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**INVESTIGATING PRE-SERVICE TEACHERS' PERCEPTIONS OF THE VIRGINIA  
COMPUTER SCIENCE STANDARDS OF LEARNING: A QUALITATIVE MULTIPLE  
CASE STUDY**

by

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Old Dominion University in Partial Fulfillment of the  
Requirements for the Degree of

DOCTOR OF PHILOSOPHY

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OLD DOMINION UNIVERSITY  
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## **ABSTRACT**

# **INVESTIGATING PRE-SERVICE TEACHERS' PERCEPTIONS OF THE VIRGINIA COMPUTER SCIENCE STANDARDS OF LEARNING: A QUALITATIVE MULTIPLE CASE STUDY**

Valerie Sledd Taylor  
Old Dominion University  
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Computer science education is being recognized globally as necessary to better prepare students in all grade levels, K-12, for future success. As a result of this focus on computer science education in the United States and around the world, there is an increased demand for highly qualified teachers with content and pedagogical knowledge to successfully support student learning. As a result, there is a call to include and improve the computer science training offered to pre-service teachers in their educator preparation programs from methods courses to practicum and student teaching experiences. Thus, it is important to understand how pre-service teachers view content, classroom practices, and teaching and learning methodologies and theories to inform teacher educators about best practices for integrating computer science.

This multi-case study investigated pre-service teachers' perceived abilities and intent to integrate the Virginia Computer Science Standards of Learning into future content area instruction, as well as any shifts that occurred in these pre-service teachers' perceptions as a result of their student teaching experience. Five elementary pre-service teachers enrolled in a teacher preparation program at a large, public research university in the Mid-Atlantic region of the United States comprised the cases in this research study. Data were collected during the participants' student teaching experience and final semester in their respective programs and was comprised of the following: pre-, mid-, and post-questionnaires, meeting transcriptions (2), semi-

structured individual phone interview transcriptions (2), and written/posted exchanges on an online discussion board. Data representing each case were analyzed using a qualitative general inductive approach as outlined by Thomas. A within-case analysis was performed to develop main categories and identify central themes for each case, and a cross-case analysis was then conducted using the NVivo Qualitative Data Analysis Software. The findings revealed similarities and differences across the cases, as well as perceived challenges and benefits to incorporating computer science and the Virginia Computer Science Standards of Learning into future content area lessons as determined by elementary pre-service teachers. Findings from this study can be used to inform and improve pre-service teacher education as well as provide insight to school administrators.

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This dissertation is dedicated to my family and friends who have supported me throughout this journey. To Ella Grace who makes me want to be a better person, to Steve for his love and support, and to my parents for their unconditional love and guidance. I could not have done this without you. I also dedicate this work to Julia, who is just a phone call away and without whom I could not have completed this process, to Jenny, Sandra, Courtney, and Karen for making me laugh and checking in when needed, to Rick for being “technical support”, and to John and Lois for being cheerleaders throughout the process. Your support and encouragement are greatly appreciated.

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## TABLE OF CONTENTS

	Page
LIST OF TABLES .....	x
LIST OF FIGURES .....	xii
CHAPTER 1 - INTRODUCTION.....	1
Relevant Computer Science Terms.....	5
Problem Statement .....	6
Purpose of the Study .....	11
Theoretical Framework .....	12
Background and Context of Research .....	14
Student Teaching .....	14
The Virginia Computer Science Standards of Learning.....	16
Overview of Methodology.....	17
Significance of Research.....	18
Key Terms and Concepts.....	19
CHAPTER 2 – REVIEW OF LITERATURE.....	22
Theoretical Lens.....	23
Constructivism.....	24
Constructivism in Teaching and Learning.....	25
Constructivism in Teacher Education.....	26
Computer Science.....	29
Computer Science in K-12 Education.....	30
Considerations Regarding Computer Science in Educational Settings.....	31
Pre-Service Teacher Education and Perceptions.....	33
Preparing Teachers to Integrate Computer Science Content.....	35
Teacher Beliefs and Perceptions.....	39
Conclusion.....	42
CHAPTER 3 - METHODOLOGY.....	44
Qualitative Multi-Case Study Research Design.....	44
The Quintain.....	46
Participants.....	47
The Cases.....	49
Jayden.....	50
Bella.....	50
Maggie.....	51
Yudi.....	51
Kim.....	52
Data Sources and Collection.....	53
Data Collection: Phase 1.....	57



