Stoilescu and McDougall (2011) that reference the impact of there being a hostile culture for women. Within the interviews



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the mentors spoke of the need to harness this diversity and find ways to overcome the anxiety that this caused to be successful in the courses.

**Evidence in Support of Career Theory**

Overall, it seems logical that the framework provided by career theory requires students to understand what jobs are available and what is involved in a career before they can pursue it. The weblog revealed an informal conversation with two students before the start of class a couple of days after the unit had ended. One student mentioned that she really enjoyed the unit because before it she had thought that she wanted to be an engineer because somehow she had gotten the idea that it would be a good fit because she loved math. She admitted that she had never really thought about what an engineer actually did other than solve math problems. Immediately after the unit, she found herself touring colleges for her brother over spring break and she indicated that she now was thinking about actual jobs. The second student thanked me for teaching the unit because she was the daughter and granddaughter of pediatricians and had always assumed it was her destiny as well. Through this unit she began conversations with her family about careers and discovered that she had her parents' permission to pursue her passion for marine biology. She indicated that thinking about careers for her had been quite liberating. As a teacher, you really cannot ask for more. The idea that we teach subjects and not how they relate to potential careers is an interesting concept. Within the student population of this study all students are in a college bound track. Perhaps it would have helped to bring back something as simple as the old-fashioned career days to provide students with a better understanding of the core courses and how they can relate to future ambitions and professions. One of the student interviews revealed that one student was the daughter of two lawyers. Her



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artifact for her future profession revealed a thoughtful analysis of what it would take to become a lawyer and how important technology was to the field. This artifact led to thinking that she would be a great student to interview because of the way she had incorporated it into her presentation. Her self-declared dislike for math was part of her reasoning for choosing law. However, she indicated that the unit provided her with an appreciation for computers and technology and that she believed everyone would benefit by a comprehensive understanding of the technology field.

**Lesson Learned In Teaching the Unit.** One of the most interesting parts of this unit was how it allowed for an opportunity to teach some general concepts about technology that didn't appear anywhere else in our curriculum. While the work of Code.org and similar agencies has focused on the need to introduce students to coding and computer science concepts there has not been an emphasis on the profession itself. Providing students with opportunities to connect their lessons to their future aspirations is a powerful opportunity that is sometimes overlooked in K-12 education. Making real-world connections should always be a goal for teachers on behalf of their students.

Based upon the findings of this study I believe that giving students an opportunity to consider career options in middle school can be empowering to the students. The work of guidance counselors and college placement personnel can also be enhanced when the students working with them have some career goals and objectives.

Therefore I would recommend to teachers the following:

- It can be empowering to students if teachers were to provide students with an opportunity to understand how what they are learning relates to future careers.
- Try to teach not only what computer coding is, but also what it does for the world.



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- Empower all students, especially girls and minority students to step outside of their comfort zone to explore fields that they might not ordinarily consider.
- Even if teachers do not have experience with computer coding, they can use these lessons to teach about the importance of computer science to our world.
- Discussion boards provide an environment for all students to be heard, even if they are shy or reticent to speak up in the classroom. Adding a discussion board component to any classroom can provide opportunities for rich and deep discussions among students that can go beyond the borders of the students in their classroom when there are multiple sections of a course.

## Implications for Future Study

This study was limited by the fact that it did not use a validated survey. Future research in this area of debunking stereotypes could be well served if a validated instrument could be found. While there are many growing initiatives (Code.org) that have been in place now and have been introducing students to coding, there has not been an effort to address the stereotypes that hurt this field. The mentor interviews noted that they had to overcome hostile environments in their college courses. While there has been work in this area it has been limited to the post-secondary school level. It would be worthwhile to investigate how education spaces could be made more gender neutral, especially when they are spaces that are aligned with stereotypes.

