BUILDING A COMPUTING IDENTITY: THE ROLE OF MIDDLE SCHOOL COMPUTER SCIENCE COURSES IN IGNITING STUDENT INTEREST TO CONSIDER A CAREER IN SOFTWARE DEVELOPMENT

by

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ABSTRACT

SUSAN GANN-CARROLL. Building a Computing Identity: The Role of Middle School Computer Science Courses in Igniting Student Interest to Consider a Career in Software Development
(Under the direction of DR. REBECCA SHORE, COMMITTEE CHAIR)

The purpose of this study was to understand whether students who took computer science courses in a prescribed sequence during middle school developed a strong enough computing identity to show an interest in continuing to take computing courses in high school and possibly pursue a career in software development. This study was quantitative and non-experimental. The participants consisted of 184 sixth through eighth grade students, across 15 middle schools enrolled in one of five computer science courses in a large urban district in the southeast region of the United States. The instrument used to analyze a student's overall computing identity was a survey form that consisted of 11 statements, of which nine were slightly modified from the model research by Mahadeo et al. (2020). Two questions were added to investigate a student's aspirations to take more software development in high school and their intention of pursuing a career in software development. All questions were answered on a five-point Likert-type scale. Six research questions were constructed for this study to compare computing identity development regarding courses, pathways, race, Title I status, and interest in coding beyond middle school. This study used descriptive statistics, F-test, and ANOVA to capture a broad understanding of the development of computing identity in middle school students who were taking computer science courses in a sequenced pathway. There were three findings: modification of the statements did not impact the overall structure of the tool, computer science pathways were not implemented with fidelity, and there was a strong likelihood students with a

high computing identity would also have a high interest in taking more courses in high school and pursuing a career in software development.

DEDICATION

This dissertation is dedicated to my amazing family, my cheering section. To my husband, Floyd, you never stopped believing in me and never complained about the ‘extra’ that fell on your shoulders. I am so grateful for our love and the adventure we share. To our children, thank you for showing your love through endless labeling, stapling, and keeping the house clean. I love you both so much and am so proud of who you are becoming.

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CHAPTER 1: INTRODUCTION

Raj Chetty and colleague's (2014) seminal economic mobility study ranked 50 metropolitan areas regarding upward economic mobility. Simply stated, if one was born poor in one of the lowest ranking cities, they most likely would remain poor. The school district for this study is in one of the lowest ranking metropolitan areas of the economic mobility study. Chetty and his colleague's study became a central point for both public and private institutions to investigate how to impact upward economic mobility so everyone living in this area had an opportunity for a good quality of life. The school district for this study requested their name not be identified. For clarity, the researcher used the name ABC School District in place of the actual name.

At the same time this metropolitan area worked to address economic mobility issues, it was growing in notoriety for employment in the technology sector. By 2018, *Forbes Magazine* named it the new 'high-flier' for locating tech companies (Kotkin, 2018, p. 1). Two notable new technology locations were a nationally known home improvement chain and an internationally-known engineering and technology company. Both corporations announced locating technology-based centers that would together employ almost 3,000 high-paying IT jobs (Cope et al., 2018; Peralta, 2019).

With this city's new popularity as a destination for technology companies came the challenge of supplying the talent pipeline. In a 2020 survey focused on hiring needs and challenges of the metropolitan region's tech companies, 53% of respondents revealed recruitment of talent was 'moderately difficult' (Slalom, 2020, p. 7). This was evidenced by 48,000 technology jobs posted in this region that same year, of which 22,700 were for software developers (Charlotte Works, 2020). These companies also identified the software development skillset as the second-most ‘talent need’ (Slalom, 2020, p. 9).

Aligning with the call from the technology industry nationally to build racial and gender diversity (National Science Foundation, 2019), this city declared an intention to become the most diverse technology hub in the U. S. (Slalom, 2020). This created a new opportunity to focus on diversity and bridge the demand to fill thousands of technology jobs while also building a path to prosperity for those who experience economic challenges. Several community task forces evolved to build solutions for economic mobility. The K12 continuum, specifically ABC School District’s Career and Technical Education in middle and high school, would be included as a key component in addressing economic mobility through building a talent pipeline to employment opportunities in the technology industry.

Statement of the Problem

At the time *Forbes* proclaimed this metropolitan area the new tech high-flier in 2018, only 25% of the 38 middle schools in ABC School District offered computer science courses. Over the next three years, the district’s Department of Career and Technical Education (CTE) expanded computer science courses to 86% of middle schools by the 2020-2021 school year. Included were 17 schools identified as Title I. To be designated as a Title I school, at least 40% of students come from low income families as defined by the U.S. Census Bureau (U.S. Department of Education, n.d.).

For all middle schools in ABC School District where the computer science courses were introduced, students learned about the technology industry and the foundational skills of computer science, including basic coding skills. Before 2018, middle school computer science courses were only provided through *Project Lead the Way* (PLTW), a purchased curriculum.

PLTW Gateway courses were nationally recognized middle school courses which offered hands-on exploration of many STEM careers, including computer science (PLTW, 2023). There were two courses that concentrated on learning to write code and could stand alone versus being offered in a sequence: 1) App Creators and 2) Computer Science for Innovators and Makers. Then in the 2018-2019 school year, the district began offering 3 additional courses Computer Science Discoveries I, II, and III because they were sequenced and could be offered to sixth, seventh and eighth grade. Table 1 gives an overview of all five courses as well as the rationale for implementation by this district's Department of Career and Technical Education. Chapter 2 reviews current literature related to middle school computer science and includes an in-depth look at these courses and their importance to ABC School District.

Table 1

Middle School Computer Science Course Descriptions

Course	Curriculum Provider	Cost	Sequential	Description
Computer Science Discoveries I, II, III	State of North Carolina Department of Public Instruction	No	Yes	A six-unit curriculum divided into three courses, covering computer programming, physical computing, HTML/CSS, and data.
Computer Science for Innovators and Makers (CSIM)	Project Lead the Way	Yes	No	Explored student's "physical world by blending hardware design and software development" (Project Lead the Way, n.d.)
App Creators	Project Lead the Way	Yes	No	Designed to "expose students to computer science by computationally analyzing and developing solutions to authentic problems through mobile app development" (Project Lead the Way, n.d.)

These middle school courses were then organized into pathways where possible to maximize student exposure over time and deepen understanding of computer science versus students taking only one isolated course. The organization of these five courses into pathways was as follows:

Pathway 1: CSD I, II, III, and App Creator

Pathway 2: CSD I, II, and III

Pathway 3: CSIM and App Creators

ABC School District sought to offer Pathway 1 and 2 in as many middle schools as possible. Pathway 3, which involved the original PLTW computer science courses, remained in schools where they were integrated as a part of a larger exposure of STEM (Science, Technology, Engineering and Math) courses.

The intent of such a wide and rapid expansion of computer science courses from 25% to 86% of middle schools was to expose as many students as possible to computer science early. The goal was to help more students discover a passion and skill for software development, and thus pursue their interest to code in high school by taking more advanced computer science classes. Maltese and Tia (2011) and Corin et al. (2020) found that if the interest in a STEM career began in middle school, the likelihood of students pursuing this interest in high school, college, and ultimately a career increased by 1.5 times.

Simultaneously, while the district's CTE department expanded computer science offerings in middle school, a new software development career pathway was launched in the fall of 2018 for high school students. A career pathway is a sequence of courses taken in high school that will help a student gain a deep understanding of a specific career area often earning industry relevant certifications aligned with those particular courses. The software development pathway was comprised of three courses to be taken sequentially: AP Computer Science Principles, Python I, and AP Computer Science A. Students who completed this pathway would learn industry-relevant languages such as Python and Java, which, at the time of this study, were two of the languages most in demand in software development (Burns et al., 2018; Coffey et al., 2020; Hite, 2012). By the 2020-2021 school year, 15 out of 20 large high schools in ABC School District, which included all six Title I high schools, offered this career pathway for students. Although thousands of students took computer science courses in middle school, many high schools struggled to identify students who wanted to complete the software development pathway, especially in Title I high schools. Did this mean that students were not interested in software development, or were they interested but enrolling instead in other courses in high school?

Overview of Conceptual Framework

Before examining what career pathways high school students were enrolling in and why, the first step was to understand whether a computing identity was beginning to develop in middle school that could contribute to pursuing more computing courses in high school. This research study used a computing identity framework to learn whether students who took computer science courses in middle school were developing a self-concept linked to computer science (Mahadeo et al., 2020). There are three sub-constructs in the framework: competence/performance, recognition, and interest (Mahadeo et al., 2020). These constructs were developed to identify key factors that influenced a student’s career identity, first in the sciences, engineering, and most recently computing identity (Carlone, 2007; Godwin et al., 2015; Hazari et al., 2010; Mahadeo et al., 2020). Chapter 2 of this dissertation builds a greater understanding of the development and application of these sub-constructs.

This expanded application of the identity framework, originally created by Carlone and Johnson (2007), offered a more holistic approach to contributing factors that could influence a student in the decision to pursue a career in computing, and aligned with other research regarding developing a career identity (Charleston, 2012; Corin et al., 2020; Flowers & Banda, 2016; Rodriguez & Lehman, 2017). This study used computing identity (Mahadeo et al. 2020) to understand whether middle school students who took computer science exploratory courses had developed a computing identity.

Purpose of the Study

The purpose of this study was to better understand whether middle school students who took computer science courses grew in their computing identity as they progressed through the course sequence or pathway. Additionally, when a student completed a prescribed sequence during middle school did they develop a strong enough computing identity to show an interest in pursuing a career in software development. By comparing results based on race and Title I status (Title I and non-Title I middle schools), the researcher hoped to understand whether these groups of students had the same level of computing identity after they took the same courses in middle school. Although 74% of students in ABC School District identify as non-White, the three largest racial groups represented are Black/African American (36.7%), Latinx/Hispanic (27.2%), and White (25.8%) (ABC School District, 2021). To narrow this study’s scope, the researcher focused on these three groups.

Another factor studied was whether a relationship existed between the strength of computing identity and intent to learn more computer science in high school. This factor, as well as whether students identified a computing career interest, was measured through the lens of eighth grade students who had taken computer science courses throughout middle school where there was an identified course sequence or pathway. These additional factors provided a baseline and gave valuable insights to CTE administration as to whether the intent of this broad application of computer science courses contributed to the growth of student interest in software development careers, especially for students who were poor and underrepresented.

Research Questions

This study took place in the ABC School District with middle school students. Research Questions 2 through 4 were based on eighth grade students who have taken a combination of courses in one of three pathways:

Pathway 1: CSD I, II, III, and App Creator

Pathway 2: CSD I, II and III

Pathway 3: CSIM and App Creators

The following research questions were investigated in this study:

RQ1: Do students enrolled in one of the five computer science courses have different average computing identity scores?

RQ2: Do students who have taken Pathway One have a different average computing identity score than those who have taken Pathways Two or Three?

RQ3: Do Title I students have a different average computing identity than non-Title I students?

RQ4: Do Black/African American and Latinx/Hispanic students have a different average computing identity than White students?

RQ5: Is there an association between a student’s plans to enroll in additional software development courses in high school and the strength of a student’s computing identity when controlling for, race, Title I status, and pathway?

RQ6: Is there an association between a student's plans to pursue computing as a career and the strength of a student's computing identity when controlling for race, Title I status, and pathway?

Data Collection

This study was quantitative and non-experimental, meaning there was no intervention or treatment in this study. This descriptive study used a convenience sample from a large school district in the southeast referred to as ABC School District. The participants consisted of sixth through eighth grade students across fifteen middle schools. These schools were invited to participate in this study because they offered computer science courses in one of the three designated pathways:

Pathway 1: CSD I, II, III, and App Creator

Pathway 2: CSD I, II, and III

Pathway 3: CSIM and App Creators

The total sample for this study included 184 participants. Research Question 1 compared computing identities across all five courses. All 184 participants were included to answer this question. The focus of the remainder of the research questions, RQ2 through 6, was investigating the development of a computing identity in eighth-grade students who had taken multiple courses in one of the pathways outlined above. To answer the remaining five questions a subset of the 184 participants who were eighth grade students was used. The sample for RQ2 through 6 was 67 participants. Enrollment data from the 2019-2020 through the 2022-2023 school years provided enrollment data for all five courses. The independent and dependent variables for this study changed based on the research question being answered. Explanation of the methodology is detailed in Chapter 3.

To examine the strength of the computing identity of the middle school students, the researcher modeled statements from the *Computing Identity Framework* study completed in 2020 Mahadeo et al. (2020). This study used nine survey statements collected from the Conceptual Understanding & Physics Identity Development (CUPID) instrument used in 2014 across 22 postsecondary institutions. Students answered the survey using a Likert scale that related to the three constructs of recognition, performance/competence, and interest. In collaboration with dissertation committee members, middle school teachers and administrators, the researcher adapted the statements in the survey instrument to language appropriate for the middle school students and used the same Likert scale as the CUPID survey. Included in this survey form were two additional questions, also using the same Likert scale, to gauge the level of student interest in taking further software development courses in high school, and interest in pursuing a career in the technology industry.

Delimitations

The researcher recognized that many influences may impact a middle school student's interest in pursuing a career in a technology field. This study attempted to focus on whether the current curriculum and mode of instruction, without intervention in the classroom, was building a computing identity in students, especially those in Title I middle schools. This study did not account for, but recognized, that students may have been influenced by external sources such as parents, out-of-school programming, summer camps, or elementary magnet programs. The researcher did not include this question due to concern for the reliability of responses. Students might not remember accurately or might have been exposed to something outside of school but not known the experience was related to software development. Accounting for external influences would have required a more rigorous qualitative approach that was outside the scope of this study.

Another limitation was time. This study was designed to understand whether a computing identity was developing as early as middle school. There was not enough time to follow students through high school to see if they did enroll in further software development courses and measure whether their computing identity response was followed by actions that confirmed their response. This is an opportunity for further research.

A final limitation was the ongoing impact of COVID-19. This study invited teachers to participate in distributing parent consent forms to students at the end of a school year. This proved challenging and stressful as the return to face-to-face learning continued. High numbers of teacher vacancies, social distancing, trying to instruct while being masked, and decisions to quarantine for safety (National Center for Education Statistics, 2022) did not create an optimum environment for a research project to receive priority at the end of a long academic year.

Assumptions

There were 61 middle school teachers who instructed one or more of the computer science courses with a wide range of experience and backgrounds. Due to the complexity of measuring instruction, an assumption was made that all curriculum was being taught with the same level of adherence to the curriculum in every classroom. Previous research conducted on developing an identity has been conducted with high school and college students (Corin et al., 2020; Maltese & Tai, 2011). These studies confirmed a link between a passion for STEM careers in middle school and a greater likelihood of following that interest into a career. The researcher assumed that building a computing identity in middle school was also possible.

In a few schools, students might have been automatically scheduled for CSD I so they understood what the course sequence was about and could develop a more informed choice as to whether they wanted to learn more in CSD II and III. The assumption was that students who were enrolled in CSD II and III were doing so freely and selected the course because they were genuinely interested in learning more about coding.

The final assumption related to scheduling. Middle schools where computer science courses were aligned to a particular pathway, the courses were offered this way under advisement of the district's department of Career & Technical Education and with buy-in from school administration. For schools invited to participate in the study, the assumption was made that these schools were scheduling students to ensure they had access to courses in the proper sequence.

Definition of Terms

Race

The researcher sought to use the most inclusive language to identify racial subgroups. This study will use Latinx/Hispanic, Black/African American, and White when referencing information or analysis based on race. Ordered by the most recent identification first, the following are the definitions and rationale as to why these identifiers were chosen.

Latinx/Hispanic. Latinx is a recent term created to bring inclusive language beyond the male form 'Latino' and female form 'Latina' (Burgett & Hendler, 2020, p. 154). Although 'Latino' is considered acceptable as a universal language when referencing people of Latin American descent living in the United States, the '-o' and '-a' suffixes are gender-centric (Burgett & Hendler, 2020; Martinez & Gonzalez, 2021). The 'x' provides space for gender neutrality and allows other ways of non-binary identification (Burgett & Hendler, 2020).

Although the Pew Research Center (2020) found Latinx was becoming more widely known at the time of this study, only 3% of 3,030 respondents preferred using Latinx over Hispanic or Latino (Noe-Bustamante et al., 2020). Even though not widely used, the researcher selected using Latinx as the most inclusive language for this study.

The Pew Research Center (2020) indicated about half of respondents preferred the term Hispanic. This is consistent with the finding of Martinez and Gonzalez (2020), who surveyed 5,028 people. Overall, a majority of those surveyed with Latin ancestry who lived in the United States preferred the term Hispanic over Latino. They found varied preferences between using Hispanic or Latino as identifiers based on analyzing various subgroups by age, country of origin, and number of generations in the U. S. of the respondent's ancestry. It is important to note that Latinx was not included in this survey. Therefore, the researcher used Latinx/Hispanic to use the most inclusive language possible at the time of this study.