Data Sources and Collection: Phase 2.....	61
Protection of Participants.....	62
Data Analysis Procedures.....	62
Cross-Case Analysis.....	64
Validity, Reliability, and Trustworthiness.....	65
Conclusion .....	65
CHAPTER 4 - FINDINGS .....	67
Context.....	67
Westwood Public Schools.....	68
Teacher Population.....	69
Student Access to Digital Technology.....	70
Oceanside Public Schools.....	71
Teacher Population.....	72
Student Access to Digital Technology.....	73
The Cases.....	74
Jayden.....	74
Bella.....	81
Maggie.....	87
Yudi.....	96
Kim.....	104
Conclusion.....	111
CHAPTER 5 – DISCUSSION AND IMPLICATIONS.....	112
Overview of the Study.....	112
Perceived Benefits and Challenges.....	114
Cross-Case Analysis.....	118
Considerations of Time Constraints.....	119
Time for Instruction.....	120
Instruction Challenges linked to Instructional Time.....	121
Time for Training.....	124
Time for Exploration.....	125
Availability of Training.....	126
Training for Pre-Service Teachers.....	127
Training for In-service Teachers.....	132
Training for Students.....	133
Value of Experience.....	135
Experience with Computer Science and the VA CS SOLs.....	135
Experience and Comfort with Technology.....	137
Experience Leading to Teacher Buy-In.....	139
Experience and Impact of the Student Teaching Placement.....	140
Implications.....	143
Support for Student Training and Opportunities to Work with Computer Science.....	143
Professional Development.....	144
Pre-Service Teacher Training.....	145
Limitations.....	147

Future Research.....	149
Conclusion.....	150
References.....	151
Appendices.....	171
Appendix A: Pre-Questionnaire.....	171
Appendix B: Mid-Student Teaching / Mid-Study Questionnaire.....	172
Appendix C: Post-Questionnaire (Google Form).....	173
Appendix D: Meeting Slides and Outlines.....	175
Appendix E: Individual Phone Interview Questions, Phase 1.....	180
Appendix F: Individual Phone Interview Questions, Phase 2.....	181
VITA.....	183

**LIST OF TABLES**

Table	Page
1. Case Descriptions.....	53
2. Data Collected.....	55
3. Membership by Subgroup - Westwood Public Schools.....	69
4. Membership by Subgroup - Oceanside Public Schools.....	72
5. Perceived Benefits to Integrating the VA CS SOLs into Content Area Instruction.....	115
6. Perceived Challenges to Integrating the VA CS SOLs into Content Area Instruction.....	116
7. Breakdown of Themes and Subthemes.....	119

**LIST OF FIGURES**

Figure	Page
1. Example Slide from the First Face-to-Face Meeting with Participants.....	59
2. Sample Post and Response on the Discussion Board .....	60
3. Example of Notes Made from a Participant’s Raw Data.....	63
4. Example of Raw Text and Subsequent Categories Created.....	64
5. Subthemes of Time .....	120
6. Subthemes of Training.....	127
7. Subthemes of Experience.....	135

## CHAPTER I

### INTRODUCTION

Globally, there is a rapid change in skills required to support a more digital and STEM-focused workforce and changing economy. In 2015, the U.S. Bureau of Labor Statistics Growth Forecast suggested that there will be more than half a million new jobs in fields related to computers and math by the year 2024. Similarly, The Computing Technology Industry Association (CompTIA), estimated that there were 700,000 technology-related jobs left unfilled in 2019 (Pfeiffer, 2019; US Bureau of Labor Statistics, 2020). Many employers are organizing problem-solving sessions and providing opportunities for applicants to demonstrate the skills associated with computer science such as computational thinking in lieu of diplomas, transcripts, and traditional interviews (Denning, 2017). Thus, schools also are working to prepare students for future education and careers in a rapidly changing world, and evidence suggests that computer science and computational thinking are becoming part of school K-12 curricula through both core classes and general technology courses on an international scale (Depta, 2015; Leonard, Mitchell, Barnes-Johnson, Unertl, Outka-Hill, Robinson, & Hester-Croff, 2017; Yadav, Hong, & Stephenson, 2016).