Another aspect that should be investigated would be to see how the perceptions would be effected in a classroom where students had not had previous lessons about coding and computer science. The students in the sample were fairly sophisticated in this regard, and it would be very interesting to see if the experiences of the intervention on a less privileged population would result in similar changes. The lack of generalizability from this study would be something to be addressed in the future. While after-school and enrichment programs have met with success in interesting girls in STEM fields, the lack of courses for them to take has remained a concern (Aschbacher,



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Ing & Tsai, 2014). An education specialist at Google had once recommended to me that one of the best ways to get courses into our schools is to get parents interested to apply pressure to boards of education. A future piece to study is to figure out how to get student views back to their parents to provide leverage to counteract the current vision of principals that there is not enough demand for these courses (Wang et al., 2016).

## Limitations and Delimitations of the Study

While this work provided an opportunity for students to contemplate their futures and documented some modifications within student attitudes it has to be acknowledged that the population in the study was highly specialized. Although the population was gender diverse, little else was diverse in the population. As a whole, the population of the independent school in the study has sought to become more diverse over the last decade but is still a long way from being socioeconomically or culturally diverse. As such, generalizations and lessons learned in terms of adjusting student attitudes cannot be generalized to any other student population. Further, the enrollment of the school is small which meant that the sample size was too small for any possible generalizations. This means that there is room to try this intervention in situations and classrooms with greater diversity to see if the correlations hopefully hold up for others.

One of the issues that emerged within the research study was that the students did not all know before the intervention that there was a gender gap in the profession (Wang et al., 2016). This could have pointed to the necessity of future research to understand if it was better to wait for this diversity to be pointed out or if it should be confronted early on in accordance with the ideas that career theory supports. A future research question could look into the timing of when and how middle school students should find out that gender differences are a reality in STEM professions.



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Another method of looking at the impacts of a learning opportunity would be to incorporate a coding exercise within the context of the unit. In the sample tested the students had completed a coding unit the previous year and a second more detailed unit in the Processing language two months before the intervention was undertaken. Putting a coding activity in with the global impacts would also mirror the content of the CSP curriculum of which the coding is one of the key components of the course. It would be interesting to see if the course could be modified for younger students as well because it would be possible that the stereotypes would not already be a part of their culture. The recommendations of the CSTA are to include computer science concepts and principles for all students in K12 education and it is never too soon to begin learning about the impacts and importance of technology in our society (The K-12 Computer Science Framework, 2016).

One of the biggest challenges for this study was the inability to find a survey that was already validated. Although there were some existing instruments, they were beyond the levels of middle school students or focused more on information technology (Elliot Tew et al., 2012; Heersink & Moskal, 2010). In the case of Heersink and Moskal (2010) the validated instrument looked at gender, interest, confidence and usefulness but the authors identified difficulties in extrapolating their findings to information technology. The inability to find an instrument with a good fit resulted in challenges in creating a survey for students to use in the study. Without such an instrument, questions were developed using the ideas and concepts that would be covered in the intervention. While some of the survey questions did show evidence of shifts of perceptions, some of the questions wound up being less than useful. For example the



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question about ethnicity was severely limited because student ethnicity data was not collected to the point that no patterns were discernable from this data. Some of the questions did evolve during the previous versions, but there could have been more attempts at isolating better questions.

The quantitative analysis of the Likert scaled items included conducting multiple t-tests on each individual survey item. These separate t-Tests each had a set Type I error rate at $\alpha = .05$ for each test. Taken together this combined family could have resulted in a multiple comparison problem and required the higher threshold to avoid the problem. As more inferences are made there is a result of a higher likelihood of a Type I error that may not have been accounted for in this study. However, the artifacts showed evidence of changes as a result of participating in the learning environment in addition to the survey data so it is hoped the convergence of sources can offset this limitation. Along these same lines the original intervention was intended to raise awareness to encourage girls to participate in courses. As a result of the intervention, both males and females gained an understanding of the gender divide that currently exists. Learning about the field and what it can offer had appealed to both genders, which was not surprising because learning what professionals do in reality has benefits for people seeing themselves in a field as is the nature of career theory (Super & Hall, 1978). Likewise, providing multiple learning opportunities helps to capture a positive reaction by providing more opportunities to connect with the preferences of the students (Bransford et al., 2000). Positive experiences could translate to more of them considering the field regardless of gender.