Black/African American. While the term Latinx is a more recent identification, the subgroups, 'Black' and 'African American', have been widely-used terms. However, their use has not been without controversy and modified definitions (Burgett & Hendler, 2020). The definition for this study does not attempt to unpack the history and use of both terms but brings an inclusive voice that connotes respect for all backgrounds. As described by E. P. Johnson, who helped define the term 'Black':

> 'African American' has a complex and highly politicized history; some people of African descent still prefer 'black' because they do not associate themselves with Africa, while others embrace 'African American' precisely because of its explicit acknowledgement of an African heritage. Still others deploy 'black' as a way of marking global affiliations that exceed 'America' (Burgett & Hendler, 2020, p. 28).

This aligns with guidance from the American Psychological Association's (APA) latest edition that cautions not to use "African American as an umbrella term for people of African ancestry because it obscures other ethnicities or national origins" (American Psychological Association, 2020, p. 143). This study used the term Black/African American to include both identity narratives with the intent of being inclusive.

White. Based on a recommendation from APA, the term Caucasian was not used. The term Caucasian "originated as a way of classifying White people as a race to be favorably compared with other races" (American Psychological Association, 2020, p. 143). The term 'White' was therefore used when discussing race based on European ancestry.

Economic Status

Economic Mobility. This phrase is a simplified interpretation of Chetty and colleague's (2014) description of inter- and intra-generational mobility (2014). The second of three measures used in that study refers to the "probability" of a child moving from "the bottom quintile to the top quintile of income distribution" during their working life. (Chetty et al., 2014, p. 7) Derived from 2014 economic mobility study and community-led work to improve economic opportunity for this region's poorest citizens, this region's task force report defined economic mobility as "the ability of a child born in the bottom income quintile to rise to the top income quintile as an adult" (Leading on Opportunity, 2017, p. i).

Title I School. A school in which at least 40% of students are from low-income families as defined by the U.S. Census Bureau (U.S. Department of Education, n.d.).

Computer Science Terminology

Computer Science. According to the *Encyclopedia Britannica*, it is "the study of computers and computing, including their theoretical and algorithmic foundations, hardware and software, and their uses for processing information" (Belford & Tucker, 2022).

Computer Science Foundational Courses. As defined by Code.org, a foundation course in computer science "includes a minimum amount of time applying learned concepts through programming (at least 20 hours of programming/coding for grades 9-12)" (Code.org et al., 2021, p. 15).

Software Development. As defined by *Science and Engineering Occupational Descriptions*, a software developer will "develop, create, and modify general computer applications software or specialized utility programs. Analyze user needs and develop software solutions. Design software or customize software for client use with the aim of optimizing operational efficiency" (Sargent, 2017, p. 32).

Computer Programming. As defined by *Science and Engineering Occupational Descriptions* a computer programmer will:

> Create, modify, and test the code, forms and script that allow computer applications to run. Work from specifications drawn up by software developers or other individuals. May assist software developers by analyzing user needs and designing software solutions. May develop and write computer programs to store, locate, and retrieve specific documents, data, and information (Sargent, 2017, p. 31).

Organization of the Study

Chapter 2 examines studies on computer science in middle school and high school as well as postsecondary success for Black/African American, Latinx/Hispanic students, and other identifiable groups such as first-generation college students. Chapter 3 explains the research methods, instrument, design, and process, including how the sample was identified. Chapter 4 presents the data and findings for each research question. The implications of the findings leading to the researcher's conclusions and recommendations are given in Chapter 5.

CHAPTER TWO: LITERATURE REVIEW

Introduction

The purpose of this study was to better understand if students taking computer science courses in middle school began to develop a computing identity. In addition, this study investigated whether there was a relationship between the strength of their computing identity, intention to take more computer science courses in high school, and identify an interest in pursuing a career in software development. Almost three-quarters (74%) of all students in ABC School District identified as non-White in the 2021-2022 school year (ABC School District, 2021). Therefore, study also compared computing identity based on race for Black/African American, Latinx/Hispanic and White students to learn whether all groups were developing the same level of computing identity. Another variable considered was understanding whether students who attended a Title I school were also building a computing identity. This was investigated by comparing the development of a computing identity in middle schools based on Title I status.

Before reviewing what was known about developing a career identity and specifically a computing identity, there were several research considerations targeting marginalized students and students from low SES backgrounds that need to be explored first. This gave a foundation as to why building a computing identity before high school could be critical in ultimately pursuing a career interest in the field of computing. Next, this chapter examines postsecondary persistence in STEM majors as well as persistence into the workplace. This can demonstrate potential matriculation into the software development workforce for marginalized students.

After establishing this groundwork, studies on developing career identities are presented. Research on developing a career identity completed during last decade on developing a career identity in the areas of physics, engineering, and computing identity is then presented. The strength of these studies gave an approach for this research. The themes found in the course of the literature review are provided in Table 2.

Table 2

Themes in Literature Review

Theme 1: The State of Computer Science in Middle School and High School	
Introduction	• (Sargent, 2017) • (Code.org, 2016) • (The White House, Office of the Press Secretary, 2016)
Middle School Computer Science Research	• (Cooper et al., 2014) • (Dou et al., 2020) • (Ferreira et al., 2017) • (Margolis et al., 2011) • (Pantic et al., 2018) • (Project Lead the Way, n.d.) • (Qian, & Lehman, 2017) • (Von Wangenheim et al., 2017)
Middle School Computer Science Participation	• (Code.org et al., 2021)
Middle School Computer Science Courses in North Carolina	• (Project Lead the Way, n.d.) • (Laanan et al., 2013)
Advanced Placement Computer Science Courses	• (College Board, n.d.) • (Brown & Brown, 2020)
High School Computer Science Course Participation	• (Code.org et al., 2020, 2021) • (Klein, 2021)
Theme 2: Postsecondary Degrees in Computer Science	
Overview	• (Code.org, et al., 2021)
Science, Technology, Engineer, and Mathematics Persistence	• (Chen, 2013) • (D'Amico & Dika, 2016) • (Mau, 2016) • (NSF: Women, Minorities, and Persons with Disabilities in Science & Engineering, 2019) • (Rilegle-Crumb et al., 2019)
STEM Persistence for Black/African American & Latinx/Hispanic Students	• (Chen, 2013)
Black/African American Persistence	• (Chen, 2013)

	• (NSF: Women, Minorities and Persons with Disabilities in Science & Engineering, 2019) • (Rilegle-Crumb et al., 2019)
Latinx/Hispanic Persistence	• (Chen, 2013) • (NSF: Women, Minorities and Persons with Disabilities in Science & Engineering, 2019)
First Generation College Student Persistence	• (Chen, 2013) • (D'Amico & Dika, 2016) • (Ishitani, 2016)
Barriers to Postsecondary Success	• (Charleston et al., 2014) • (Chen, 2013) • (D'Amico & Dika, 2016) • (Dahl et al., 2021) • (Ishitani, 2016) • (Means & Pyne, 2017) • (Strayhorn, 2012) • (Yeager et al., 2016)
Academic Readiness	• (Burgiel et al., 2020) • (Chen, 2013) • (D'Amico & Dika, 2016)
Sense of Belonging	• (Charleston et al., 2014) • (Dahl et al., 2021) • (Ishitani, 2016) • (Means & Pyne, 2017) • (Strayhorn, 2019) • (Yeager et al., 2016)
Theme 3: Software Development Employment Trends	
Under-representation in Software Development Jobs	• (Park John & Carnoy, 2019) • (Gayfield & Martinez, 2019) • (Hawley et al., 2014) • (NSF: Women, Minorities and Persons with Disabilities in Science & Engineering, 2019) • (U.S. Equal Employment Opportunity Commission, n.d.)
Latinx/Hispanic & Black/African American	• (Park John & Carnoy, 2019) • (NSF: Women, Minorities and Persons with Disabilities in Science & Engineering, 2019) • (Gayfield & Martinez, 2019) • (Equal Employment Opportunity Commission, n.d.) • (Hawley et al., 2014)
Projected Job Growth in the Field of Computing	• (Sargent, 2017) • (Projection Central, n.d.) • (National Center for O*NET Development, n.d.)

Projected Earnings in Computing	• (Bureau of Labor Statistics, n.d.)
Skills Demand	• (Burns, et al., 2018) • (Hite, 2012)
Education Alternatives to a Four-Year Computer Science Degree	Apprenticeships • (Eadicicco, 2020) • (Sargent, 2017) • (Road to Hire, n.d.) Industry Credentials • (Gomillion, 2017) • (Waguespack et al., 2018) Coding Bootcamps • (Waguespack et al., 2018) • (Thayer & Ko, 2017)
Theme 4: Building A STEM Computing Identity	
Defining Career Identity	• (Meijers, 2013)
Science Identity	• (Carlone & Johnson, 2007) • (Godwin et al., 2015) • (Hazari et al., 2010) • (Mahadeo et al., 2020)
Physics Identity	• (Hazari et al., 2010)
Engineering Identity	• (Godwin et al., 2015) • (Hazari et al., 2010)
Computing Identity	• (Flowers & Banda, 2016) • (Mahadeo et al., 2020) • (Lehman and Rodriguez, 2017) • (Maltese and Tai, 2011)
Summary	• (D'Amico and Dika, 2016)

Computer Science Education in Middle School and High School

The fastest-growing jobs in the career cluster of Science and Engineering are those related to computer science (Sargent, 2017) and are the top source of growing wages in the United States (Code.org, 2016). This new growth influenced former President Barack Obama to launch the "Computer Science for All" initiative (The White House, 2016). This brought national attention and support to computer science education and began a movement to expose students to coding as early as possible. As a result, many innovative efforts such as after school programs, weekend programs, STEM magnet schools, and embedded courses through Career and Technical Education in secondary education were begun.

Middle School Computer Science Research

There have been several studies investigating a variety of ways middle school students can explore coding outside of school. The most popular of these opportunities were summer coding camps. Coding camps generally targeted elementary and middle school students and provided skill building. They also provided researchers with ways to study how student perceptions of pursuing a career in computer science might change during the camp, or study student perceptions about what computer scientists do (Cooper et al., 2014; Dou et al., 2020; Pantic et al. 2018).

Another aspect of research focused on the need for more computer science teachers (Margolis et al., 2011; Von Wangenheim et al., 2017) and on building instructional capacity among computer science teachers (Qian & Lehman, 2017). Teachers often found themselves teaching computer science with no previous coding background; building content knowledge and pedagogy was a challenge (Ferreira et al., 2017; Margolis et al., 2011; Qian & Lehman, 2017). While both research generated descriptions of those working in computer science and the need for instructional support were important contributions to the narrative on computer science, neither addressed what was happening in the minds of students during these experiences to develop their computing identity.

Middle School Computer Science Participation

The first annual *State of Computer Science Education* (2018) was published to describe how computer science education was implemented across the country. This report emphasized data indicating high schoolers' access to AP computer science courses, but did not discuss younger students. It gave an overview, though, of how states were approaching computer science education based on nine measures ranging from making computer science a graduation requirement to policies affecting K12 implementation. For the first time, the 2021 report included middle school course offerings and enrollment across the country. By the 2020-2021 school year, only 3.9% of middle school students, defined as grades six through eight, across 17 states were enrolled in computer science courses (Code.org et al., 2021).

Of the 3.9% of middle school students enrolled in computer science 46% were considered low SES in the 2020-2021 school year, which was slightly less than the overall state student population across the same 17 states included in the data (Code.org et al., 2021). This was also true for enrollment by race, except for Black/African Americans, which was slightly higher based on the proportion of state enrollment for the same 17 states included in the data (Code.org et al., 2021). Thirty percent of K8 schools were offering computer science courses across 19 states compared to 26% of schools in North Carolina, where ABC School District is located (Code.org et al., 2021). Although additional demographic data was available for most other states, it was not included for North Carolina.

Middle School Computer Science Courses in North Carolina

Before 2018 in North Carolina, middle school computer science courses were only provided through *Project Lead the Way* (PLTW), a purchased curriculum. PLTW Gateway courses were nationally recognized middle school courses which offered hands-on exploration of many STEM careers, including computer science (PLTW, 2023). There were two courses that concentrated on learning to write code: *App Creators* and *Computer Science for Innovators and Makers*. Both courses were one semester but were stand-alone courses and not intended to be progressive; students could take these courses independently and be successful. In 2013, a longitudinal study was conducted in Iowa for all PLTW participants beginning in the eighth grade. Participants in these courses chose a STEM major in college (whether two- or four- year institutions) compared to non-participants (Laanan et al., 2013).

As discussed in Chapter 1, North Carolina began offering courses titled Computer Science Discoveries I, II, and III in 2018. These courses were offered in a six-module curriculum intended to be taken in three sequential courses. Because these courses were so recently added as an option for middle schools, there were no studies available on their benefit for this group. Nationally, no study was found that explored the impact of coding courses in middle school that are sequenced for foundational skill building. This study sought to fill this gap in the literature. It examined the impact over time on students who took a sequence of coding courses in middle school and whether or not they began to develop a computing identity. This study also examined whether a student's computing identity changed based on where they were at in the progression of courses.

Computer Science in High School

The College Board provides many different high school level advanced curricula intended to be a rigorous introduction to college level material. Most commonly this group of courses are referenced as Advanced Placement or "AP courses". When taken in North Carolina, a student will receive extra weight on their grade point average because of the rigorous nature of these courses. If students pass the exam given at the end of the course with a score of 3, 4, or 5, they would earn college credit recognized at many postsecondary institutions (College Board, 2023). For the discussion regarding computer science in high school, the notation "AP" refers to the common term of Advanced Placement.

Implications of AP Computer Science Enrollment

In 2016, the College Board introduced a high school course called Computer Science Principles or AP Computer Science Principles, designed to be an introduction to computing. According to the College Board AP Computer Science (APCS) Principles Course Overview, AP CS Principles "provides students with a broad introduction to computer science and how it relates to other fields" (College Board, 2023., p. 1). ABC School District's Department of Career and Technical Education adopted this course as the foundation of a three-course pathway called Software Development in the 2017-2018 school year.

On the same webpage as the course overview for APCS Principles, a description of APCS A was given. This course focused on learning the computer science language called Java (College Board, 2023). The importance of Java is discussed later in this chapter in connection with languages most needed for software development.

Brown and Brown (2020) studied the impact of students who enrolled in APCS and their subsequent enrollment in higher education. This study included two large school districts, one on each coast, with a total of 89 high schools and 59,592 graduates over a two-year period. Whether students enrolled in APCS Principles or APCS A, the likelihood they enrolled in college increased by 17%. However, a student who completed APCS A, where students learn the computing language called Java, was 34% more likely to enroll in college compared to 12% for APCS Principles. Even more encouraging for underrepresented students who took APCS A, 38% were more likely to enroll in college. Brown and Brown (2020) concluded their study with a recommendation that students enroll first in APCS Principles to build "foundational skills" (p. 21) before enrolling in APCS A.

High School Computer Science Course Participation

According to the 2022 *State of Computer Science* report, 76% of all high schools in the nation offered foundational computer science courses, which was an increase from 35% in the 2017-2018 school year (Code.org et al., 2022, Code.org et al., 2018). In line with the nation, 78% of high school students in North Carolina in 2020-2021 attended a school in which a computer science course was offered (Code.org et al., 2021). However, only 38% of high schools offered computer science courses where 75% or higher of students were economically disadvantaged (Code.org et al., 2020).

For the *State of Computer Science* report, the courses AP Computer Science Principles and AP Computer Science A were the basis for analyzing data regarding participation/enrollment in computer science courses in high school. The 2021 report also included other foundational computer science courses that were not considered advanced placement courses. For North Carolina, only enrollment data for both AP Computer Science courses was included in the report even though there are other computing courses available like Python I notated in the high school Software Development pathway for ABC School District discussed in Chapter 1.

Table 3

North Carolina AP Computer Science Participation/Enrollment by Race

Race	Participation in AP Computer Science Course		Participation in AP Computer Science Exam	
	2018-2019*	2019-2020**	2018-2019*	2019-2020**
Black/African American	25%	24%	9%	9%
Latinx/Hispanic	18%	17%	11%	10%
White	48%	50%	52%	54%

*Source: Code.org, CSTA, & ECEP Alliance (2020). *2020 State of computer science education: Illuminating disparities* (https://advocacy.code.org/stateofcs)
**Source: Code.org, CSTA, & ECEP Alliance (2021). *2021 State of computer science education: Accelerating action through advocacy* (https://advocacy.code.org/stateofcs)

It is important to note that there was a sudden shift to remote learning due to COVID-19 in March of 2020. The data in Table 3 demonstrate that Black/African American high school students participated in AP Computer Science courses in North Carolina at half the rate as White students and less than half for Latinx/Hispanic students. Equally important was the wide gap in whether students took the *AP Computer Science* exam at the end of the course. In an interview with *Ed Week*, the president of Code.org, K. Hendrickson called for greater attention be given to correcting inequities to access that existed for all students of color despite the measured growth in the number of states offering computer science courses (Klein, 2021). The pass rate of *AP Computer Science* exams was not given in the report. This trend continued in postsecondary persistence as well.