Importantly, elementary education is now being included in the focus on computer science integration with standards that include K-5 education being developed in states across the United States. Continued research suggests that students need experiences with computer science as early as possible and topics such as sequencing and debugging are appropriate for students as young as Kindergarten (Fessakis, Gouli, & Mavroudi, 2013). It has been noted that although young students have limited knowledge and experience in computer science, they have positive attitudes toward it and are open to learning new concepts (Krauss & Prottsman, 2017).

Similarly, exposure to hardware, software, and computer science skills in early grades not only encourages enrollment and success in computer science courses in middle and high school but helps boost confidence and prepare students for life in our digitally connected world (Krauss & Prottsman, 2017, Ozturk et al, 2018). As a result of this increased commitment to integrating and expanding computer science in lower grades, campaigns such as “Computer Science for All” focused on making sure students are exposed to computer science and computational thinking skills and concepts (Ladner & Israel, 2016) have been launched in an effort to help all students, regardless of grade level, gain exposure to computer science practices and habits. However, there is a growing need for more highly qualified K-5 teachers who can meet the demands of changing standards and focus of instruction. Unfortunately, many teachers and administrators perceive computer science as technically challenging and even frightening (Yadav et al, 2016a) and often avoid expanding their knowledge in the area. As a result, there is a lack of elementary teachers with the content and pedagogical knowledge to effectively provide instruction in computer science and computational thinking (Ozturk, Dooley, & Welch, 2018).

The heightened attention to computer science and associated computational thinking skills in education necessitates training in both methods and subject matter for those expected to integrate it into curricula. Classroom teachers must have a clear understanding of the content they are expected to teach, as well as knowledge of the tools, pedagogical methods, and practices deemed important for promoting the construction of knowledge in the subject (Ertmer & Ottenbreit-Leftwich, 2010; Leonard et. al., 2017; Schulman, 1986). Although considerable efforts have been made in some countries to train teachers in general computing content and pedagogy, there is an increasing demand for educators with computer science experience (Tucker, Deek, Jones, McCowan, Stephenson, & Verno, 2003; Yadav, et. al., 2016b).

Unfortunately, many in-service and pre-service teachers feel challenged, and often uncomfortable, introducing computer science, digital technology, and the associated skills into instruction in meaningful ways (Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Ottenbreit-Leftwich et., al., 2018; U.S. Department of Education, 2001; Yadav et al, 2016a).

Within the United States, many school systems are beginning to require computer science instruction as part of their curricula (Ozogul, 2018). In 2016, the commonwealth of Virginia became the first state in the United States to include computer science standards as a mandatory part of the curriculum spanning all grade levels (CodeVA, 2020), and teachers are encouraged to integrate computer science standards with other disciplines. Recently, 32 other states have adopted computer science standards in different capacities increasing the number of teachers needed with computer science experience. In turn, pre-service teachers stepping into their practicum classrooms for the first time must not only take on the duties of a full-time teacher, but also be active participants in their own professional growth and construction of knowledge (Darling-Hammond, 1994) to understand and implement the computer science standards, concepts, and skills. While it is noted that novice teachers may be described as digital natives and open to technology use in the classroom (Gao, Wong, Choy, & Wu, 2011; Starkey, 2010), many in-service teachers, regardless of experience, have had to learn the required skills associated with integrating computer science through means other than professional training (Ertmer & Ottenbreit, 2010). Providing pre-service teachers opportunities to consider technology implementation, computational thinking, and computer science during teacher education classes and student teaching may be useful for examining perceptions related to these areas of instruction.

As the need for elementary teachers with computer science experience continues to grow, it is imperative to consider the perceptions of pre-service teachers concerning computer science standards as they will immediately be tasked with integrating them into their content area lessons. Elementary pre-service teachers who perceive computer science, and the associated methods and skills required to participate in computer science, as essential may integrate the concepts into content area lessons more frequently and in different ways than those entering into the classroom with skepticism (Chang & Peterson, 2018). Additionally, a better understanding of pre-service teachers' perceptions of computer science, linked skills like computational thinking, and the VA CS SOLs, will give teacher educators and researchers a better understanding of what should be included and what is missing in teacher education concerning computer science.