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## Concluding Thoughts

One promising practice that has been identified in the literature to help with the gender digital divide is to adapt the design of physical spaces (McGrath Cohoon, 2011). In 2010 the University of Washington changed hallway and classroom appearances by adding plants, pictures and removing technology posters with the intent of creating more inviting spaces for female students. Research in this area has shown the importance of changing environments so that they do not promote stereotypes that perpetuate gender biases (Cheryan, Ziegler, Plaut & Metlzoff, 2014). This research shows another example of the impact that stereotypes can have on the decisions that people make. Part of the goal of this research study was to challenge the stereotypes that middle school students had about computer science. Although the population is highly specialized and we cannot make generalizations, it was learned that it was possible to influence the pre-existing stereotypes that the students harbored. In this case, the ability to modify those images led to a greater understanding and respect for the importance of the field. While the intervention did not result in every student opting to take a computer science course, it was corroborated in the surveys and interviews that students increasingly understood the global impacts and importance of the field and several of them will now consider it who would not have prior to the intervention.

Career theory tells us how important it is for a person to have a working knowledge of a career for us to consider it for our future (Super & Hall, 1978). Clearly any information about careers that help students develop perceptions of what a field involves could influence future career decisions. Therefore, the importance of introducing students to the profession can prove to be a critical component within their thought processes to their future career decisions (Grover et al., 2016). This can show



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that perhaps not only do we have to teach students what coding is about, we have to go deeper and teach them what the professionals do for more of them to develop an interest for pursuing the field.

While the work of Code.org has shown millions of people the power of computer science and coding, perhaps we also need to introduce them to the faces and needs of the profession (Code.org 2015 Annual Report, 2016). We have slides and data from the Department of Labor that point to the growth in the field and the salaries that can be earned, and yet the pipeline remains underserved for what we need (Bureau of Labor Statistics, 2016). Perhaps we need to also educate about the global impact of the field and as the students in the study pointed out in their discussion that the field is more than just sitting alone at a computer, but rather impacts all professions and everyone's lives.

Today there are programs like SciGirls on PBS that are designed to help alter female attitudes about STEM in a more general fashion (Cheryan et al., 2013). Hopefully progress will continue to be made specific to computer science by organizations like NCWIT that has awards for ambitions for girls and initiatives such as Google's Made with Code. While these types of efforts are clearly needed something more simple as making an adjustment to middle school curriculum to include lessons not only about the coding but about the people of the field may help in the long run. Perhaps the field would be well served if within the fight to include computer science in terms of coding is included in education that we be careful to include the bigger picture of the field as well.



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There was a study in Israel in which girls were introduced to mentors in STEM through visits with professional women at a high-tech company (Bamberger, 2014). While the girls changed their perceptions about the stereotypes and the masculinity of the field, the outcome was that they felt that "We can, I can't" (Bamberger, 2014, p.557). Within this study we have seen a number of students change their perceptions about the field but many may still not enroll in courses, which is a similar outcome.

The results of this intervention did serve to move the needle forward in raising awareness about the issues and concerns for computer science among this population. As a society anything we can do to move the needle even a slight bit is a move in the right direction. Hopefully, all of the students from this study will carry the message forward in some positive way. Positive movement could be anything from more students enrolling in high school or a male student gaining an appreciation when someday he finds himself side by side with females in his class or office.



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APPENDIX A
SURVEY QUESTIONS



# Post-Unit Survey

Please answer the following questions about computer science careers. You will not be graded on this survey and this survey will have no impact on your science grade at any time. You may choose to not participate in this survey and you will not have any penalty for not completing it. The purpose of this survey is to help Mrs. Barrett gather data about attitudes about the field of computer science.