Postsecondary Persistence in Computer Science

Based on the literature cited, if only 51% of high schools in the United States in 2021 were offering an introductory computer science course in high school (Code.org et al., 2021), then students who choose a software development major in college may have had little or no computer science or foundational coding experience because they have had no access to explore computer science before enrolling in college. With a lack of underrepresented students engaged in computer science courses, it is not surprising that there was also a lack of persistence in computer science in postsecondary institutions.

Overall STEM Persistence and Computer Science

According to a plethora of recent research studies, a critical issue regarding the STEM talent pipeline, which includes computer science, was the percentage of students who did not persist and graduate from college with a STEM degree (Chen, 2013; D’Amico & Dika, 2016; Mau, 2016; NSF: Women, Minorities, and Persons with Disabilities in Science & Engineering, 2019; Rilegle-Crumb et.al., 2019). Chen (2013) published a longitudinal study that analyzed a national cohort of approximately 16,700 STEM majors from the beginning of their postsecondary training in 2003 through graduation and employment. Six years were allotted for degree attainment in this study. By 2009, approximately 91% of this cohort had ‘at least one college transcript to analyze‘ (Chen, 2013, p. 7). Through transcript and employment analysis, Chen (2013) traced student movement as they changed majors from STEM, left their institution, or chose another STEM major (Chen, 2013).

Chen (2013) also compared non-STEM and STEM majors rate of change in and out of majors. He found 59% of computer science majors who attended four-year schools and 72% in two-year institutions either left their institution completely or changed to a non-STEM major within their first year. Therefore, only 41% of students in Chen’s study who successfully persisted through degree completion in computer science at a four-year institution.

STEM Persistence for Black/African American and Latinx/Hispanic Students

Although Chen (2013) did not disaggregate data based on ethnicity of computer science majors, he did look at attrition for STEM majors by race/ethnicity (Chen, 2013). Table 4 shows how subgroups relevant to this study performed as far as persistence in their STEM major.

Table 4

2003-2004 First Year STEM Major Exit Based on Race and Income

Race and Income Level	STEM entrants among beginning bachelor’s degree students		STEM entrants among beginning associate’s degree students	
	Left PSE[1] without a degree or certificate	Switched major to a non-STEM field	Left PSE without a degree or certificate	Switched major to a non-STEM field
Race				
Black/African American	29.3%	36.0%	41.5%	36.3%

Latinx/Hispanic	23.1%	26.4%	39.9%	37.6%
White	19.8%	28.1%	35.8%	30.3%
Income				
Lowest 25 percent	29.2%	28.6%	45.9%	25.1%
Highest 25 percent	15.4%	28.0%	42.6%	34.1%

1 ‘‘PSE” refers to postsecondary education. ‘students who left PSE without a degree or certificate’ are also referred to as students who dropped out of college’ (Chen, 2013, p. 18 & 19)
Source: Chen, X. (2013). *STEM Attrition: College Students' Paths Into and Out of STEM Fields*. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, D.C..

Black/African American STEM Persistence. The data from Table 4, combined with the National Science Foundation's report *Women, Minorities, and Persons with Disabilities in Science and Engineering* (2019) showed a poor rate of persistence for Black/African American students who earned a bachelor's degree in computer science. Chen (2013) discovered the exit from STEM majors for Black/African American students in the first year of college during 2003-2004 to be 29.3% for four-year institutions and 41.5% who left a two-year institution. A total of 70.8% Black/African American STEM majors left their institution, compared to 55.2% of White students (Chen, 2013; Rilegle-Crumb et. al., 2019). Regardless of whether Black/African American students were pursuing bachelor's or associate degrees, 72.3% switched to a non-STEM major in their first year (Chen, 2013). The number of computer science degrees earned was only 8.7% of the bachelor's degrees awarded nationally in 2016 to Black/African American students, which was a 2.3% decrease from 2006 (NSF, 2019).

Latinx/Hispanic STEM Persistence. Latinx/Hispanic students were not as likely to leave their institution as Black/African Americans, but still left at a higher rate than Whites (Chen, 2013). While 63% of Latinx/Hispanic STEM majors left their institution completely, 64% switched their major to a non-STEM major during their first year of college (Chen, 2013). However, unlike their Black/African American peers, there was a 3.2% increase in the percentage of Latinx/Hispanic students who earned a bachelor's degree in the area of science and engineering, from 7% in 2006 to 10.1% in 2016 (NSF, 2019). This is still a far smaller share of the bachelor's degrees earned by White students, who have consistently earned over half of the degrees in Computer Science degrees between 2006 to 2016 (NSF, 2019).

First-Generation College Students STEM Persistence

A review of persistence in computer science would not be complete without highlighting the journey of first-generation college students. First-generation college students (FGCS) have continued to struggle to persist at the same rate as their continuing generation peers (Chen, 2013; D'Amico & Dika, 2016; Ishitani, 2016). Ishitani (2016) studied over 7,500 students enrolled in four-year institutions and found that "compared to students whose parents graduated from college, first-generation students were approximately 80 percent more likely to leave college during their second year of enrollment." (Ishitani, 2016, p. 28).

In line with Ishitani (2016), Chen (2013) found that STEM majors seeking a bachelor's degree whose parents earned a high school degree or less were almost twice as likely to leave the institution than students whose parents held a bachelors or higher degree. For students starting an associate's degree, income had less impact, meaning that students left their institution at the same rate regardless of whether their parent had a high school diploma or a postsecondary degree (Chen, 2013).

Barriers to Postsecondary Success

Understanding some of the reasons why students with STEM majors were leaving creates a link as to why this study was important to conduct. Two main themes emerged as research was examined regarding why FGCS, Black/African American, and Latinx/Hispanic students were not persisting in STEM majors: math preparedness and a sense of belonging (Charleston et al., 2014;

Chen, 2013; D'Amico & Dika, 2016; Dahl et al., 2021; Ishitani, 2016; Means & Pyne, 2017; Strayhorn, 2012; Yeager et al., 2016).

Academic Readiness. While a student's high school GPA was a strong indicator for persistence (Chen, 2013; Mau, 2016), not taking enough advanced level math courses in high school was a common reason as to why STEM majors were not persisting (Chen, 2013; D'Amico & Dika, 2016). Twenty-four percent of STEM majors who took an advanced math course such as calculus in high school switched their major in college less often than did those who took pre-calculus or algebra II/trigonometry (Chen, 2013). Additionally, Chen's analysis showed that students who took math in their first year of college were less likely to leave their STEM major (Chen, 2013).

This finding aligns with D'Amico and Dika's (2016) study of first generation college PEMC-STEM (physical science, engineering, math, and computer science, a subset of STEM majors) students where student self-perception of math readiness, as well as their success in their first semester, influenced whether they persisted and earned a degree in PEMC-STEM. Related to readiness for computer science, Burgiel et al. (2020) showed a significant correlation between students who experienced more coding in high school and earning a higher grade in the introduction to computer science course in college. Their study was an important link to the fundamental need to build coding courses in middle school.

Sense of Belonging. Ishitani (2016) found that the more social integration students experienced in college, the lower their likelihood of dropping out (Ishitani, 2016). This was difficult for marginalized and FGCS students when they often did not feel like they belonged once on a college campus (Charleston et al., 2014; Dahl et al., 2021; Means & Pyne, 2017; Strayhorn, 2019; Yeager et al., 2016). Research showed that overt racism and micro-aggressions were a reality for them at most predominately White postsecondary institutions (Means & Pyne, 2017). This impacted the sense of belonging for many marginalized students in how welcomed they felt while on campus and how they were treated by their White peers (Means & Pyne, 2017). Dahl et al. (2021) discovered that for Black/African American students, a sense of belonging increased when they were able to live on campus and experience a positive peer network. Many FGCS miss the opportunity to live on campus and build a sense of belonging because of the costs associated with housing. Yeager et al. (2016) found that simply helping students understand that their feelings of being overwhelmed and lack of belonging were not uncommon and would subside. This advice significantly impacted a student's ability to persist through their first year (2016).

Software Development Employment Trends

Chapter 1 referenced the strong growth in software development job opportunities in metropolitan area where ABC School District is located in 2020. This section will explore employment trends that align with postsecondary trends. It will also present a variety of training programs, like apprenticeships and industry certifications, that will allow an individual to qualify for different entry points into software development workforce without obtaining a four-year bachelor's degree.

Underrepresentation in Software Development Jobs

As the number of marginalized students who persisted through to a degree in computer science was small, it was not a surprise to see this trend carry over into employment in the technology industry. Although trends showed a slight growth in the number of Black/African American and Latinx/Hispanic people who held software development jobs; their representation as a percentage of the overall technology workforce was very low compared to those who identified as White (Gayfield & Martinez, 2019; Hawley et al., 2014; NSF, 2019; Park et al., 2019; U.S. EEOC, n.d.).

Silicon Valley, a region in the San Francisco, California area was the first in the country to become known for developing many technology innovation companies. John and Carnoy (2019) studied employment trends for software developers related to race and gender in the Silicon Valley for a six-county region from 1980 to 2015. They used employment and wage data and found the number of Latinx/Hispanic and Black/African Americans earning computer science degrees had increased. However, their representation in software development jobs had not kept pace with their White male peers or foreign-born workforce (Park & Carnoy, 2019). The percentage of Latinx/Hispanic who held programming jobs dropped from 4.41% in 1990 to 2.84% in 2015, though the number of Latinx/Hispanic who held a bachelor's degree increased from 3.8% in 1990 to 7.89% in 2015 (Park & Carnoy, 2019).

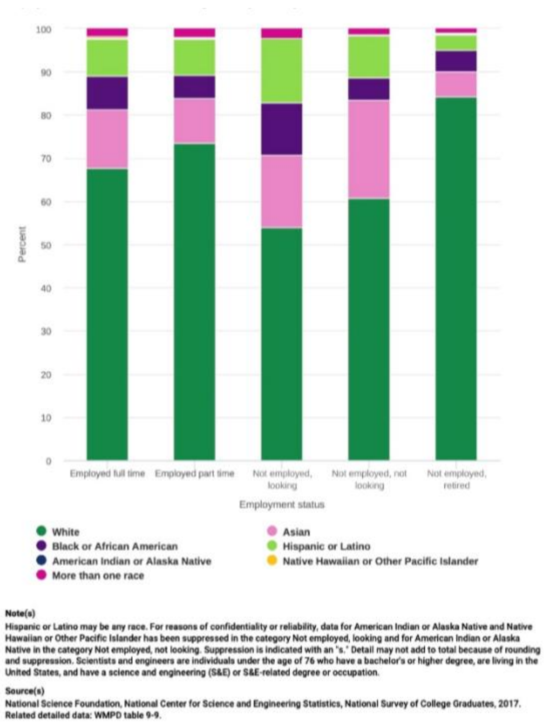
Although the same lack of representation held true for Black/African American programmers, access, employment, and degree attainment were much lower than their Latinx/Hispanic peers. In Silicon Valley, the number of Black/African Americans who held a bachelor's degree dropped from 3.76% in 1990 to only 1.11% in 2015 (Park & Carnoy, 2019). This was mirrored by the drop in Black/African Americans who held a programming job from 3.27% in 1990 to 1.09% in 2015 (Park & Carnoy, 2019). White peers comprised 72.37% of the programming job market in 1990 but decreased significantly to 35.25% by 2015. This decrease was partially attributed to the "non-citizen status programmers" who were sometimes seen as a less expensive programming alternative (Park & Carnoy, 2019, p. 429).

To examine this trend on a national scale, the 2019 bi-annual report *Women, Minorities and Persons with Disabilities*, offered many insights from data for the 2017 workforce.

Computer programming was considered a part of the Science and Engineering job sector. Figure 1 from this report illustrates that, when adding all non-White racial groups together, did not equal the share of science and engineering jobs that are held by Whites (NSF, 2019).

Figure 1

2017 Employment Status of Scientists & Engineers by Ethnicity & Race



This disparity became of greater concern when compared to the population projections by the Bureau of the Census, that predicted non-White racial groups will account for 56% of the population by 2060 (NSF, 2019). In line with the National Science Foundation, the U. S. Equal Opportunity Commission (EEOC, n.d.) used 2014 EEOC data and had similar findings regarding the state of diversity in high-tech occupations in the U. S. Black/African Americans held 7.4% of technology positions, Latinx/Hispanic fared slightly better at 8%. Whites, however, held 68.5% of high-tech positions (EEOC, n.d.). This was just under half the percentage of positions held by Black/African Americans and Latinx/Hispanic in all private industries (EEOC, n.d.).

Projected Job Growth in the Field of Computing

The growth in STEM careers has become a research topic of interest. In late 2017, the Congressional Research Service released a report authored by John Sargent, Jr., who was a Specialist in Science and Technology Policy. This report presented the current and projected future state of science and engineering regarding job growth, wages and unemployment. Sargent (2017) found 4.9% of all employment in the United States were scientists and engineers according to the 2016 occupational employment statistics. Out of the 6.9 million people employed as scientists and engineers, 57.6% of the occupations were classified within one of the 97 computer occupation job codes out of 867 total job codes in the U.S. (U.S. Bureau of Labor Statistics, n.d.). Additionally, projected job growth between 2016 and 2026 predict six out of the top ten jobs projected were computer-related with projections for software developers for applications being first (Sargent, 2017).

To gain a better understanding of how this projection translates for North Carolina, Table 5 highlights the projected growth for six specific job codes. The average projected growth for all job codes for North Carolina was 5.21% by 2028 (Projection Central, n.d.). All six job codes outpaced the average, but software developer for applications aligned with national projections and was also projected to grow almost six times higher than the average for North Carolina. The growth for five of the six codes was above the national projected growth with, software development for applications exceeding national growth by 3.5%.

Table 5

Projected Job Growth for Computing Occupation by Rank

Occupation Name (Occupation Code)	Job Growth Rank w/in S&E 2016-2026[1]	Projected # of Jobs in U.S. by 2028[3]	% Growth in U.S. 2018-2028[3]	Projected # of Jobs in North Carolina by 2028[3]	% Growth in North Carolina 2018-2028[3]

Software Developer, Application (15-1132)	1	1,185,709	25.6	41,250	29.1
Computer User Support Specialist (15-1511)	2	742,700	10.6	26,680	11.9
Computer Systems Analyst (15-1121)	3	689,900	8.8	31,370	12.8
Software Developer, System Software (15-1133)	4	463,900	10.1	7,840	6.4
Computer & Information Manager (11-3021)	5	461,100	11.3	15,090	15.5
Computer Occupation, All Others (15-1199)	9	455,000	10.2	7,140	10.7

[1]Data compiled from The U.S. Science and engineering workforce: Recent, current, and projected employment, wages, and unemployment. *Congressional Research Service*. http://www.crs.gov/
[2]O*NET OnLine (n.d.) https://www.onetonline.org/
[3]Projections Central (n.d.) *Long Term Occupational Projections (2018 - 2028*). https://projectionscentral.com/Home/Index

Projected Earnings in Computing

To further define the opportunity for those employed in computing occupations, these jobs offer a higher-than-average wage in the metropolitan area where ABC School District is located. In 2019 the average annual wage in this area for all occupations was $52,150 (Bureau of Labor Statistics, n.d.). High growth occupations in North Carolina have the potential to almost double the average wage for an individual in the metropolitan area. Even the computer user support specialist on average earns $25 per hour without having to earn a degree (Bureau of Labor Statistics, n.d.). Table 6 shows projected earnings in this urban area along with education requirements. A discussion of a variety of pathways to software development has not yet been done at the national level.

Table 6

Education & Annual Wages for Computing Occupations by Rank

Occupation	Job Growth Rank w/in S&E 2016-2026[1]	Entry Level Education by Degree[1]	Mean Annual Wage for ABC School District's Region 2019[2]

Software Developer, Application	1	Bachelor	$104,040
Computer User Support Specialist	2	Some college, no degree	52,050 or $25.03/hour
Computer Systems Analyst	3	Bachelor	$98,110
Software Developer, System Software	4	Bachelor	$104,040
Computer & Information Manager	5	NA	Not Listed
Computer Occupation, All Others	9	Bachelor	$93,400

[1]Data compiled from The U.S. science and engineering workforce: Recent, current, and projected employment, wages, and unemployment. *Congressional Research Service*. http://www.crs.gov/
[2]Source: U.S. Bureau of Labor Statistics (n.d.). Bureau of Labor Statistics

This study investigated the possibility of developing a computing identity in middle school in hopes that the process of taking courses in computer science might spark a student's interest to pursue a career in software development or another computer related career. While Table 5 demonstrates the extensive growth in software development jobs, Table 6 connects career opportunity and the possibility of changing the economic trajectory for students whose upward economic mobility has many obstacles.