Indeed, it has been argued that the practicum is the most powerful influence in pre-service teachers' education (Mule, 2006), and it may be the time in their licensure program where they learn the most about curriculum needs, student needs, and content knowledge (Hill, Ball, & Shiling, 2008; Yadav et al, 2016a). With the emergence of computer science standards in K-12 education, it is now more important than ever to provide pre-service teachers with opportunities during their practicum placement to engage in professional conversations, collaboration, and inquiry focused on refining their understanding of the computer science standards. To provide the learning experiences needed to best support these beginning teachers, teacher educators and school administrators need to collect and understand their perspectives of computer science, computational thinking, and specifically, computer science learning standards, as research suggests that pre-service teacher perceptions are critical for developing personal lenses and awareness of a classroom environment (Tarman, 2012) that may ultimately shape their future identities as teachers.



Pre-service teachers' perceptions about content, learning theories, and teaching methodologies may be greatly influenced by the activities, lessons, and field experiences in which they take part. Recently mandated standards of education in many areas around the world suggest that teachers should be prepared to integrate computer science in their classrooms to help students develop the skills needed to thrive in our technology-driven society (Fluck, Webb, Cox, Angeli, Malyn-Smith, Voogt, & Zagami, 2016), and deciding how to best equip teachers begins with having a clear understanding of their perceptions (Yadav et al., 2016a). Therefore, investigating pre-service teachers' perceptions has the potential to inform educators about best practices for integrating computer science into their teacher preparation programs.

### **Relevant Computer Science Terms**

Computer science, computational thinking, and educational technology are terms often used interchangeably in the field of education although there are some very distinct differences in meaning and application. Computer science can be defined as the study of how we use computing technology to solve human problems. More specifically, it is “the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society” (Tucker et. al, 2003, p. 2). Computer science includes programming, logic, computation, and applications, and builds on concepts related to computer literacy, digital citizenship, information technology, and educational technology (CSTA, 2011; VDOE, 2020). Computational thinking, although often broadly defined in the fields of education and computer science, is a problem-solving approach that yields a solution in a manner similar to that of a computer, through computation or algorithms. Computational thinking practices include decomposition, pattern recognition, abstraction, organizing and analyzing data, and algorithmic processes (Chang & Peterson, 2018; CSTA & ISTE, 2011; VDOE, 2020). Computational

thinking processes and skills are integrated within K-12 computer science standards in many states, including Virginia, and within ISTE's educational technology standards for students (2019), and often discussed by preservice teachers as an important component in education. Educational technology applies aspects of the general use of computers and programs to school subjects and pedagogies (VDOE, 2020). In classrooms today, technology plays a pivotal role that improves student learning in content areas by providing them with opportunities for collaboration and access to resources and tools not available within the classroom walls (Fatimah & Santiana, 2017; Olszewski & Crompton, 2020). For educators, technology can be used to help students have authentic learning experiences through interesting activities and individualized instruction that allows for more effective teaching of all learners (VDOE, 2020). Teachers' perceptions directly influence their teaching practices (Domingo & Garganté, 2016), and understanding the way these concepts and skills are seen by all educators, especially pre-service teachers preparing for their own classrooms, is an important first step to advancing computer science education. "Teachers develop certain characteristic patterns in their instructional practices. These patterns may be manifestations of consciously held beliefs, values, thoughts, decisions, judgments, preferences, experiences, or perceptions that teachers bring to the classroom in addition to their content knowledge" (Harbin & Newton, 2013, p. 539). In areas such as computer science education that are becoming more prominent in schools around the world, understanding the way perceptions and experiences influence how teachers, especially pre-service teachers, interpret and plan for computer science is an important step to providing necessary support and training.