Your email address (**jbarrett@odathunder.org**) will be recorded when you submit this form. Not **jbarrett**? Sign out

1. **Question 1: Please describe what you think a computer professional does when they are at work.**

   ________________________________

2. **Question 2:**
   *Mark only one oval per row.*

| | Do not understand | Somewhat unsure | Somewhat sure | Completely understand |
|---|---|---|---|---|
| I understand what computer science professionals do in their jobs. | ⬭ | ⬭ | ⬭ | ⬭ |

3. **Question 3: I know someone who works as a computer science professional.**
   *Mark only one oval.*

   ⬭ Yes
   ⬭ No

4. **Question 4:**
   *Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| I think that computer science professionals have jobs that are boring. | ⬭ | ⬭ | ⬭ | ⬭ |

5. **Question 5:**
   *Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| I think that programming a computer is boring. | ⬭ | ⬭ | ⬭ | ⬭ |





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6. **Question 6:**
*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| Most people who work as computer science professionals are geeks or nerds. | | | | |

7. **Question 7:**
*Mark only one oval per row.*

| | Strongly DIsagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| Most computer science professionals spend their time working alone at their computer. | | | | |

8. **Question 8:**
*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| Computer science professionals spend most of their time working with people to solve real world problems. | | | | |

9. **Question 9:**
*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| My family thinks it is important for me to learn about computer science and how to program a computer. | | | | |

10. **Question 10:**
*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| My friends think computer science is cool. | | | | |

11. **Question 11:**
*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| People who share my gender are well represented in the field of computer science. | | | | |



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12. **Question 12:**
*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| People who share my ethnicity (or my family's culture) are well represented in the field of computer science. | ⬭ | ⬭ | ⬭ | ⬭ |

13. **Question 13:**
*Mark only one oval per row.*

| | Never | Almost Never | Almost Always | Always |
|---|---|---|---|---|
| I enjoy working with puzzles and do not give up on them easily even when they are difficult. | ⬭ | ⬭ | ⬭ | ⬭ |

14. **Question 14:**
*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Agree | Strongly Agree |
|---|---|---|---|---|
| It is important to me that my future career will allow me to work with people. | ⬭ | ⬭ | ⬭ | ⬭ |

15. **Question 15:**
*Mark only one oval per row.*

| | Definitely will not | Not Likely | Possibly I will | Definitely I will |
|---|---|---|---|---|
| Do you think you will take a computer science course in high school? | ⬭ | ⬭ | ⬭ | ⬭ |

16. **Question 16:**
*Mark only one oval per row.*

| | Definitely will not | Not Likely | Possibly I will | Definitely I will |
|---|---|---|---|---|
| Would you want to someday work as a computer science professional? | ⬭ | ⬭ | ⬭ | ⬭ |

17. **Question 17: What do you think are the biggest challenges for computer science professionals?**





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18. **Question 18: What do you think are the typical goals of someone who works as a computer science professional?**

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APPENDIX B
LESSON PLAN RUBRICS

**Lesson 1 – Student Rubric**

| Component | 5 | 4 | 3 | 2 | 1 | SCORE |
|---|---|---|---|---|---|---|
| Name, date and location of birth | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Bio information including education | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Bio information including work experience | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Information about contributions to the field | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Interesting information and facts discovered during research | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |



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**Lesson 2 - Student Rubric for Elevator Speech**

| Component | 5 | 4 | 3 | 2 | 1 | SCORE |
|---|---|---|---|---|---|---|
| Detailed description of the innovation, including key features and use. | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Identifies benefits of the innovation to society. | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Identifies resources the innovation will use and the challenges it must overcome | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Stays within time limit 2-3 minutes and presented in professional manner | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Adequately describes the innovation and its impact on society | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |



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**Lesson 2 – Student Rubric for Report on Innovation**

| Component | 5 | 4 | 3 | 2 | 1 | SCORE |
| --- | --- | --- | --- | --- | --- | --- |
| Detailed description of the innovation, including key features and use cases. | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Detailed assessment of the risks and benefits of the innovation to society. | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Detailed assessment of the technological resources the innovation will use and the challenges it must overcome | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Contains a mock-up of the technology | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |
| Adequately describes the innovation and its impact on society | Exemplary goes beyond criteria | Meets all of the requirements | Has some of the requirements but is incomplete | Some facts | Has incorrect information | |