Skills Demand

The employment opportunity of working in computing cannot be discussed without also examining the primary hard skills needed to qualify for one of these lucrative positions. The coding languages most often listed on job postings for programming-related positions were Java, SQL, JavaScript, and HTML (Burns et al., 2018; Hite, 2012). Hite (2012) examined technology job postings by comparing over 20,000 employment postings in 2004 and over 70,000 in 2011. In a rank order comparison of skills mentioned in job postings for programming, SQL and Java were ranked first and second in both years. Although the computer language group of C++, C#, and Visual C++ was ranked eighth in 2004, it jumped to third in demand in 2011(Hite, 2012). Burns et. al. (2018) discovered the same skills prioritized for programming in 2017 when they examined 204 technology job postings across the nation. Students enrolled in AP Computer Science A were also learning to code in *Java* language (College Board, n. d).

Education Alternatives to a Four-Year Computer Science Degree

Apprenticeships. Although most of the job market still required a bachelor's degree as a minimum requirement to access high paying technology jobs, in ABC School District's region, there was innovation in short-term programs to support students to access entry-level, technology-based positions (Eadicicco, 2020; Sargent, 2017). The cybersecurity apprenticeship offered through Road to Hire, a not-for-profit incubated within a large technology company, Red Venture, LLC, is one such program. The Road to Hire program served underrepresented young adults in ABC School District's region and prepared participants "for in-demand technology careers" (Road to Hire, n.d.). This was a progressive approach to skills development that was opening the door for students, primarily underrepresented and FGCS to employment in the technology industry. In addition, Road to Hire's pathways supported students to complete a two- or four-year degree so they were able to continue to move into higher paying positions.

Industry Credentials. Industry certifications also play a larger role to help job seekers validate their skill level and perhaps gain an edge to land an interview over another candidate who on paper appeared to have the same skill set but no certification (Gomillion, 2017). Gomillion (2017) also noted that high schools and community colleges were more likely to offer industry certifications than four-year universities. Both boot camps and industry certifications translate to a possible path for students who could not afford, or did not want to attend a traditional, four-year institution (Gomillion, 2017; Waguespack et al., 2018).

Coding Bootcamps. Because there are so many software development jobs to fill, another approach toward computer science recruitment has emerged called coding bootcamps.

These bootcamps are generally 8-12 weeks of highly focused, quick skill-building programs for an entry level coding position (Waguespack et al., 2018). Coding bootcamps offer an opportunity for students right out of high school or someone who wants to reskill quickly. The goal of bootcamps was more “skill-building, rather than problem shaping or theorizing” (Waguespack et al., 2018, p.52). Waguespack et al. (2018) compared this process to a construction worker who hammered nails versus the architect who created the blueprints.

In 2017, a qualitative study by Thayer and Ko (2017) revealed possible challenges related to bootcamps. Their study included 26 participants in the Puget Sound area of Seattle, Washington who either were participating in or had completed one of six different bootcamps. Participants were 18 to 39 years old and varied by race, gender, and sexual orientation. Thayer and Ko (2017) identified formal and informal boundaries that existed for participants after completing their bootcamp. The informal boundaries were of particular interest in this study. As with persistence of students on a college campus or employers in the workplace, the theme of identity and belonging was at the forefront. In this study, some participants did not feel like they were real programmers because they were working alongside programmers with more education and experience.

The lack of a sense of belonging stemmed from working in mostly White male environments and feeling out of place or unprepared for the work culture. This was not to imply that coding bootcamps were risky; 25 out of 26 participants obtained full-time coding jobs (Thayer & Ko, 2017). It did, however, demonstrate the theme in the literature regarding the importance of perceived belonging and to some degree, persistence. The study measured whether a computing identity could be developed as early as middle school in hopes of building the confidence and identity around computing that might contribute to a sense of belonging to the technology industry.

Building a STEM Career Identity

Before thinking about a STEM career identity, it was important to define career identity more generally. Meijers et al. (2013) defined career identity as “the commitment a person has towards specific occupational activities or a specific career” (p. 53). In their study, they defined self-knowledge and self-confidence that results from the act of studying for that work over time. Carlone and Johnson (2007) did not use these words specifically, but there is alignment in their definition of career identities also.

Science Identity

A lack of college degree attainment in STEM majors and subsequently persevering in a White male-dominated workplace for underrepresented subgroups triggered more research about who persisted and why. In 2007, Carlone and Johnson (2007) released findings from an ethnographic study that included 15 women of color who were enrolled in the sciences at a university in a small, predominately White, rural state. To begin to understand persistence, they first defined what comprised a science identity:

> She is competent; she demonstrates meaningful knowledge and understanding of science content and is motivated to understand the world scientifically. She also has the requisite skills to perform for others her competence with scientific practices (e.g., uses of scientific tools, fluency with all forms of scientific talk and ways of acting, and interacting in various formal and informal scientific settings). Further, she recognizes herself, and gets recognized by others, as a science person (Carlone & Johnson, 2007, p. 1190).

This was their basis for the interconnected science identity sub-constructs of competence, performance, and recognition (Carlone & Johnson, 2007). This seminal study became the basis for other studies focused on developing reliable identity sub-constructs that were likely to be present for students who pursued careers in other STEM areas (Godwin et al., 2015; Hazari et al., 2010; Mahadeo et al., 2020). Carlone and Johnson (2007) initially identified competence, performance, and recognition as the three sub-constructs. At the conclusion of their study, they shifted their construct to include interest as another key component, but recognition from others was the most important component (Carlone & Johnson, 2007).

Physics Identity

Hazari et al. (2010) used this same construct to examine how physics students develop their identity to the point they want to pursue physics as a career, with a specific interest in gender differences. This was a quantitative study that used data collected in fall of 2007 from the *Persistence Research in Science and Engineering Project*. Their research sample included 3,829 students from 34 colleges and universities who had taken a physics course in high school (Hazari et. al., 2010). This survey was completed by university students in the U. S. enrolled in Introduction to English courses to learn about "interest and experiences in science" (Hazari et al., 2010, p. 985). These investigators found a strong correlation existed for all students with a strong physics identity and the sub-constructs of interest, competence, performance and recognition. However, they also discovered an aspect that was not part of Carlone and Johnson's (2007) study: the grounding of the sub-constructs in the student's self-perception of these four areas (Hazari et al., 2010). Hazari et al. stated:

> In other words, it is not enough for teachers to prepare students for performing required tasks or making the subject interesting. Teachers need to also provide opportunities for

> recognition, recognize students themselves, and focus on practices, such as conceptual understanding, that will not only increase competency but also feelings of competency (Hazari et al., 2010, p. 998).

Engineering Identity

Godwin et al. (2015) and Hazari et al. (2010) applied the same identity framework to understand how students built an engineering identity. They focused on “students’ self-beliefs at the transition from high school to college to understand the impact of these beliefs on engineering choice” (Godwin et al., 2015, p. 5). Their results demonstrated that interest and recognition by others held greater influence than performance/competence in engineering (Godwin et al., 2015). This confirmed earlier findings that teaching content alone was not adequate. Giving students opportunities to gain recognition from their teachers and peers played a critical role in developing an identity in physics or engineering that could lead to a college major and career choice (Godwin et al., 2015; Hazari et al., 2010).

Computing Identity

Mahadeo et al. (2020) applied an adapted conceptual framework to define a computing identity. This new application of the identity framework brought a new and more holistic approach to the contributing factors that motivated students to pursue a career in computing. Collapsing performance and competence into one construct, recognition and interest were now the three-legged stool that was tested for significance for a computing identity:

> Computing performance/competence refers to students’ beliefs in their ability to accomplish required computing tasks and understand the content. Computing recognition refers to how recognized they feel as being a “computing person”. Finally, interest refers

to how interested students feel in computing topics and practices (Mahadeo et al., 2020, p. 3).

This study emphasized that self-efficacy, which was often discussed as an important factor for students to identify with computing, was more task-focused in the moment, whereas computing performance and competency builds a broader scope over time and develops self-efficacy (Flowers & Banda, 2016). Figure 2 is the Venn diagram Hazari et al. (2020) used to illustrate a student's computing identity, showing the interdependence of sub-constructs.

Figure 2

Computing Identity Framework Sub-Constructs

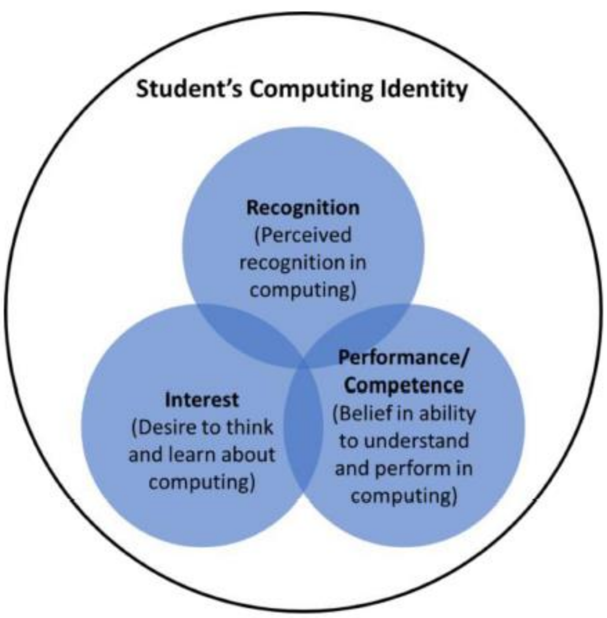


Figure from Hazari Z., Mahadeo J., & Potvin, G. (2020. Developing a computing identity framework: Understanding computer science and information technology career choice. *ACM Transactions on Computing Education.* 20(1) Article 7, p. 4. https://doi.org/10.1145/3365571

While Hazari et al. (2020) tested physics identity constructs with high school students, Mahado et al. (2020) researched computing identity in college students nationwide. They embedded nine statements as a pre-survey for the 2014 Conceptual Understanding & Physics

Identity Development (CUPID) survey. This instrument was created collaboratively by education researchers and scientists. Mahadeo et al. (2020) felt this was an adequate sampling since it was administered to introductory physics courses, where there were likely to be a high number of students interested in computing. The CUPID project resulted in 1704 surveys to review. Nine survey questions were identified for analysis that aligned with the computing sub-constructs (Mahadeo et al., 2020). Table 7 gives the survey questions and their associated sub-constructs.

Table 7

Computing Identity Survey Questions on CUPID Survey

Sub-Construct	CUPID Survey Questions
Recognition	My family sees me as a computer savvy person.
	My friends/classmates see me as a computer savvy person.
	My instructors/teachers see me as a computer savvy person.
Interest	Topics in computing excite my curiosity
	I like to peruse forums, social media, or online videos about computer related topics.
	Computer programming is interesting to me.
Performance/ Competence	I can do well on computing tasks (e.g. computer programming and setting up servers)
	I understand concepts underlying computer processes.
	Others ask me for help with software (applications/programs)

Source for CUPID questions aligned to recognition, interest and performance/competence are from Mahadeo et al. (2020) study. Mahadeo J., Hazari Z., &Potvin, G. (2020). Developing a computing identity framework: Understanding computer science and information technology career choice. *ACM Transactions on Computing Education* (1). Article 7. https://doi.org/10.1145/3365571

To further understand who participated in the survey, the racial/ethnic groups for the 1704 students were: 47.1% White, 25.8% Asian, 14.5% Latinx/Hispanic, 7.2% Black/African American, 2.1% Native Hawaiian or Pacific Islander and 1.9% American Indian or Alaskan Native. This study was also equally balanced between male and female with 4.5% more females than male and 2.2% identifying as another gender identity. Of the 1704 students, 10.8%

responded as being intentional towards computer science and information technology in college (Mahadeo et al., 2020).

The results were that “the computing identity sub-constructs all strongly predict a CSIT [Computer Science Information Technology] career choice, with interest being the strongest” (Mahadeo et al., 2020, p. 9). The present study, though, sought to go beyond whether students were simply taking computer science courses in middle school, to understand whether they were developing a computing identity based on a prescribed sequence of courses.

Maltese and Tai (2011) discovered a strong correlation between students in the eighth grade who identified an interest in a STEM career and completing a STEM degree in college. Corin et al. (2020) also found that students interested in STEM majors in middle school were 1.5 times more likely to still have that interest at the end of high school compared to students interested in non-STEM careers.

So how does a student develop an identity that is strong enough to pursue a career in software development? Lehman and Rodriguez (2017) examined developing a computing identity and the sense of belonging. They identified the need to develop a computing identity as a critical part of building interest in computing among underrepresented students. This is the central question of this study: Are middle school students in ABC School District developing a computing identity based on a prescribed sequence of computer science exploratory courses?

Summary

Rather than simply analyze the number of computer science courses a student has taken during middle school and high school. The emphasis was about developing their computing identity as it related to the number of courses taken in a prescribed sequence. The researcher also attempted to shed light on how students begin to identify with a career in computing. D’Amico and Dika (2016) found a connection between physical science, engineering, math, and computer science (PEMC-STEM) majors who were first-generation college students and their strong connection to their major. Is it possible to ignite an interest as early as middle school for a career in software development and continue to build on that identity to successful employment?

Chapter 2 reviewed relevant literature to address the research questions. Chapter 3 will explain the methodology used for this study.

CHAPTER 3: METHODOLOGY

Introduction

The purpose of this study was to determine whether middle school students in ABC School District enrolled in computer science courses were developing a computing identity related to a sequenced pathway, Title I status, and race. This study also investigated to what extent students identified an interest in pursuing additional computer science courses in high school and ultimately a career in software development. As discussed in Chapter 2, the Computing Identity Framework examined the correlation of nine statements from the Conceptual Understanding & Physics Identity Development (CUPID) survey to analyze a student's overall computing identity. This identity was also found to have three constructs: recognition, interest, and competence/performance (Mahadeo et al., 2020). While this chapter references the constructs, this study focused primarily on the overall computing identity as the first factor to understand the student's experience in these courses. Chapter 3 presents how the research questions were answered, the research design, the instrument used, how data was collected, and the planned data analysis.

Research Questions

In the 2018-2019 school year, the ABC School District began offering Computer Science Discoveries I, II, and III because they were sequenced and could be offered aligned to sixth, seventh and eighth grade. These courses combined with the two previously offered computer science courses: App Creators and Computer Science for Innovators and Makers (CSIM) were the focus of this study. These courses were organized into pathways where possible to maximize student exposure over time and deepen understanding of computer science versus one isolated course.

This study took place in the ABC School District with middle school students. Research Questions 2 through 4 were based on eighth grade students who have taken a combination of courses in one of three pathways:

Pathway 1: CSD I, II, III, and App Creator

Pathway 2: CSD I, II and III

Pathway 3: CSIM and App Creators

The following research questions were investigated in this study:

RQ1: Do students enrolled in one of the five computer science courses have different average computing identity scores?

RQ2: Do students who have taken Pathway One have a different average computing identity score than those who have taken Pathways Two or Three?

RQ3: Do Title I students have a different average computing identity than non-Title I students?

RQ4: Do Black/African American and Latinx/Hispanic students have a different average computing identity than White students?

RQ5: Is there an association between a student's plans to enroll in additional software development courses in high school and the strength of a student's computing identity when controlling for, race, Title I status, and pathway?

RQ6: Is there an association between a student's plans to pursue computing as a career and the strength of a student's computing identity when controlling for, race, Title I status, and pathway?

Research Design & Rationale

This study used a quantitative non-experimental design to investigate the development of a computing identity in middle school students who are enrolled in computer science exploratory courses in a prescribed sequence. This was the first study of its kind in ABC School District, and potentially the first of its kind, as the model research used for its design was published only two years earlier.

All five-computer science exploratory courses discussed in the introduction and Table 1 were included in this study: CSD I, II, and III, CSIM, and App Creators. A quantitative approach that used a survey form constructed of similar statements as the model study measured a student's overall computing identity as the student progressed through CSD I, II, and III, and especially when enrolled in CSD III. Of the 15 middle schools invited to participate, 11 schools offered the CSD sequence. Thus, CSD I and II were included in the sample in order to compare the overall computing identity over time. This step was important to answer RQ1 regarding how students' average computing identity scores compared when enrolled in CSD I versus II, and III.

Of additional interest was how computing identity developed among students based on race and Title I status. CSD III, CSIM, and App Creators were most often offered to students in eighth grade. From the larger sample, a second sample consisting of all eighth-grade students in one of three courses were analyzed to learn whether students who opted to take multiple computer science courses throughout middle school were showing signs of developing a strong computing identity.

Researcher's Role and Positionality

At of the time of the study, the researcher had worked in ABC School District since the fall of 2016 in the role of the Director of Career and Technical Education. The rapid expansion of computer science courses to a majority of middle schools in the district was a response to the growing job opportunities in the field of software development and the desire to build a pipeline of employment opportunity for all students, but in particular for those having economic barriers. This study took place early in the process of implementing these courses and with the knowledge that many teachers were still learning the curriculum. The research questions structured this study to ensure that future students who completed the survey form that show a strong computing identity development could be nurtured in that identity beyond middle school by teachers, counselors, and parents.