### **Problem Statement**

It is becoming increasingly important for students today to engage in computer science as jobs in a multitude of areas, from finance to design to public policy, require technology-based, 21st-century skills (Ozogul et al, 2018; Smith, 2016). Society's increased dependence on technology has led many countries around the world to incorporate computer science standards across grade levels to help students gain knowledge in areas such as computational thinking and problem solving, coding, and programming (Vickory, 2016; Williams, 2017; Yadav, Mayfield, Zhou, Hambrusch, & Korb, 2014). In the United States, government and educational leaders are taking the necessary steps to make computer science a core requirement spanning grade levels and content areas (Kafai, 2016; Ozogul, 2018; Project Tomorrow, 2014). Relatively, Virginia currently has the highest number of computer science and cybersecurity jobs in the United States (Bakner, 2019) making it extremely important to have highly skilled educators working with students in this area. Yet, the training opportunities, classes, and resources available to help teachers, both in- and pre-service, figure out what these standards mean or how to accomplish them is often lacking from school leaders (Knobel & Kalman, 2016) leaving teachers to come up with their own ideas of what computer science is, why it needs to be part of the elementary curriculum, and what is explicitly outlined in the standards.

The goal of integrating computer science education into existing curricula is to help students better understand how computers work as well as the skills and processes associated with them (CodeVA, 2020; NGSSLS, 2013; VDOE, 2020) such as solving problems, designing systems, and collaborating in teams (Leonard et. al., 2017). Today, classes in science, technology, engineering, and math (STEM) are working to engage students in activities that mimic real-world situations while fostering 21<sup>st</sup>-century skills such as computational thinking and computing (Smith, 2016; Yadav et al., 2014). These concepts are best learned if introduced

during the elementary years (Utting, Cooper, Kölling, Maloney, & Resnick, 2010; Yadav et al., 2014) and result in students with advanced problem-solving and decision-making skills (Flannery, Silverman, Kazakoff, Bers, Bontá, & Resnick, 2013) in upper grades and beyond. Unfortunately, the 2018 State of Computer Science Education Report (CSER) identifies that only 35% of high schools in 24 states in the United States of America offer computer science courses (2018). Even less information is currently available within elementary classrooms where computer science must be integrated into content and not provided as a separate class as it is in high school grades. This indicates the need for a better understanding of how elementary pre-service teachers perceive integrating computer science standards into instruction, as well as their perceived ability to teach these standards in future content-area instruction.

In Virginia, an effort has been made to align computer science standards with those already in place for other content areas (VDOE, 2020), but often teachers are unaware these frameworks exist or have not been given opportunities to collaborate or discuss their take on the standards. Many teachers are left on their own to decipher what these standards mean and determine how they can best be incorporated (Angeli, Voogt, Fluck, Webb, Cox, Malyn-Smith, & Zagami, 2016). Further, an additional level of planning, training, and awareness is required for teachers in the state of Virginia because they are also charged with assessing the computer science standards in a variety of ways, including performance tasks, that allow students to apply their knowledge (VDOE, 2020). The Computer Science Standards of Learning for Virginia document (VDOE, 2020) lists skills and actions that students should take starting in Kindergarten and running through 12th grade. It is increasingly important, given these charges, that researchers and building administrators consider how teachers, and pre-service teachers, perceive these standards, skills, actions, and corresponding assessments.

From a national perspective, many states are working to increase the opportunities available for students in the area of computer science expanding the need to prepare teachers in this area (Ozogul, 2018). However, there are not enough teachers trained in computer science principles and content to meet the demand (Ozogul et. al, 2018), especially in the early grades. To address this need for more highly qualified teachers with computer science knowledge and experience, there is a call for the addition and improvement of the way computer science is introduced to pre-service teachers (Whipp, Eckman, & van den Kieboom, 2005; Yadav et al, 2014) within content area courses. Unless integrated into their teacher licensure programs in either core classes or practical experiences, pre-service teachers may not fully appreciate or understand the computer science concepts students should learn or how to teach and incorporate relevant material into their instruction in a way that benefits all learners. Similarly, teacher attitudes and perceptions that are often formed during student teaching experiences required for licensure play an important role in classroom technology integration (Regan, Evmenova, Sacco, Schwartzer, Chirinos, & Hughes, 2019), a topic that is seen as synonymous with computer science by many. The perceptions surrounding technology integration could be indicative of potential perception-related obstacles for pre-service teachers in computer science integration.