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APPENDIX C
STUDENT FUTURE CAREER PROJECT ARTIFACT

## MY CHOSEN CAREER: DANCE MEDICINE SPECIALIST

[redacted]

## DANCE MEDICINE: WHAT IS IT?

- Primarily focuses on the cause and cure of a dancer's injury
- Helps educate young dancers on injury prevention
- Rehabilitates injured dancers while improving their overall technique and form
- Branched from Sports Medicine and Physical Therapy with an emphasis on dance



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## DEFINITIONS OF DANCE MEDICINE

- "Medicine is the science and art of preventing and alleviating or curing disease. Dance medicine and science is the application of that realm to the specific life and body of the dancer. As a discipline it investigates the causes of dance injuries, promotes their care, prevention and safe post-rehabilitation return to dance, and explores the 'how' of dance movement. Some specific concerns include the biomechanical, physiological, and neuromotor aspects of dance, nutrition, psychological issues, and the body therapies and somatics area."
- "Dance Medicine is a form of Sports Medicine but with some very unique characteristics. The dance is different in many ways. This included not only their types of injuries but also their physical exam, evaluation, and treatment."

## EDUCATIONAL REQUIREMENTS

- No exact educational requirements because the field is so diverse
- Each part of the field has its own educational requirements
- Students should generally have a strong foundation in anatomy and health



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## SUCCESS RATE

- Dance Medicine is a newer field and is changing rapidly
- Having attained post-graduate experience in Dance Medicine and Science will lead to multiple careers such as physical/physiotherapist, orthopedic surgeon, or psychologist
- Qualities of a successful healthcare professional include emotional stability, attention to detail, problem solving skills, and excellent communication

## USE OF TECHNOLOGY

- Modern technology has improved overall healthcare in many aspects such as time management and coordination
- Patient files are kept in databases which makes them easier to access
- Growth in nuclear medicine technology has allowed specialists to diagnose a patient without intrusive procedures
- The development of advanced instruments and technology can help patients progress quicker



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## COMPUTER SCIENCE INTERACTION

- Computer science is a necessity for the growth of healthcare
- Data used in healthcare can be analyzed by modern computer systems to sort out the important data from the unimportant data
- The career interchange of computer science and healthcare is health informatics
- Health informatics has different types such as consumer health informatics, public health informatics, clinical informatics, clinical research informatics, and translational bioinformatics

## WORKS CITED


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- http://healthinformatics.uic.edu/resources/infographics/when-healthcare-and-computer-science-collide/
- http://allhealthcare.monster.com/benefits/articles/3854-top-10-qualities-of-a-great-health-care-professional?page=9%22
- http://www.drnick.com/resources/sports-medicine/dance-medicine/




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APPENDIX D

MENTOR INTERVIEW CLASS QUESTIONS

Final interview questions that were combined from student homework assignment and provided to mentors before the live interviews took place.

| Mentor Interview Questions | |
|---|---|
| 1 | Can you briefly tell us who you are, what you do, where you do it and about your educational background. |
| 2 | What was your first job and did you ever think you would become what you are today? |
| 3 | How did you choose your career and was there someone who guided you? |
| 4 | What got you interested or what inspired you in computer science and/or technology fields? |
| 5 | What obstacles did you have to overcome to be where you are today? |
| 6 | What do you most enjoy, or what is your favorite part of your job? Do you get to travel? |
| 7 | Have your career goals changed over time? |
| 8 | What benefits if any would we see from your work? |
| 9 | How might your job benefit people and the planet? |
| 10 | What is the biggest goal you are working towards? |
| 11 | What achievement are you most proud of in your work? |
| 12 | What is the biggest obstacle you have had in your job? |
| 13 | What was one of the biggest surprises you have ever had in your work? |
| 14 | Have you ever felt intimidated being a woman in a field dominated by men? |
| 15 | What has been the hardest part of being a woman in the field of technology/engineering? |
| 16 | How much is your field changing and how fast is it growing? |
| 17 | What advice would you give someone who wanted to become part of the computer science world? |
| 18 | Where do you (and maybe your company) see yourself in 2 years and 10 years? |
| 19 | Do you prefer mac, windows or something else? |
| 20 | What is your favorite motto/saying? |