Instrumentation

The instrument used in this study closely aligned to statements from the CUPID survey used by Mahadeo et al. (2020) to determine how students are self-reflecting regarding computing. The CUPID survey was also designed for college students in introductory physics classes and created to extract "demographics, academic background, STEM experiences" as well as towards computing (Mahadeo et al., 2020, p. 6). To support content validity in their study, sample surveys were administered to key stakeholders that included professors and students to elicit feedback and further refine the survey statements. Survey responses had a five point Likert-type scale where zero represented "not at all" and four represented "very much so" (Mahadeo et al., 2020, p. 6).

Adaptation

In this study, the nine statements were used but the language was modified to be more appropriate for middle school students. Table 8 compares the statements from the CUPID survey and the adaptation for this study. Changes to the questions are italicized.

Table 8

Comparison of CUPID Survey and Adaptation for Middle School Students

	CUPID Survey Questions	Adaptation for Middle School
Recognition	My family sees me as a computer savvy person.	My family sees me *as a person who is really good with computers.*
	My friends/classmates see me as a computer savvy person.	My friends/classmates see me *as a person who is really good with computers.*
	My instructors/teachers see me as a computer savvy person.	My teacher sees me *as a person who is really good with computers.*
Interest	Topics in computing excite my curiosity	*I am very curious about topics (social media, websites etc.) about computers.*
	I like to peruse forums, social media, or online videos about computer related topics.	I like to *learn about computing on my own outside of class*.
	Computer programming is interesting to me.	*Software development/coding* is interesting to me.
Performance/ Competence	I can do well on computing tasks (e.g., computer programming and setting up servers)	I do well on computing tasks.
	I understand concepts underlying computer processes.	I understand coding concepts *I am learning in class.*
	Others ask me for help with software (applications/programs)	Others ask me for help in my computer class.
Career	Category not on CUPID survey	I want to take more software development/coding classes in high school.
		I think I would like to pursue a career in software development/coding.

Note: Source for CUPID questions aligned to recognition, interest and performance/competence are from: Mahadeo, J., Hazari, Z., & Potvin, G. (2020). Developing a computing identity framework: Understanding computer science and information technology career choice. *ACM Transactions on Computing Education*. *20*(1). Article 7.

Three studies that informed this study investigated the identity constructs retrospectively by surveying college students (Godwin et al., 2015; Hazari et al., 2010; Mahadeo et al., 2020). In addition to examining the overall computing identity of middle school students, this study also focused on whether a middle school student through self-evaluation would identify as having an interest to pursue computing beyond middle school. Therefore, two additional questions were added about a student's aspirations to take more software development/coding courses in high school and about the possibility of the student pursuing a career in the field. The final survey form had 11 statements instead of 9 as in the Mahadeo et al. study and was administered online. All statements were answered on the same five point Likert-type scale as the CUPID survey (0-4) with the same language associated with 0 and 4, "not at all" and "very much so," respectively (Mahadeo et al., 2020, p. 6).

Students were asked to provide their student identification number so ABC School District could obtain data regarding race and past course enrollment for eighth grade students. The historical course enrollment was necessary to see whether eighth graders had completed the prescribed courses before enrolling in the semester in which the instrument was used. It was the researcher's judgement that relying on student memory to give past course names would risk inaccurate information. Although the researcher understands and respects that students may self-identify their race differently from how their parent or guardian identified their race based on school registration categories, it was not the intent of this research to address that dissonance in identity. Title I status was tracked by the survey form link sent to the student to ensure completed surveys were linked in separate files. However, the survey forms were identical.

Construct Validity and Reliability

The study conducted by Mahadeo et al. (2020) regarding the computing identity framework conducted extensive testing for validity and reliability. To give the context of how the researcher determined construct validity and reliability for this study, it is necessary to understand some of the approach to determining validity and reliability of the model study.

Model Study Validity and Reliability

Mahadeo et al. (2020) used confirmatory factor analysis to measure the validity of each statement in Table 8 and its alignment to each construct: recognition, interest, and performance/ competence. Their sample size was 1,615 students. They established the minimum standardized factor loading to be 0.4 to show validity. While all nine statements/factors measured on their survey exceeded 0.4, seven of the nine statements were above 0.8. This established construct validity, meaning each statement is measuring what it was intended to measure. The two lowest items were statements about exploring computing information through social media or other means, and identifying programing as interesting.

To determine reliability, Mahadeo et al. (2020) used the square of the standardized factor loading and established an acceptable minimum to be 0.5. They found item reliability to be above the acceptable limits for all items except the one exploring computing information through social media or other means. Instead of excluding this item, they made the decision to retain it due to its importance to the rest of the interest construct. The validity of the constructs was also found to be above the acceptable level of minimum of 0.7: recognition=0.9, performance/ competence=.88 and interest=.83 (Mahadeo et al., 2020).

Mahadeo et al. (2020) also used confirmatory factor analysis to examine the measurement invariance for gender and ethnicity. The measurement invariance determined whether the same levels of significance existed for different groups (Cheung & Rensvold, 2002). Based on gender and the two ethnic subgroups included in this study, Black/African-American and Latinx/Hispanic, the level of invariance was significantly less than the threshold set at .01(Mahadeo et al., 2020). This added an additional layer of confidence that the nine statements designed for the Mahadeo et al. (2020) study were reliable and were measuring what they are intended to measure regardless of gender and race.

To add yet another layer of confidence, Cronbach's alpha was also used to measure reliability to establish internal consistency, which "describes the extent to which all the items in a test measure the same concept or construct" (Tavakol & Dennick, 2011, p. 53). All items were above the accepted level of 0.7: recognition=0.9, performance/competence=.88, and interest=.86 (Mahadeo et al., 2020). Based on the combination of the results of each test, the survey form was found to be a reliable instrument to use to measure computing identity.

Middle School Instrument Validity and Reliability

Exploratory Factor Analysis (EFA) was used to assess construct validity of the modified instrument. Given the modifications made to the original instrument for this study, the researcher attempted to reproduce validity evidence as generated through an EFA in the model study for comparison purposes in an effort to evaluate the legitimacy of the modified instrument. In alignment with the model study, .4 will be the minimum to demonstrate validity of each item (Mahadeo et al., 2020).

Data Collection

This section explains the process of identifying the potential sample to create a context for the final sample. Data collection and protection of human subjects are also outlined along with the final results of administering the survey.

School Selection

In the 2021-2022 school year, there were 9,872 computer science seats filled by 8,741 students in 38 middle schools in the ABC School District. How schools offered a combination of computer science courses was a determining factor included in this study, along with balancing the number of schools based on Title I status. For middle schools with sufficient enrollment and teacher capacity, Computer Science Discoveries (CSD) plus App Creators (Pathway 1) was seen as the ideal course sequence. CSD was offered as a three-course sequence, each with enough curriculum for a quarter but students would need an entire semester to complete the course as they would have that class every other day. This was the model most middle schools in ABC School District use to offer electives. These courses were considered progressive and the district recommended students begin CSD I in sixth grade, CSD II in seventh, and CSD III in the eighth grade. Students may enter the sequence at another grade level because of other mitigating circumstances but it was still recommended students follow the sequence. When schools offered App Creators, the recommendation was to offer CSD III in the first semester of eighth grade and App Creator in the second semester. This allowed students to build foundational knowledge about coding before learning application creation. When enrollment would not support the addition of App Creators, ABC School District recommended offering CSD I, II and III (Pathway 2).

A final combination of courses was Computer Science for Innovators and Makers (CSIM) paired with App Creators (Pathway 3). As noted in Chapter 1, both courses were offered before CSD courses were available in 2018 and some schools found this course combination worked best for how they offered electives. Both courses are also a semester long also most likely meeting every other day. Table 9 demonstrates the variety of ways these computer science courses could be offered across all 38 middle schools.

Table 9

Computer Science Course Combinations for 38 Middle Schools in ABC District

CSD I	CSD II	CSD III	CSIM	AppCr	# of Schools
x	x	x		x	7

x	x	x			6
x	x				10
x					2
x	x		x	x	1
x				x	2
x	x			x	2
			x	x	5
			x		1
				x	2

Source: ABC School District course enrollment, 2021-2022 school year.

Although 38 middle schools offered one or more computer science courses, there were too many options for how courses could be offered to build meaningful outcomes. Table 10 shows the three pathways that were most relevant for this study and the corresponding number of schools. These were the 15 middle schools invited to participate in this study.

Table 10

Computer Science Pathways Included in Sample

Pathway	CSD I	CSD II	CSD III	CSIM	AppCr	# of Schools
Pathway 1	x	x	x		x	6
Pathway 2	x	x	x			5
Pathway 3				x	x	4

Source: ABC School District course enrollment, 2021-2022 school year.

Potential Sample

A convenience sample was used based on the researcher’s access to schools due to her role in the district at the time this study began. The researcher intended to conduct this study over one semester, but a low response rate initially made it necessary to extend it another semester. This study took place in the second semester of the 2021-2022 school year and first semester of the following school year. For this reason, and for transparency of the process, the potential sample size is reported in two ways.

The first is to present the potential sample by course as RQ1 examined the comparison of computing identity between courses. As shown in Table 11, a potential sample of 4,429 existed if all teachers chose to participate from all 15 schools. It is also important to note that the small enrollment in the CSIM course was due to the continued shift towards the suite of CSD courses as the primary set of courses for middle school. While having a lower enrollment, including CSIM in the sample to measure computing identity in this course was important.

Table 11

Potential Participants by Middle School Computer Science Course

Semester	CSD I	CSD II	CSD III	CSIM	App Creator
Spring 2022	613	590	544	192	447
Fall 2022	723	669	333	41	277
Total	1,336	1,259	877	233	724

Source: ABC School District course enrollment, 2021/22 & 2022/23 school years.

The potential sample size also needed to be shown in terms of the number of eighth grade students enrolled in one of three courses at the 15 middle schools: CSD III, CSIM, and App Creators. RQ2-6 were designed to understand whether computing identities developed at the same rate for all students based on pathway, race, and Title I status. RQ5 and 6 examined whether a correlation existed between computing identity and a student's interest in computer science beyond middle school.

Table 12 gives the potential sample for the second semester of the 2021-2022 school year of eighth grade students for all 15 schools based on pathway, race, and Title I status. Table 13 shows the potential sample for first semester of 2022-2023 school year, while Table 14 shows the combined potential sample. The researcher was concerned about sample size for the intersection of all three factors. However, the decision was made to pursue this complex association because of the importance of exploring the developing computing identity for these subgroups.

Table 12

Spring 2022 MS Computer Science 8th Grade Potential Participants

Demographic n=675	CSD+App Creators	CSD I, II, III Only	CSIM+App Creators	Total (%)
Title I	117	47	113	277(41.0%)
Non-Title I	253	98	47	398(59.0%)
Black/African American	209	37	83	329(48.7%)
Latinx/Hispanic	116	33	48	197(29.2%)
White	45	75	26	146(21.6%)
Title I Black/African American	70	26	70	---
Non-Title I Black/African American	139	11	13	---
Title I - Latinx/Hispanic	36	16	41	---
Non-Title I Latinx/Hispanic	80	17	7	---
Title I - White	11	5	2	---
Non-Title I - White	34	70	24	---

Source: ABC School District course enrollment, 2021-2022 school year.

The researcher noted that the fall sample in Table 13 had fewer students in some subgroups compared to spring. Also, a school from the spring sample that offered CSIM offered no computer science courses in the fall. While this did call into question the scheduling practices of these schools, this observation was outside the scope of this study.

Table 13

Fall 2022 MS Computer Science 8th Grade Potential Participants

Demographic n=643	CSD+App Creators	CSD I, II, III Only	CSIM+App Creators	Total (%)
Title I	159	110	51	320(52.6%)
Non-Title I	202	53	68	323(47.3%)
Black/African American	196	66	57	319(45.0%)

Latinx/Hispanic	124	53	43	220(29.9%)
White	41	44	19	104(16.9%)
Title I Black/African American	83	60	36	---
Non-Title I Black/African American	113	6	21	---
Title I - Latinx/Hispanic	58	45	15	---
Non-Title I Latinx/Hispanic	66	8	28	---
Title I - White	18	5	0	---
Non-Title I - White	23	39	19	---

Source: ABC School District course enrollment 2022-2023 school year

To capture the full potential sample, Table 14 shows the combination of both spring and fall. The distribution of Title I status and race was determined by the researcher to be balanced enough to provide a large enough pool to provide an adequate sample for RQ2 through 6. As outlined in Table 11, only 233 or 5.2% of students were enrolled in CSIM due to the districts continued movement towards the other two pathways. The researcher expected to see a small potential sample size for those subgroups.

Table 14

Combined MS Computer Science 8th Grade Potential Participants

Demographic n=1,318	CSD+App Creators	CSD I, II, III Only	CSIM+App Creators	Total (%)
Title I	276	157	164	597(45.3%)
Non-Title I	455	151	115	721(54.7%)
Black/African American	405	103	140	648(49.2%)
Latinx/Hispanic	240	86	93	417(31.6%)
White	86	119	45	250(19.0%)
Title I Black/African American	153	86	106	---
Non-Title I Black/African American	252	17	34	---
Title I - Latinx/Hispanic	94	61	56	---
Non-Title I Latinx/Hispanic	146	25	35	---

Title I - White	29	10	2	---
Non-Title I - White	57	109	43	---

Source: ABC School District course enrollment 2022-2023 school year.

Data Collection Process

Parental consent and student assent were given according to the ABC School District's and the University of North Carolina at Charlotte's IRB procedures.

Parental Consent

Research Question 2 through 6 examined computing identity development for eighth graders when controlling for pathway, Title I status, and race. While Title I status was identified by sending two different survey links based on Title I status, further data collection was necessary to identify a student's course history and race. This was necessary only for eighth grade students who participated in the study, however a completed parent consent form was necessary for all students. Student information was collected in accordance with the IRB process for both institutions. A parental consent letter was provided to every student in the class to ensure that all students felt included even though the study centered on only three race identifiers: Black/African American, Latinx/Hispanic, and White.

To further protect student privacy, an envelope was attached to each consent form with instructions to enclose the consent form in the envelope so the teacher would not be aware of whether consent was given. To ensure that parents gave informed consent, their student's identification number was required to extract their race and historical enrollment, and the parent needed to check two boxes 'yes' or 'no.' The first box approved using the student identification number and the second gave approval for their student to answer the survey form. A link to the survey form was provided if a parent wanted to review the survey questions. This link was separate from the link provided to students. Also, the parental consent was provided in Spanish, the predominant non-English language spoken in the schools that participated.

Student Assent

The email sent to students stated the survey form was optional and confidential. The text called for confidentiality from teachers; specifically, that they ensure the student understood they had complete freedom to not take the survey or stop at any time. The last line of the email stated, "If you would like to proceed and answer the eleven statements, please click on the link below." Once students clicked on the survey link, the first question was, "I agree to participating in this survey" with a 'yes' or 'no' option. If a student chose "no", the survey took them to the exit page with a statement thanking them for participating. A copy of the parental consent letter, student assent, and survey are in the Appendices.

To control for bias, the researcher met with teachers before administering the survey form and explained the benefits of collecting unbiased data. While enough information was shared to gain buy-in to support the study, minimal information was shared about developing a computing identity. This meeting took place virtually and towards the middle of the semester. As an additional control, a written script was provided so the invitation for student participation by completion of the parent consent form was introduced and administered in the same way across schools.

As this study was conducted over two semesters in two separate school years, the process differed slightly for survey administration each semester. The data collection process began in April 2022. Figure 4 shows the steps to gain teacher buy-in and support to distribute and collect parental consent forms. Research (Esbensen et al., 2008; Rodgers, 2006) has shown that when teachers collect the consent forms instead of the researcher, the return rate is generally much higher. As the researcher held a position of influence in the district, care was taken to ensure teachers did not feel pressured to participate. To this end, no teacher or student incentives were given to return the parental consent forms. Incentives often have a positive impact on the rate of return (Esbensen et al., 2008).

Figure 3

Teacher and Student Consent Process

Once teachers agreed to participate, each was given a parental consent form kit, which included:

- A script to be read to students before distributing the consent forms
- A poster to remind students to return their parental consent forms
- A poster to remind students to take the survey once it had been sent
- Parent consent forms for each student in the class
- A number of parent consent forms translated into Spanish for these schools.

There were a few teachers in the spring and fall who, once receiving the sample kit, chose not to distribute the forms.

Rate of Return of Parent Consent Form

The total potential sample was 4,429 students (see Table 11). This sample represented 15 middle schools and included 26 computer science teachers. Table 15 gives school and teacher participation. Seven teachers from the spring also participated in the fall. This resulted in 2,986 parental consent forms distributed and total of 432 (14.4%) of the parental consent forms returned. This was well below an average return rate of 81% based on a study conducted by Esbensen et al. (2008). Ninety-six (22.2%) of forms were returned either incomplete or declined participation for their student.