Research indicates there is a direct link between the quality of teacher preparation programs and teacher effectiveness (Darling-Hammond, 2000). A Blue-Ribbon Panel created by The National Council for the Accreditation of Teacher Education (2010) concluded that there are gaps between the ways that teachers are prepared to work with students and what schools truly need. A similar study by The National Council on Teacher Quality (2013) found that educational preparation programs are not preparing future educators adequately to meet the demands of students today. Reasons for this include the manner that student teaching practicums are set up,

minimal occasions for peer collaboration for student teachers, and limited training opportunities provided to on-site mentor teachers (NCATE, 2010), referred to as clinical faculty in this study. Similarly, because the area of computer science is fairly new and not widely included in teacher education programs (Higher Education Act Title II Data, 2018; Ozogul et al, 2018), it is important to consider their perceived ability to teach and incorporate computer science standards in future instruction. Ultimately, pre-service teachers may not fully grasp what is required of them or may have a skewed perception of what the standards say, directly influencing their perceived capabilities to successfully incorporate computer science in content area instruction. This is specifically important to consider in regards to elementary pre-service teachers as research suggests that computer science is integrated into instruction much less during elementary education than in upper grades (Fanscali, Tigani, Isaza, & Cole, 2018).

The addition of computer science standards to public elementary education is the first prominent curricular revision since the addition of physical education (Bakner, 2019). Although teachers are required to implement computer science standards of learning, they are faced with several challenges including isolation, lack of background knowledge in the area, and limited professional development and collaboration opportunities (Yadav, Gretter, Hambrusch, & Sands 2016). Professional development in the area of computer science is currently available to many in-service teachers through programs such as CodeVA or in training opportunities provided through school systems. However, many teacher education programs lack the comprehensive training required for new teachers to incorporate computer science standards into an already packed schedule (Code.org Advocacy Coalition & CSTA, 2018; Gal-Ezer & Stephenson, 2010). Further, many teacher preparation programs lack varied and extensive opportunities for teacher candidates in their clinical experiences to connect with what they have learned with technical

practice, to engage in professional discussion and receive feedback and peer review, or to work with others in similar situations in a professional learning community (NCATE, 2010; NCTQ, 2018) with the goal of improving student and teacher learning. This proposed study seeks to understand how pre-service teachers, when presented with opportunities to consider computer science standards and how they might be integrated into content, perceive these standards and their ability to integrate them into their future content area lessons.

### **Purpose of the Study**

There is a lack of understanding of the interpretations and perceived abilities of elementary pre-service teachers regarding computer science within the classroom. As school systems around the world integrate computer science standards into their curricula, it is increasingly important to provide effective resources and professional development to help them gain exposure to computer science and to understand how pre-service teachers might react to and interpret these standards. Although research in educators' experiences and perceptions with computer science at the elementary level is limited, previous problems have been reported regarding the ability and comfort of teachers, especially those in grades K-5, integrating digital tools, technology, and associated skills (Hutchison & Reinking, 2011). With the addition of new computer science standards and changing demands of skills important to thrive and succeed in a digital world (Depta, 2015; Yadav et al, 2016a), educators, both in-service and pre-service, need to be given the appropriate tools and activities to build computer science knowledge.

Requiring elementary teachers to integrate computer science into their content area lessons is challenging and providing them with the most effective training requires a better understanding of their initial perceptions and experiences (Sentence & Csizmadia, 2017) as this has been found to correlate with interest and participation (Wang, Hong, Ravitz, & Moghadam,

2016). Pre-service teachers need to understand and be confident in their abilities to teach the components of computer science education before they can integrate them into their lessons successfully (Angeli et al., 2016). The purpose of this study is to gain a better understanding of elementary pre-service teachers' perceived ability to incorporate the Virginia Computer Science Standards of Learning into content area instruction, as well as the perceived benefits and challenges to incorporating computer science as a result of their teacher preparation program and student teaching practicum experience. Thus, the research questions guiding this study are:

RQ1) How do elementary pre-service teachers perceive their ability to teach and integrate the Virginia Computer Science Standards of Learning in future content instruction?

RQ2) What shifts, if any, occurred in these pre-service teachers' perceptions in response to their student teaching experience?