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APPENDIX E
DISCUSSION BOARD EXTRACT

Discussion Post Sample Extracts

I learned that technology helps us in more ways than we realize. Without computer science, we would not be where we are today. With computer science, we create apps, programming, engineering, analyzing, software developing, developing websites and much more. I learned you do not have to be only into programming or software developing when doing computer science because there are many jobs out there like managing, architects also have a computer science degree, engineering, and website designing, even entrepreneurs have a computer science degree. Before we started learning about computer science, I did not know that it was so popular. Many people in the US study computer science in college, which I did not know. I never really gave computer science a shot before this and never really thought much of it. But after we did the interviews, it gave me a better perspective about computer science, I think it is cool that people actually create languages for programming and how they create games that we play on our phones. I also thought that it was very interesting and I certainly did not think that mostly men specialize in this area. I was very inspired by these women and how they work in an environment that is mostly dominated by men and how difficult it must be. To conclude, computer science is definitely not what I had thought it would be at all, and I think it is very fascinating to learn about.

After listening to what our guests had to say, I learned many surprising things about computer science. First off, I learned that women aren't only discriminated socially in the computer science field, but they are also neglected academically. For example, one guest was assigned a project in a which being a woman was a disadvantage for her.

What surprised me the most about the interviewers was how gifted they were at public speaking. I assumed that people studying computer science would lack social skills because of their long amounts of time they spend on the computer, but my assumptions were proven wrong. This leads me to my assumption of the guests being shying. They were exactly the opposite; I thought that they were very engaging, outgoing, individuals.

I definitely thought there would be alot more sitting at a desk rather than interacting with others to solve problems. I never realized how much computer science impacts us in our daily lives as well.

I thought that someone had to program one thing, and then the computer would do the rest. It turns out that it is much harder than putting in two lines of code and clicking enter.

What surprised the most about these interviews were how different everyone was. Usually, when people think of science professions, they have one general idea. With these interviews, I learned a lot about how every job is different. Some people were managers while some worked hands-on with their assignment. What also surprised me was the different backgrounds that everyone came from. For example, one lady came from Algeria but worked in Hong Kong. Some interviewee's parents were engineers and supported them while other's parents were not supportive and held them back. This proves that anyone can be anything, despite your upbringing or where you live.
I agree with C. I thought it was surprising that each interview was different. Since they were all in the same field, I expected them all to say the same things, but they each had personal responses. They were so diverse in their jobs and their backgrounds. I also found it surprising



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that their personalities were so opposite. I anticipated them all having the same personality, but they each had their own. Some were more upbeat, while others were kind of boring. I liked the more upbeat ones. They seemed the most excited and enthusiastic about their jobs.

I have learned that the impact of technology is everywhere. Everything is the modern world is surrounded by technology. Computer science professionals and other specialists help shape our world by working on improving technology.

I thought that science technology would be a lot different. I thought that it was evolving at a much slower rate, and that there was only one or two languages of code. I did not know that everything, including the language of coding, was changing as fast as it is.

I also thought that computer science would be completely different than what is actually is. I thought it would mostly be a desk job where you have to program and code, but it's not like that at all!

I did not think that technology would be evolving so quickly. What do you all think?

I knew that it was a growing industry, but I had no idea it would be evolving that quickly! I never realized how many different jobs are classified under the technological category. The rate in which new technologies are coming out is also shocking! I totally agree that technology is evolving so much faster than I ever thought!