Table 15

Parent Consent Forms Received

				Parent Consent Form		
	Schools Invited to Participate	School Actual Participation	Teachers who Participated	Forms Distributed	Returned with Permission	Returned Incomplete or No Permission
Spring 2022	15	8	17	1,366	n=134	n=56
Fall 2022	14*	9	16	1,620	n=202	n=40
Total	--	--	--	2,986	n=336	n=96

* One school offering CSIM/APP pathway did not offer either course in the fall. The same schools invited to participate in the spring and fall

Spring Survey Administration

The spring survey form was sent three weeks before the end of school. This allowed for the maximum instruction time while also leaving time for teachers to remind students to check their email. The survey form was sent directly to the student's email for those who had been granted permission by their parent. Although the teachers knew to alert the class that the email had been sent, the teacher did not know which students were given consent in each class. They only reminded the entire class to check their email.

Of the 134 students who were sent the survey form, 46 (34.2%) completed the survey form. Two responses had to be removed due to both students being enrolled in a course not covered by this study. One student chose not to participate and was automatically exited out of the survey. This left 43 spring surveys completed. Therefore, the researcher needed to complete another survey cycle in the fall to try to increase the sample.

Fall Survey Administration

The Department of Career & Technical Education had planned to start giving the 11-question survey to all computer science students after this study was completed. With this knowledge, the district and UNC-Charlotte agreed to amend their IRB process to allow teachers to administer the survey form to their entire class. The researcher then included students who had completed their surveys and returned their parent consent forms returned. As with the spring distribution, permission was needed to complete the survey form and use the student identification number. The ability to survey the entire class yielded better results for completed surveys. Of 202 parent consent forms, 141 surveys were completed (69.8%) versus only 34.2% of surveys completed in the spring.

Of the 336 students who were granted permission to complete the survey form, a final sample of 184 (6.2%) students completed the survey form following 2,986 parent consent being distributed. Table 16 details the distribution of surveys completed by course. Sixty-four percent of responses were students enrolled in CSD I and II, 25% were enrolled in CSD III, 10% in App Creators while only 1% were enrolled in CSIM.

Table 16

Surveys Completed by Course

Responses by Course n=184	CSD I n=57	CSD II n=60	CSDIII n=46	CSIM n=2	App Creator n=19

Table 17 shows the sample to answer RQ2 through 6, which is a subset of Table 16. This sample was only eighth grade students, disaggregated by Title I status, race, and pathway. With only 5.2% of students enrolled in CSIM, the sample distribution was not unexpected. The low response rate overall presented a challenge for analysis and is discussed in Chapter 4.

Table 17

Eighth-Grade Participants Disaggregated by Pathway, Title I Status, and Race

Demographic n=67	CSD+App Creators	CSD I, II, III Only	CSIM+App Creators
Title I Black/African American	--	n=6	n=1
Non-Title I Black/African American	n=9	n=1	n=1
Title I - Latinx/Hispanic	--	n=5	--
Non-Title I Latinx/Hispanic	n=4	n=4	n=2
Title I - White	--	n=3	--
Non-Title I - White	n=5	n=22	n=4

Data Management

Students were given a week to provide responses to the items on the survey form. Once all of the responses were completed, a master file was constructed with student identification numbers for those in the eighth grade. This file was sent through a secure process designated by the district. They returned the list through the same process with the student’s race and previous computer science course enrollments for sixth and seventh grades. One student enrolled in two different computer science courses in the eighth grade. The survey form associated with the class closest to the end of the course sequence was included, permitting the most exposure to computer science.

The researcher then created one master file of participants. To randomize and anonymize the participants, the researcher ran a random number generator in *Excel* to assign a number between 1 and 184. Student identification numbers were then deleted from the data file. This completed the data collection and readiness necessary to use *SPSS Statistics* to answer the research questions.

A 184 survey forms were completed. Seven surveys had one value missing for one of the nine items being replicated from the model study. In an effort to keep all 184 participants’ responses in the analysis, the researcher averaged the responses for each item and then replaced the missing value with the calculated average rounded to a whole number.

Data Analysis

This study used descriptive statistics, F-test, and ANOVA to capture a broad understanding of the development of computing identity in middle school students who were taking computer science courses in a sequence. All analysis was completed using *SPSS Statistics*. Because the independent and dependent variables change based on the question or group of questions being asked, this section has been organized by sequence of research questions. Each question will be followed by a null and research hypothesis and a brief description of the data analysis.

RQ1

Question and Hypothesis. RQ1: Do students enrolled in one of the five computer science courses have different average computing identity scores?

$H1_0$: $\mu_{CSD\ I} = \mu_{CSDII} = \mu_{CSDIII}$

$H1_1$: At least one μ is different.

RQ1 Data Analysis. The purpose of RQ1 was to understand whether there was a difference in the development of a computing identity between students who are taking CSD I, II or III. The independent variable was enrollment in one of the three CSD courses. The dependent variable was computing identity. The ANOVA used the F-test to examine the means for significance. The level of significance was set at α=.05. If the level of significance fell below .05, the researcher rejected the null hypothesis (Coladarci & Cobb, 2014; Patten & Newhart, M. 2018). Tukey-Kramer was used post hoc to test for significance between each independent variable.

RQs 2-4

Questions and Hypotheses. Based on eighth grade students who were enrolled in the last course in the sequence and have taken a combination of courses in one of three pathways:

Pathway 1: CSD I, II, III, and App Creator

Pathway 2: CSD I, II and III

Pathway 3: CSIM and App Creators

RQ2: Do students who have taken Pathway 1 have a different average computing identity score than those who have taken Pathways 2 or 3?

$H2_0$: $\mu_{\text{CSD+AppCr}}=\mu_{\text{CSD Only}}=\mu_{\text{CSIM+AppCr}}$

$H2_1$: At least one μ is different.

RQ3: Do Title I students have a different average computing identity than non-Title I students?

$H3_0$: $\mu_{\text{Title I students=Non-Title I Students}}$

$H3_1$: $\mu_{\text{Title I students}}\neq\mu_{\text{Non-Title I Students}}$

RQ4: Do Black/African American and Latinx/Hispanic students have a different average computing identity than White students?

$H4_0$: $\mu_{\text{Black/African American}}=\mu_{\text{Latinx/Hispanic}}=\mu_{\text{White}}$

$H4_1$: At least one μ is different.

RQs 2-4: Data Analysis. In RQ1, the researcher sought to discover whether there was a significant correlation between computing identity all five courses. For RQ2 through 4, a three-way ANOVA measured whether there was a main effect of developing a computing identity when controlling for the pathway a student takes (RQ2), whether there was an interaction based on race (RQ3), or Title I status pathway (RQ4). The ANOVA will use the F- test to examine the means for significance. The level of significance was set at $\alpha = .05$. If the level of significance fell below .05, the researcher rejected the null hypothesis (Coladarci & Cobb, 2014; Patten & Newhart, 2018).

Questions 1-4: Assumptions

Three of the six assumptions necessary for conducting ANOVA analysis were met. First, the dependent variable, computing identity, was a scale score based on multiple Likert items and therefore continuous. Second, for each set of questions regarding career and high school courses (RQ5 for additional high school courses and RQ6 for pursuing career) the independent variable was categorical based on race, Title I status, and the student's computer science pathway. Finally, participants did not cross over into multiple groups for each question (Coladarci & Cobb, 2014). The level of significance was set at $\alpha = .05$.

RQ 5 and 6

Question and Hypothesis

RQ5: Is there an association between a student's plans to enroll in additional software development courses in high school and the strength of a student's computing identity when controlling for, race, Title I status, and pathway?

$H5_0$: There is no association between the strength of a student's computing identity and plans to enroll in additional software development courses in high school.

$H5_1$: There is an association between the strength of a student's computing identity and plans to enroll in additional software development courses in high school.

RQ6: Is there an association between a student's plans to pursue computing as a career and the strength of a student's computing identity when controlling for, race, Title I status, and pathway?

$H6_0$: There is no association between the strength of a student's computing identity and plans to pursue computing as a career.

$H6_1$: There is an association between the strength of a student's computing identity and plans to pursue computing as a career.

RQ 5 and 6: Data Analysis. Research Questions 5 and 6 were also based on eighth grade students who were enrolled in the last course in the pathway and have completed one or more courses in one of three pathways. In both questions, computing identity shifted to the independent variable. The dependent variable for RQ5 was a student's desire to enroll in additional software development courses in high school. The dependent variable for RQ6 was a student's plans to pursue computing as a career. To determine whether race, Title I status, or the pathway a student has taken predicts either a desire to take more computer science courses in high school or pursue a career in software development, ordinal regression analysis was used. Below is the regression equation where β_1=race, β_2 =Title I status, and β_3 =the pathway the student completed by the eighth grade. The level of significance was set at $\alpha = .05$ ($Y = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + c$).

Summary

The purpose of this study was to understand whether middle school students who were enrolled in sequenced computer science courses had developed a strong computing identity by the end of that pathway. The process of collecting and analyzing the data was designed to examine computing identity using multiple factors (i.e., a student's pathway, race, and Title I status). The purpose of studying these three factors was to understand whether there was a difference in whether a student's computing identity varied based on their Title I status or race. These questions gave the researcher foundational knowledge that would inform the next steps in the application of these courses and strengthening the student experience. Chapter 4 discusses the findings.

CHAPTER 4: RESULTS AND DISCUSSION

Validity and Reliability

The model study used Confirmatory Factor Analysis to establish validity and identify the sub-constructs. This study used Exploratory Factor Analysis to attempt to confirm the same results. However, the model study (Mahadeo et al., 2020) had 1,615 participants compared to the 184 participants for this study. A more comparable sample size for this study, could have provided greater degree of confidence in the outputs.

Validity

Exploratory Factor Analysis for this study included examining Kaiser-Meyer-Olin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity. The KMO measure was .845 which was well above the acceptable minimum of .5. Bartlett's was $p < .001$ which demonstrates that the 9 statements did correlate with each other. Also, when examining Communalities in Table 18, eight of the nine statements were found to be just above the minimum of .4 but did not demonstrate a strong correlation.

Table 18

Communalities

Item	Initial	Extraction
Recognition 1	1.00	.480
Recognition 2	1.00	.588
Recognition 3	1.00	.554
Interest 1	1.00	.655
Interest 2	1.00	.416
Interest 3	1.00	.587
Perf/Comp 1	1.00	.551
Perf/Comp 2	1.00	.440
Perf/Comp 3	1.00	.299

Extraction Method: Principal Component Analysis

The last computing identity statement from the model study stated, “Others ask me for help with software,” which was not relevant for middle school students based on what was taught in each course. This was altered to, “Others ask me for help in my computer class,” which may have not been close enough to the original language. There could also be other reasons this did not correlate.

The eigenvalues outlined in Table 19 show that only one factor exists versus three in the model study based on only one component with a total greater than one. While the sample size of this study does not allow for conclusive evidence from the factor analysis, the results did not create concerns for using the instrument with modifications made to the model study statements.

Table 19

Total Variance Explained: Eigenvalues

	Initial Eigen Values			Extractions Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.569	50.767	50.767	4.569	50.767	50.767
2	.989	10.991	61.758			
3	.886	9.846	71.604			
4	.699	7.767	79.370			
5	.566	6.286	85.656			
6	.421	4.677	90.334			
7	.380	4.221	94.555			
8	.261	2.898	97.453			
9	.229	2.547	100.000			

Extraction Method: Principal Component Analysis

Reliability

As with the model study, Cronbach’s alpha was used to measure internal reliability. Using *SPSS Statistics* for analysis, there was a high level of internal reliability. Cronbach’s alpha for the 184 participant responses measured .874, which was above the .7 minimum set for this study and aligned to the model study. This meant there was a high degree of confidence in how students responded to the survey statements within the scale.

Within the analysis for Cronbach's alpha was the *Inter-Item Correlation Matrix*. This matrix measures the correlation between items that would result in the three sub-factors created in the model study. Table 20 does reveal a fairly strong correlation between two items that would have been grouped in the model study. Two statements within recognition show a strong correlation. One and two have a correlation of .617, as well as statement two and three at .643. Within the statements aligned with interest, statement one and three have a strong correlation at .718. Consistent with communalities from the EFA, the third statement in the performance/ competence group shows a lack of correlation with any statements. While there are encouraging results for a few items overall, the correlation is not pronounced enough to create the sub-factors as was done in the model study.

Table 20

Inter-Item Correlation Matrix

Item	Recog 1	Recog 2	Recog 3	Inter 1	Inter 2	Inter 3	Per/Com 1	Per/Com 2	Per/Com 3
Recog 1	1.000	.617	.455	.483	.419	.322	.409	.384	.353
Recog 2		1.000	.643	.492	.350	.452	.459	.381	.487
Recog 3			1.000	.500	.442	.487	.462	.425	.296
Inter 1				1.000	.597	.718	505	.475	.332
Inter 2					1.000	.525	.331	.246	.220
Inter 3						1.000	.560	.461	.297
Per/Com 1							1.000	.603	.400
Per/Com 2								1.000	.273
Per/Com 3									1.000

These findings also align with the conclusion drawn from the Exploratory Factor Analysis: namely, that no sub-factors truly emerge from the analysis of items on the survey form used for this study, though there is some alignment within the first three items as well as within the second three items. A larger sample size would help better define these relationships and create a more comparative analysis to the model study. However, the researcher did not see any results from either analysis that would cause concern that the statements modified from the model study undermined the overall structure of the instrument and intended use, particularly given the aim to assess computing identity, as opposed to one or more sub-constructs of computing identity.

Computing Identity Results

The next section of this chapter explores the results for each research question. The researcher acknowledged that the small sample size most likely impacted the output of the analysis. There was still great value in the process. What was learned from these questions is discussed in Chapter 5.

Comparing Computer Science Exploratory Courses

Research Question 1 asked whether there was a difference in the overall computing identity between all five courses. Computer Science for Innovators and Makers (CSIM) was removed from this analysis due to only having two survey forms completed for this course. Included for analysis in this question were students enrolled in Computer Science Discoveries (CSD) I, II, III, and App Creators. Table 21 details the descriptive statistics associated with all four courses. The Likert-type scale used for each statement on the survey form was zero for “not at all” through four “very much so” (0-4).

Table 21

Computing Identity Descriptive Statistics by Course

Item	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
CSD I	57	2.58	.84	.11	2.36	2.81	.11	4.00
CSD II	60	2.53	.70	.09	2.35	2.71	.89	4.00
CSD III	46	2.35	.81	.12	2.12	2.59	.22	4.00
App Cr	19	2.15	.90	.21	1.71	2.58	.33	4.00
Total	182	2.46	.80	.06	2.35	2.58	.11	4.00

The average computing identity for CSD I (M=2.58, S=.84) was almost a half a point higher than students in App Cr (M=2.15, S=.90), which is recommended as the last course in the sequence. There were no students in App Creators who completed the survey form who had also completed the full recommended course sequence. The researcher also expected to see a higher computing identity average for students in CSD III (*M*=2.35, *S*=.81) than CSD I or II, but the mean was .23 and .18 lower, respectively.

Next, an ANOVA was run using an F-Test with the level of significance set at $p < .05$ to demonstrate level of significance between computing identity based on which course a student was taking. The four courses included were the independent variable, while computing identity was the dependent variable. The findings were that whether a student was enrolled in CSD I, II, III, or App Creators was not statistically significant to their computing identity score, $F(3,178)= 1.94$, $p = .125$. As there was no statistical significance according to which course a student took and their level of computing identity, it was not necessary to run a post-hoc test.

Analysis for Pathway, Title I Status, and Race

Table 22 gives the sample size for each factor. The sample group for pathways and race had to be modified for the analysis, and the rationale is given in the appropriate section below.

Table 22

Sample Size for Pathway, Title I Status, and Race

Factor		Value Label	N
Title I Status	0	Title I	15
	1	Non-Title I	52
Race	0	Black/African American & Latinx/Hispanic	33
	1	White	34
Pathway	0	CSD Pathway	41
	1	App Creator w/0 or 1 + CS Course	26

The analysis of RQ2 through 4 used a subset of completed survey forms from RQ1, focused on eighth grade students. Research Question 2, 3, and 4 used univariate analysis to measure the main effect of the pathways that students were aligned to at their school, Title I status, and race. For questions two, three, and four, the dependent variable was the computing identity. The independent variable was the student's pathway, Title I status, and race, respectively.

Association of Computing Identity and Pathway

Research Question 2 had three pathways associated with it:

Pathway 1 (n=18): CSD I, II, III, and App Creator

Pathway 2 (n=41): CSD I, II and III

Pathway 3 (n=8): CSIM and App Cr

Pathway 2 had the majority of the sample size at 41 students, with 18 who had completed the full pathway. The remaining 23 had taken a combination of CSD I and II but were all enrolled in CSD III when they took the survey. No students aligned to Pathway 1 had completed the pathway; this included 11 students who had taken only App Creators. This fact, combined with having only 8 students aligned to the Pathway 3, led to the decision to shift the comparison.

The common factor between the surveys enrolled in Pathways 1 and 3 was that all students were enrolled in App Creators when they completed the survey. The researcher made the decision to combine Pathways 1 and 3 and rename the variable "App Creators with additional Computer Science Courses". This created a sample of 26 surveys to compare to the 41 students enrolled in Pathway 2. The lack of fidelity in how students were accessing the various pathways was a valuable finding from this question for the researcher.

Table 23 gives the results of the main effect based on pathway. The p-value was .526, well above the acceptable limit of .05. This showed there was no association with the development of the computing identity based on the pathway a student was enrolled in or courses taken. The expectation was there would be such an association between the strength of a computing identity and the pathway a student completed. This was not the case, however.

Table 23

Computing Identity Score & Pathways: Tests Between Subject Effects

Dependent Variable: Computing Identity Score					
Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.265[2]	1	.265	.406	.526
Intercept	320.079	1	320.079	490.008	<.001
Pathway[1]	.265	1	.265	.406	.526
Error	42.459	65	.653		
Total	362.803	67			
Corrected Total	42.724	66			

[1] Pathway means students who align with either the CSD pathway or took App Creator only with possibly another computer science course
[2] R Squared = .006 (Adjusted R Squared = -.009)

Association of Computer Science and Title I Status

Research Question 3 examined the overall computing identity based on Title I status. Table 24 shows the results of the main effect. There were 15 survey forms completed for Title I versus 52 survey forms completed for non-Title I. The output showed p=.226, well above the alpha limit of .05. This finding demonstrates the lack of a strong association between the development of computing identity and whether a student was in a Title I middle school. The expectation was there would be a significant relationship between these variables.

Table 24

Computing Identity Score and Title I Status: Tests Between Subject Effects

Dependent Variable: Computing Identity Score					
Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.959[1]	1	.959	1.492	.226
Intercept	320.079	1	320.079	498.147	<.001
Title I Status	.959	1	.959	1.492	.226
Error	41.765	65	.643		
Total	362.803	67			

Corrected Total	42.724	66

[1] R Squared = .006 (Adjusted R Squared = -.009)

The Association of Computing Identity and Race

Research Question 4 considered overall computing identity based on race, specifically the three racial subgroups that comprise ABC School District: Black/African American, Latinx/Hispanic and White. Of the 67 eighth grade students included in this sample, 18 identified as Black/African American, 15 identified as Latinx/Hispanic, and 34 identified as White. To balance the sample size, the researcher decided to combine the first two groups, bringing the sample size to 33. Table 25 reveals no association between the strength of the overall computing identity and a student's race with $p = .566$, well above the established level of significance of $p < .05$.

Table 25

Computing Identity Score and Race: Tests Between Subject Effects

Dependent Variable: Computing Identity Score

Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.217[1]	1	.217	.333	.566
Intercept	320.079	1	320.079	489.458	<.001
Race	.217	1	.217	.333	.566
Error	42.507	65	.654		
Total	362.803	67			
Corrected Total	42.724	66			

[1] R Squared = .006 (Adjusted R Squared = -.009)

For RQ2 through 4, the null hypothesis is accepted as no significant difference was found between the computing identity based on each factor of pathway, Title I status, and race.

Computing Identity Association with Future Interest in Coding

Research Question 5 and 6 focused on a student's interest in taking more coding classes in high school and pursuing a career in software development, respectively. An ordinal regression analysis was run for each question. The dependent variable for RQ5 was interest in taking more classes in high school and for RQ6 it was interest in pursuing a career in software development. While the first four research questions examined average computing identity, for ease of interpretation, RQ5 and 6 used total computing identity which ranged from 0 (no computing identity) to 36 (the highest level of computing identity) on all nine questions.

To examine students' interest in additional courses and software development careers, pathway, Title I status, race, and total computing score covariates were incorporated into the regression model for both questions. For RQ5, this model represented a 17.7% improvement relative to the intercept-only model ($\chi^2(4)=37.540$, $p<0.001$). For RQ6, this model represented a 16.6% improvement relative to the intercept-only model ($\chi^2(4)=32.865$, $p<0.001$). Additionally, the proportional odds ratio assumption was met for RQ5 and 6, as given by a non-significant result in the test of parallel lines: $\chi^2(12)=8.440$, $p=0.750$ and $\chi^2(12)=11.993$, $p=0.446$, respectively.

Tables 26 and 27 summarize the analyses and show that after controlling for differences in computing identity, there is no relationship between a student's pathway, Title I status, or race and their interest in taking additional coding courses or pursuing a career in software development. For the first outcome, taking an additional coding course, the log-odds estimate for pathway is -0.664 (SE=0.558, Wald=1.148, p=0.234), Title 1 status is 0.124 (SE=0.677, Wald=0.034, p=0.855), and race is 0.404 (SE=0.528, Wald=0.586, p=0.444). All were not significant. In like manner, for the second outcome, pursuing a career in software development, the log-odds estimates for pathway is -0.793 (SE=0.592, Wald=1.794, p=0.180), Title 1 status is -0.146 (SE=0.700, Wald=0.044, p=0.835), and race is -0.663 (SE=0.558, Wald=1.411, p=0.235). These were also all non-significant. However, in Table 26 the log-odds estimate for computing identity is 0.210 (SE=0.041, Wald=26.198, p<0.001), which is significant, and indicates the likelihood of a student rating a higher level of interest in taking an additional coding course is 1.233 times greater for every one-unit increase in computing identity score. In Table 27, a similar result is found. The log-odds estimate for computing identity is 0.207 (SE=0.043, Wald=23.035, p<0.001), also significant, indicates the odds of a student rating a higher level of interest in pursuing a career in software development is 1.230 times greater for every one-unit increase in computing identity score.

Table 26

Interest in Taking Coding Courses in High School: Parameter Estimates

Interest in More Courses In HS		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[@10Future = 0]	1.863	.824	5.116	1	.024	.249	3.478
	[@10Future = 1]	3.832	.921	17.327	1	<.001	2.028	5.636
	[@10Future = 2]	5.082	.994	26.123	1	<.001	3.133	7.031
	[@10Future = 3]	6.732	1.111	36.691	1	<.001	4.554	8.911
Location	Title I	.124	.677	.034	1	.855	-1.202	1.450
	Race	.404	.528	.586	1	.444	-.631	1.440
	Pathway[1]	-.664	.558	1.418	1	.234	-1.758	.429
	Total Comp Identity	.210	.041	26.198	1	<.001	.130	.291

[1.] Pathway means students who align with either the CSD pathway or took App Creator only with possibly another computer science course

Table 27

Interest Software Development/Coding as a Career: *Parameter Estimates*

Interest in Career in Coding		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Threshold	[@11Future = 0]	2.086	.863	5.845	1	.016	.395	3.777
	[@11Future = 1]	4.015	.964	17.337	1	<.001	2.125	5.905
	[@11Future = 2]	5.068	1.027	24.351	1	<.001	3.055	7.080
	[@11Future = 3]	6.347	1.126	31.799	1	<.001	4.141	8.553
Location	Title I	-.146	.700	.044	1	.835	-1.518	1.225
	Race	-.663	.558	1.411	1	.235	-1.756	.431

Pathway[1]	-.793	.592	1.794	1	.180	-1.953	.367
Total Comp Identity	.207	.043	23.035	1	<.001	.122	.291

[1.] Pathway means students who align with either the CSD pathway or took App Creator only with possibly another computer science course

Summary

The studies highlighted in Chapter 2 of this study sought to understand the constructs that build a student’s career identity in science, physics, engineering, and computing (Carlone & Johnson, 2007; Godwin et al., 2015; Hazari et al., 2010; Mahadeo et al., 2020). Central to this study was the research Mahadeo et al. (2020) that introduced a Computing Identity Framework using nine self-reflective statements. By slightly modifying these statements, this study attempted to understand whether middle school students were developing a computing identity when taking exploratory computer science courses.

Due to the small sample size of this study (184 participants versus 1,615 in the model study), the results are largely inconclusive, but not without value. This research opened the door to a process and tool that could prove useful as educators seek to understand the student experience in middle school coding courses. Chapter 5 discusses key findings, implications, recommendations, and suggestions for further research.

CHAPTER 5: FINDINGS, RECOMMENDATIONS, AND CONCLUSIONS

Introduction

This chapter outlines key learnings from this research study and how they can be used to inform educational practitioners and the research community. An overview of the study highlights the overall intent of this study. Next the researcher will describe key findings and one unexpected finding. Following the findings is a discussion of the limitations, implications, and recommendations for future research, and conclusion of this study.

Summary of Research

When this study was conducted, there were two major issues troubling a large urban area in the southeastern region of the United States. The first was the study by Chetty and colleagues (2014) that named this urban area as one of the worst for upward economic mobility for its citizens who were born in poverty. As civic and industry leaders rallied for a call to action to address this finding, a boon was taking place due to the presence of major technology companies to the area. Most of these new or expanded companies struggled to fill their talent needs for software developers (Slalom, 2020).

The large urban school district, called the ABC School District in this study, saw an opportunity to become a part of the solution for the talent pipeline and provide a path to prosperity for graduates who could become employed as software developers. To do this, the district's Department of Career and Technical Education (CTE) quickly broadened exposure to coding to 86% of middle schools by the 2020-2021 school year. An equally aggressive expansion of a high school software development pathway took place in which students could learn multiple coding languages already used in this sector (Burns et al., 2018; Coffey et al., 2020; Hite, 2012). This pathway was added to 15 of 20 comprehensive high school's CTE pathways during the 2020-2021 school year. This included all Title I middle schools and high schools. While the pathway was carefully constructed with advice from the industry, a problem became evident: students were not choosing to enter the software development pathway at the high school level, especially in Title I high schools. The researcher, who worked as the Director of CTE for this district at the time of this study, was struggling to understand why students were not choosing the pathway. The investigator saw an opportunity examine part of this problem by seeking to understand more about the student's own evaluation of their interest and abilities towards computing in middle school, at the end of the sequence of computer science exploratory courses.

This study was modeled after a study that examined computing identity for college students by using a subset of statements from a national survey administered in 2014 to colleges and university (Mahadeo et al., 2020). The study created the possibility that computing identity could be measured through participant self-reflection and correlated to three sub-constructs: recognition, interest, performance/competence (Mahadeo et al., 2020). The purpose of this study was to determine whether middle school students in ABC School District enrolled in computer science courses were developing a computing identity and to what degree they were also identifying an interest in pursuing additional computer science courses in high school and ultimately a career in software development.

This study explored whether computing identity was beginning to develop for middle school students enrolled in computer science exploratory courses by examining several factors. The foundation of this study was whether computing identity differed based on a progression of three courses: Computer Science Discoveries I, II, and III. This research also sought to establish whether the computing identity students developed differed based on the pathway of courses, Title I status, and race. Finally, this study was conducted to understand whether the strength of a student's computing identity correlated to an interest to pursue software development courses in high school and possibly lead to a career in coding.

This was a quantitative and non-experimental study using a sample of convenience conducted in a large urban school district in the southeastern region of the United States. In an attempt to recreate the model study, the nine statements from the 2014 survey were slightly altered to have more appropriate language for middle school students. A cross-section of 15 middle schools from ACB School District were invited to participate in the study based on how they offered a combination of the five-computer science exploratory courses (Computer Science Discoveries I, II, and III, Computer Science for Innovators and Makers, and App Creators).

There was no treatment for this study and no previous exposure for teachers regarding the development of a computing identity. Teachers supported this research through the dissemination and collection of parent consent forms. The researcher asked participants to enclose their parent consent form in an attached envelope to maintain anonymity. This study took place over two semesters, Spring and Fall of 2022.

In the spring, there was a low rate of return (13.9%) for parent consent forms (n=190) out of 1,366 forms distributed. The survey form was then sent directly from the researcher to the students had been given permission, resulting in 43 completed surveys. This prompted a different approach for a fall survey administration. In the fall, the entire class was given the survey form and only the students with a parent consent form were included in the study. Of a potential sample from both semesters (n=4,429), 2,986 parent consent forms were distributed, and 432 students (14.4%) returned their form with a response. Of these 432 returned, 336 had consent for their student to complete the survey form. This resulted in 184 students who completed the survey.

Exploratory Factor Analysis and Cronbach's alpha were used to determine validity and reliability of the instrument, with alpha set at .05. A combination of descriptive statistics and an ANOVA using F-test and univariate tests were used to analyze the research questions. The dependent and independent variable shifted based on the question being answered. Ordinal regression analysis was used to analyze RQ5 and 6, which considered a student's likelihood to have an interest in taking more computing courses in high school and a career in software development.

This study aimed to understand whether students in middle school who had taken sequenced computer science courses developed a strong computing identity by the end of those courses. The model study, with at sample size of 1,615 students, used the *Conceptual Understanding & Physics Identity Development* (CUPID) survey administered to physics students across 22 universities (Mahadeo et al., 2020). While the focus of this study was on a student's overall computing identity, the researcher hoped to have a large enough sample to answer the research questions with confidence. Though the analysis was inconclusive for understanding the development of a computing identity related to pathway, Title I status and race, there are three findings that add to the research regarding middle school students in computer science courses.

Findings

At the time of this study, there was a lack of research regarding student experience in middle school computer science courses. The projected job growth in the region that required some level of computing education was outpacing the talent pipeline being developed (Projection

Central, n.d.; Sargent, 2017). This was a call to action for school districts and state and local governments to offer more computer science courses in the K-12 education continuum (Code.org et al., 2020, 2021, 2022). The purpose of implementing these courses was to clarify who should take computer science courses and expose students to computer science in hopes of helping them identify an interest and talent in this area (Code.org et al., 2022). The findings related to this study open the door to a means to begin to understand how students reflect on their own computing skills and identity.

Adapted Survey Tool

The results of the validity and reliability analysis demonstrated that modifications to the statements did not impact the overall structure of the model study instrument. While the Exploratory Factor Analysis identified only one construct instead of the three identified in the model study, within the analysis there were small consistencies of correlation between two statements within the sub-constructs of ‘recognition’ and ‘interest.’ For the sub-construct of ‘recognition’, the statement, “My family sees me as a person who is really good with computers,” demonstrated some correlation with the statement, “My friends/classmates see me as a person who is really good with computers” (r=.617). Additionally, within ‘recognition’, a slightly stronger correlation existed between the statement, “My friends/classmates see me as a person who is really good with computers.” and “My teacher sees me as a person who is really good with computers.” (r = .643).

Within the three statements aligned to interest in the model study, a moderately strong correlation existed between the modified statements, “I am very curious about topics (social media, websites etc.) about computers” and “Software development/coding is interesting to me” (r =.718). The statements aligned to performance and competence did not show any relationship within the three modified statements. Is it possible that a student knows they are doing well on tasks in class and recognizes that others ask them for help but, in fact, are not at the point of understanding coding concepts? Did middle school students interpret the revised statements the same as students in college? The correlation creates more questions than answers. As students in middle school may just be starting to build skills in computer science, how does that impact their self-perception of their performance and understanding? More research is needed to gain insight into these questions.

Course Sequence and Computing Identity Development

A surprising finding was the lack of growth in computing identity for eighth grade students over the CSD and App Creators sequence. The CSD courses were designed to be exploratory and progressive. The researcher expected to find a stronger development in computing identity from the first to the third course. A potential impact on the analysis was the low number of students, 18 out of 67, who had taken all CSD courses in succession. Most students had completed one or two courses in the CSD sequence, and no student had completed the course sequence that added App Creators. Conclusions based on these findings cannot be confidently made due to the lack of fidelity in completing the intended pathway sequence. The lack of difference in computing identity based on the sequence of the courses likely means that a student with a strong computing identity score had that identity before taking those courses.

Alignment of Computing Identity and Career Interest

The final finding of this research was the strong likelihood that a student with a high computing identity would also likely want to take more computing courses in high school and be interested in a career in software development. The lack of enrollment in the Software Development pathways in high schools, especially Title I high schools, was what interested the researcher to determine how students evaluated their interests for computing while in middle school. Though the last two survey statements were not part of the model study, adding them to the survey tool provided a way to understand the future intent of students concerning software development.

Limitations

The limitations of this research relate to sample size, the lack of students progressing in the prescribed course sequence, and not knowing their out-of-school computing exposure. Each one can be addressed using further research.

Sample Size

There are three possible reasons for a low sample size: how the spring survey form was administered, the lingering impact of COVID-19, and the lack of incentives for returning parent consent forms. This study first invited teachers to participate in the distribution of parent consent forms to students at the end of the 2021-2022 school year. Throughout most of that school year there was a substantial concern of contracting the virus, and necessitated teachers to instruct through masks most of the year and try to keep students socially distanced (NCES, 2022). The high number of teacher vacancies and a lack of substitutes often resulted in a teacher’s planning time being eliminated due to covering a class without a teacher. These were just some of the factors contributing to higher than usual teacher fatigue by the end of the 2021-2022 year (NCES, 2022). This was not an ideal environment to conduct a research project.