I'm so surprised at the rate that technology is evolving these days! If you think about it, it really is fascinating how much we have improved in the past few years. Before, it was

I was also suprised at the growing rate of technology. We basically count on technology. Several years ago, it was hard to think that we would have self-driving cars.

I learned that there was a lot more creativity involved in computer sciences. I never had really thought about when a computer scientist really did. Now, I really understand what a computer scientist does and how they use many skills other than just coding. I never knew how fast the computer science field was growing and how much of a variety there is in the field. You can work with the computer science field of whatever interests you.

I didn't realize how much creativity was involved in computer science either.

I learned that everybody in today's world use technology. The problem is that most of them don't know how it works.

I was very intrigued by Brittany. At first I was not really into computer science. Brittany showed me that computer science does not just mean sitting in front of a computer coding. She told us mie how she will use her skills in coding and computing to help save lives. She is currently working on a project to try and customize medicine for each individual person based on DNA. If I ever want to become a computer scientist I would try and follow in the footsteps of Brittany.



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APPENDIX F
INTERVENTION CHRONOLOGY



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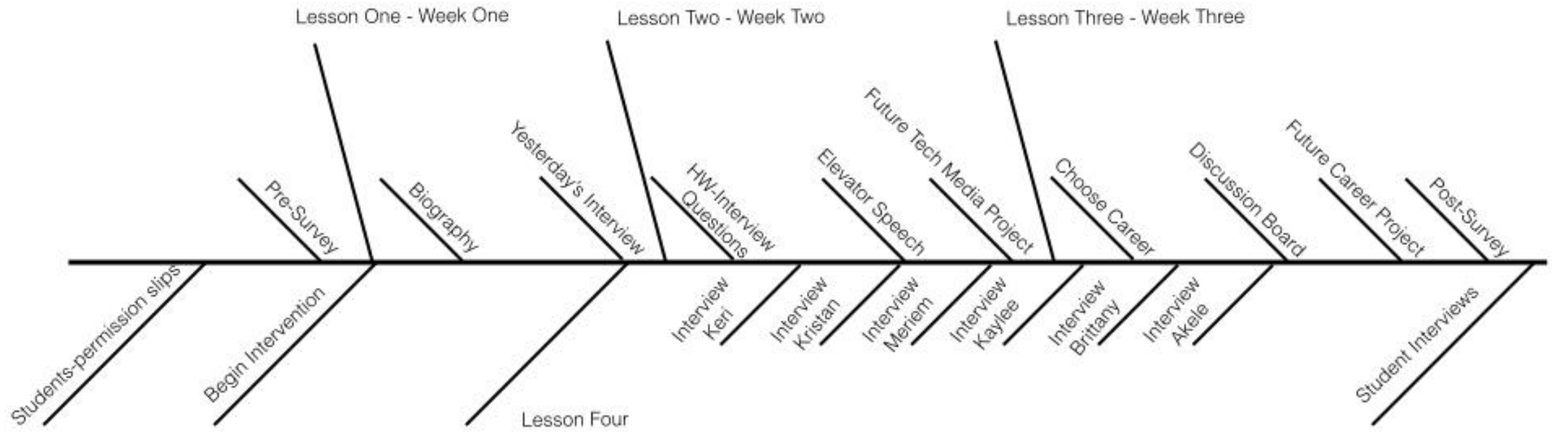




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## BIOGRAPHICAL SKETCH

Joanne started her professional career as a computer programmer for the Federal government. While in Washington, D.C. she earned her master's degree at Georgetown University in Public Policy. Her love of coaching girls' volleyball led her to a career in education and she has been a technology educator for more than twenty years. She has implemented laptop/1:1/BYOD programs and has guided technology integration into middle and high school classrooms. Joanne is the president and founder of the CSTA-Florida chapter and is extremely interested in computer science education in the K12 environment. Old enough to remember programming on punch cards, Joanne is thrilled to work with students and faculty on creative ways to use technology across the curriculum and grade levels. Being a mom to three and grandmother of six helps her to understand the value of staying connected.



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