There are numerous promising practices that can increase the rate of return for paper consent forms (Esbensen et al., 2008, Rodgers, 2006). Due to the researcher’s position with ABC School District at the time of this study, and concern for ensuring teachers did not feel pressured to participate, none of these practices were used during the parent consent return process. The distance and lack of engagement between the researcher and teachers (other than an occasional reminder email) may have inadvertently decreased the return rate.

The third limitation regarding as to why there was a small sample size is possibly the process of survey administration required for the spring administration. In tandem with the end of a stressful year, and to adhere to the IRB requirements of both institutions, the researcher needed to send the survey directly to the student's school email. While the participating teacher did make an announcement for students to check their email and there was a brightly colored poster to also remind students, teachers did not know who in their class received a survey form to complete. Thus, teachers could not remind students individually to check their email. Of the 134 students who were given permission by their parent to take the survey, only 46 (32.1%) completed it. This left the other 88 surveys undone. An additional 88 responses would have contributed to greater reliability in the analysis. This was adapted for fall and the survey form completion rate was significantly higher (69.8%) based on more consent forms returned that granted permission.

Lack of Fidelity in Course Progression

A limitation and unexpected finding was the lack of adherence to the course sequence with which students had completed one of the designated pathways for this study. Because of the researcher's role as CTE Director at the beginning of this study, there was a high level of confidence that the three pathways identified for study were adopted and implemented correctly at each school. An assumption was made in Chapter 1 that schools invited to participate in the study enrolled students in the courses aligned to their pathway.

This assumption was challenged due to the lack of pathway completion for the 67 eighth grade students who participated in this study. Of those 67 students, 59 should have completed

CSD I, II, and III as a part of two different pathways. However, only 30.5% of students had done so. In addition to the small sample size, this lack of fidelity in a student's experience may have contributed to a lack of significance in the computing identity scores between courses. The researcher acknowledges that this problem of implementation could also be related to the impact of COVID-19. Many master schedules were disrupted for numerous reasons. Students from either spring or the fall sample were in remote learning for a portion of their sixth and seventh grades.

Out-of-School Computing Experiences

Not knowing what contributed to a student's high computing identity was a final limitation of this study. As the results of this study pointed to a promising correlation between a high computing identity and interest in future coding education and career, there were possible influences outside the classroom that might have had a role in developing a strong computing identity. These experiences could have taken place in a variety of ways, including summer camps and after school clubs. To keep the scope of this study focused on computer science courses, the researcher opted not to include questions that would include a student's out of school experiences.

Recommendations

The recommendations from this study are divided into three groups:

- For ABC School District, based on findings and limitations;
- For the education profession that demonstrate how this contributes to the broader narrative of middle school computer science courses;
- For researchers, as to how this study adds to current knowledge compared to the model study.

Recommendations for ABC School District

An implication for ABC School District is that closer examination concerning how well the middle schools offers the CSD sequence to students is needed. Where enrollment was large enough, ABC School District implemented the course series in order to give students time to develop their computing interest and skills as opposed to one course that was an isolated experience. This study shed light on an area where theory and practice appear to be misaligned. As discussed in the limitations, there may be a larger issue of access for students to participate in the full sequence of courses. It is recommended that the district examine how the master schedule supports the course sequence and how students request to enroll in CSD II and III.

In tandem with this step, another recommendation is to discuss with teachers whether they are able to teach the full content of CSD III if students have not had the first two courses. Understanding this will help create the best scheduling practice to ensure students are not unintentionally turned off to computer science simply because they were placed in a class where they did not have the prerequisites. Also, there may be best practices that emerge as a result of this discussion.

Another recommendation concerns having an interest in taking more courses in high school and can shed light on how to build a bridge between the middle school and high school experiences for students with a strong computing identity. In the introduction of this study, the researcher noted that examining whether students are developing a computing identity over time was essential before attempting to answer the larger question of low enrollment in the software development pathway in many high schools, especially Title I schools. While the larger question regarding the intersection of race and Title I status remains unanswered, there is hope that students who identify a strong interest in taking more computer science will, given access, take those courses. The leadership of ABC School District needs to build a master schedule that prioritizes students with this strong interest.

Related to the question of future interest in software development is how to more adequately introduce students who indicated they have an interest in computing as a career to the variety of jobs in the computing industry. The final question in the survey helps identify which students might benefit from a work-based learning experience for the computing industry, as well as building understanding and exposure to various educational pathways in order to qualify for software development or related careers. Through the district's CTE department, a process should be created to match student interest and industry internships.

Finally, ABC School District should continue to use the survey form for all computer science courses in grades 7-12. By analyzing survey results from middle schools and high schools, there is an opportunity to see whether sub-constructs of computing identity are present regardless of grade level or expertise, and learn whether constructs such as self-perception of performance and competence, develop as their skills grow. This feedback on student self-perception of their computing identity can inform teachers how to approach instruction. The researcher suggests not using the language of computing identity as a goal. It only should be leveraged as a way to better understand student experience. Once confidence is gained in accurately defining a student's computing identity, there may be opportunities to do the same in other career areas.

Recommendations for Education Professionals

As the nation continues to develop computer science courses for all levels of education, their impact on students, through their eyes, needs to be understood. While this study was not able to answer all research questions with confidence, it did begin a process of asking the questions. How do students assess their own computing identity? By starting the process to better understand how identity is developed in middle school, instructional stakeholders could use student responses to inform teaching and student experience. For example, if a student identifies an interest in taking more coding courses in high school, they should be assured of access to them. Also, might a student with a strong computing identity who has expressed a marked interest in software development as a career be identified for field trips, speaker series, job shadows, or internships?

The first nine questions of the instrument were analyzed for validity and reliability by the model study. The analysis of the adapted statements for middle school students showed encouraging evidence that they also had were valid and reliable. What needs to be understood is whether the final statements related to how a student perceives their performance and competence is applicable to a middle school student. These statements were originally answered by college students. Is a middle school student who is learning to code able to discern their own level of performance or competence to code?

A suggestion for educators is to begin using these statements to understand the student experience and look more closely at whether the sub-constructs of computing identity are true for middle school, or should a different set of statements be explored. The computing identity framework begins to personalize the experience to the internal dialogue of students. The awareness of that dialogue can help teachers begin to shape future possibilities for their students.

Recommendations for Scholars

When this study was done, there was a gap in research regarding student experience from the perspective of middle school computer science students. The CSD sequence offered in North Carolina provided an opportunity for a longitudinal study about how a computing identity might develop over time. A study with a larger sample size could confirm the results or at least have findings in greater alignment with the model study. There are indications that the revised statements could be used as a reliable way to measure computing identity and career interest as early as middle school.

The most valuable contribution of a research study is sometimes the process used (Patton, 1998). This is true for this study, which created a process for survey administration that could be used by any school district. Flipping the opportunity to learn about computing identity from a retrospective lens to one of examining computing identity from the beginning will help districts understand how students are growing in and responding to computer science. The tool created by adapting the survey tool of the model study creates a snapshot of a student's internal dialogue about computing. A larger sample would further validate the process and instrument.

Finally, a recommendation is made to continue to use the revised computing statements with the two additional questions regarding an interest in continuing to pursue coding classes in high school and a possible career interest in software development/coding. Modifying these statements did not appear to impact the overall structure of the nine statements from the model study. As to the final two questions that were added by the researcher, the strong relationship between a high computing identity and future interest in coding suggests that continuing to include these questions in future studies for students may give added insight about how the student sees their future interest in coding.

Opportunities for Further Research

There are opportunities for further investigation beyond this research. The opportunity to conduct this study in multiple states and districts using the same process and statements could give a much larger sample size. A larger sample allows the opportunity to test for the sub-constructs of the model study. If the sub-constructs can be validated with a larger sample size, it can lead to a better understanding of whether they develop at the same equal rate during middle school. While a pathway sequence for middle school students may be unique to North Carolina, the opportunity to learn how students are internalizing their coding experience by race and Title I status continues to be important enough to shift the narrative to accessing employment pathways that lead to prosperity.

Another potential study would be to use the survey form as a pretest for an introductory course. The format is very short and easy to administer. This could give insight into the level of computing identity a student has before taking the course. It also provides a way to learn whether students had other experiences with coding, perhaps by attending an elementary magnet school with a coding program or some other out-of-school experience.

As stated in the literature review, much of the research for computing education has centered on building teacher capacity. As teachers increase their capacity for coding, an opportunity for further study would be to compare the computing identity of students whose teacher has a high degree of confidence and competence in their instruction, compared to the computing identity development for a teacher new to coding and has little coding experience. This could ensure administrators hire only teachers who will add value to a course.

Finally, there is an opportunity for a mixed methods study that would let a researcher explore how students interpret the modified statements and the Likert-type scale using student interviews. If conducted across middle school and high school, the researcher could learn whether the statements should be modified further or return to those from the model study as students mature in their skills.

Conclusion

This study contributed to the gap in research regarding the experience of middle school students in computing courses. The findings of this study were not as conclusive as had been hoped regarding the importance of a pathway, Title I, or race. As the computer science movement in K-12 continues to advocate for more classes being offered at all grade levels (Code.org et al., 2022), this research begins the dialogue to better understand how students are internalizing computer science and therefore build more opportunities to grow their interest and talent. This study began to tell the story of whether students might begin a computing identity as early as middle school. The survey instrument adapted from the model study opened a door to understand how students process what they have learned and how they perform in computer science courses. By using this tool, is it possible that educators can begin to move beyond instruction to also include how their students experience their own computing identity. The responsibility then becomes to continue to find experiences beyond the classroom to enrich students and support further development.

Education should be about more than delivering content; it also needs to be about how our students interact with that content. How do they self-evaluate what they are doing with the content (i.e., their performance/competence)? Do they have an opportunity to show what they know (recognition)? Most importantly, do we ask our students what is interesting to them (interest)? This has been the purpose of most of the studies highlighted in this study. It is the researcher’s opinion that to bring life into education, we must remember that there are developing people on the other end of instruction who need to be active participants in their education. Those responsible for forming, delivering, or supporting instruction should see this survey tool as an opportunity for dialogue with students about who they see themselves becoming. While this study did not solve the talent pipeline issue for software development, it does show that students are self-aware about their own computing identity. Now, how do we nurture that identity?

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APPENDIX A: PARENT CONSENT FORM

Parent or Legal Guardian Consent for Child/Minor Participation in Research

Title of the Project: Building a Computing Identity: The Role of Middle School Computer Science Courses in Igniting Student Interest to Pursue a Career in Software Development

Principal Investigator: Susan Gann-Carroll, Director of Career & Technical Education, Charlotte-Mecklenburg Schools and Education Leadership Doctoral Student, University of North Carolina Charlotte

Faculty Advisor: Dr. Rebecca Shore, Educational Leadership, University of North Carolina Charlotte

Your child is invited to participate in a research study. Your child's participation in this research study is voluntary. The information provided is to help you decide whether or not to allow your child to participate.

Important Information You Need to Know:

- The purpose of this research study is to better understand whether taking computer science courses during middle school is developing a strong enough computing identity in your child to identify an interest in pursuing a career in software development.

- Participation to this research is voluntary. Your child will complete a short online eleven statement survey at the end of their course to learn about their self-perceptions regarding coding.

- The survey will collect your child's Student ID, which allow the primary investigator to learn about the level of interest in coding for all students, regardless of race and socio-economic status.

- You may review the survey at the following URL: https://forms.gle/k1xaZe3BiLvpfSzM6

- This will be a one-time survey given at towards the end of the semester and will require approximately 5 minutes of your child's time. The survey will be completed during regular class time.

- Total study duration is for the current semester.

- We do not believe that your child will experience any risk from participating in this study. The survey will occur during normal class time. Your child may benefit from reflecting about their own ability to code. This will inform the Department of Career & Technical Education about the overall impact of these courses and where possible additional supports and career exposure may be needed.

- If you are allowing your child to participate in this study and you are interested in learning more about this study, please continue to read below.

- While all students will be taking the survey, only data from students with parental consent forms signed will be used in this study.

- Please read this form and ask any questions you may have before you decide whether to participate in this research study.

Why are we doing this study?
The purpose of this research study is to better understand whether students taking computer science courses during middle school are developing a strong enough computing identity to identify an interest in pursuing a career in software development.

Why is your child being asked to be in this research study?
You are being asked to allow your child to participate in this study because they are enrolled in one of the following computer science courses this semester: Computer Science Discoveries I, II, or III, App Creators or Computer Science for Innovators and Makers.

What will children do in this study?
Your child will complete a short eleven statement survey at the end of their course that includes collecting their Student ID but not their name. You may review the survey at the following URL: https://forms.gle/k1xaZe3BiLvpfSzM6

What benefits might children experience?
Your child may benefit from reflecting about their own ability to code and the possibility of taking more classes in high school or possibly pursuing as a career.

What risks might children experience?
We do not believe that there are any risks to your child because this study will occur as part of routine classroom teaching.

How will information be protected?
Your child's Student ID and name will be stored in a Charlotte-Mecklenburg Schools secure electronic file which can only be accessed by the primary investigator. After the survey responses have been received, the researcher will use your student's ID to access your student's race and computer science course enrollment history. After this is completed, their Student ID and name will be deleted and replaced with a randomized participant number. This separate file will have no student identifiers. The file with all student identifiers will then be stored only on the secure CMS server. The file without student identification will be the only file accessed by the co-investigator.

How will information be used after the study is over?
Per CMS policy, this data will only be used for this study and no future studies.

<u>Will children receive an incentive for taking part in this study?</u>
Your child will not receive any incentive for being in this study.

<u>What if I don't want my child to take part in this study?</u>
By signing this form and checking "no" for one or both items, your child's information and survey responses will not be used for this study.

<u>What are my child's rights if they take part in this study?</u>
Participating in this research is voluntary. Even if you decide to allow your child to be part of the study now, you may change your mind and stop their participation at any time. Even if you agree to let your child participate, your child may choose not to participate at any time.

<u>Who can answer my questions about this study and participant rights?</u>
For questions about this research, you may email Susan Gann-Carroll at sgann5@uncc.edu or call at 704.560.3391. You may also email Dr. Rebecca Shore at rshore6@uncc.edu or call at 704.687.8976.

If you have questions about research participant's rights, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Office of Research Protections and Integrity at 704-687-1871 or uncc-irb@uncc.edu.

<u>Parent or Legally Authorized Representative Consent</u>

Please sign below and check the box Yes or No on both lines to indicate whether you are allowing your child to participate in this study. *Both statements must be marked yes in order for your child to participate.* Make sure you understand what the study is about before you sign. You will receive a copy of this document for your records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I understand what the study is about, and my questions so far have been answered.

________________________________ ________________________________
(PRINT) Student Name **Student ID**

I consent to my child's participation by taking an 11-question survey: _____Yes

_____No

I consent to my child's Student ID being given on the survey: _____Yes

_____No

____ ________________________
(PRINT) Parent/Legally Authorized Representative Name **Relationship to Participant**

____ ____________

Signature of Parent/Legally Authorized Representative Date

____ ____________

Susan Gann-Carroll, Primary Investigator Date

APPENDIX B: TEACHER SCRIPT

Dear Students,

Because you are enrolled in this course, you are invited to participate in a research study through the University of North Carolina at Charlotte. The purpose of this study is to better understand whether students taking computer science courses during middle school are developing a strong enough computing identity to identify an interest in pursuing a career in software development. This is not an assignment but an opportunity to help leaders in Charlotte-Mecklenburg Schools better understand how you are processing what you learn in this course. There are no right or wrong answers and the answers to the survey will be combined with responses from 14 other schools. The only personal information the researcher is collecting will be your Student ID. Using your Student ID, the researcher will access data to identify your race and also find out what computer science courses you took previously in middle school if you are a 7^{th} or 8^{th} grade student. Your name will not be collected and all responses are only seen by the researcher and kept in strict confidence.

Although everyone will take the survey towards the end of the course, only the survey responses where parent consent has been given will be used in the study.

Today, I will be giving you a letter for your parent or guardian to sign to allow your survey responses to be used in the study as well as accessing data to identify your race. Please take this form home and ask your parent or guardian to review and sign. You will put your permission form in this envelope and give it to me. I will not even know whether your parent or guardian gave permission for you to answer the survey. Only the researcher will know. Please return the form as soon as possible.

If there are questions, I will send them to the researcher if I am unable to answer. She will respond and I will pass those answers along to you.

APPENDIX C: STUDENT EMAIL

Dear Student,

This survey is to help the district better understand how taking computing courses in middle school might or might not impact how well students like to code. It includes eleven short statements and should take approximately five minutes to complete. Your participation is not required. Your teacher will not know whether you completed the survey or not. All of your responses will be kept confidential. If you choose to answer the questions, please do so as honestly as possible. You may opt-out at any time by simply closing the survey. Your responses will not be sent until you click submit at the end.

If you would like to proceed and answer the eleven statements, please click on the link below.