### **Theoretical Framework**

The increased demand for computer science education in K-12 classrooms around the world has elevated the need for more teachers familiar with the concepts and pedagogies that have been proven most successful for integration into content area lessons (Ozogul et. al., 2018; Tucker et. al., 2003). Teachers, both in service and pre-service, are now facing new challenges as they navigate understanding and planning for computer science lessons. Elementary teachers, specifically, are faced with integrating computer science skills, concepts, and processes into their already packed classroom curricula to help students engage in critical thinking and problem-solving practices required for middle and high school and beyond. Often, before integration of computer science occurs, educators, especially pre-service teachers, must take on the role of students of computer science before they can effectively teach the content. As such, the learning theory of constructivism that suggests learners actively construct their own knowledge and



meaning from their experiences and reflections of those experiences (Ackermann, 2001; Creswell, 2013, Stake, 1995) applies to teaching and learning computer science. With roots in both philosophy and psychology, constructivism “acknowledges the learner's active role in the personal creation of knowledge, the importance of experience (both individual and social) in this knowledge creation process, and the realization that the knowledge created will vary in its degree of validity as an accurate representation of reality” (Doolittle & Camp, 1999, p.6). Cognitive constructivism, specifically, frames this study as it emphasizes the role of the student to make sense of new information and to construct knowledge within the mind (Kasemsap, 2015).

The theory of cognitive constructivism is based on the work of Jean Piaget (1953) and asserts that learning is a personal process where each person must construct his/her/their own knowledge built on existing beliefs, background, and experiences (Ackermann, 2001; Piaget, 1953; Powell & Kalina, 2009). According to the Berkeley GSI Teaching and Resource Center (2015):

Cognitive constructivism states knowledge is something that is actively constructed by learners based on their existing cognitive structures. Therefore, learning is relative to their stage of cognitive development, and understanding the learner’s existing intellectual framework is central to understanding the learning process. ....Cognitivist teaching methods aim to assist students in assimilating new information to existing knowledge, and enabling them to make the appropriate modifications to their existing intellectual framework to accommodate that information (p.5).

Pre-service teachers completing their student teaching practicum experiences are in a unique situation, acting as both student and teacher. Although it is preferred that pre-service teachers start student teaching with a basic knowledge of the standards they are expected to teach, immersing preservice teachers into an authentic learning experience, such as commanding their own classroom, aids with their construction of knowledge (Meyers & Lester, 2013) elevating their professional competencies. Additionally, elementary pre-service teachers entering the field may not have had exposure to computer science standards or the often-associated learning technologies during their methods courses (Change & Peterson, 2018), and many of their ideas and beliefs regarding computer science standards are formed during their student teaching experience. Thus, this research is grounded in cognitive constructivism to help understand how elementary preservice teachers understand and plan to incorporate the Virginia Computer Science Standards of Learning into their future content area instruction, as well as the perceived benefits and challenges to integrating computer science into their daily lessons as a result of their student teaching experience.

### **Background and Context of Research**

The background and context for this research are situated in two areas: (1) pre-service teachers' student teaching practical experiences, and (2) the recently mandated Virginia Computer Science Standards of Learning.

### **Student Teaching**

The student teaching practicum experience is a key component of teacher preparation programs. Known by different titles, such as the final practicum, internship, or capstone field placement, it is a K-12 classroom-based experience that typically occurs near the end of a student's program. Student teaching provides pre-service teachers with an opportunity to practice

and apply what they have learned in their coursework to a practical setting. Here, student teachers work in a typical classroom setting under the supervision of an experienced classroom teacher who serves as a mentor or guide as teacher candidates take on more responsibility for instruction (NCTQ, 2018; Zeichner, 2010). The opportunity to work in a classroom setting with all the responsibilities of a licensed teacher allows pre-service teachers to apply what they learned during their coursework in a fairly safe setting that supports the construction of new beliefs and knowledge. Pre-service teachers gain field experience teaching while receiving guidance from a practicing classroom educator (Zeichner 2010) as well as a university supervisor assigned to help support and reflect on learning experiences in student teaching. However, because pre-service teachers in their student teaching placement are put in a “sink or swim” scenario removed from their learning cohorts (Darling-Hammond, 1994), cognition results from one’s own experiences and perceptions.

The goal of teacher education programs is to prepare professional educators who have content knowledge, pedagogical skills to support diverse learners, and a commitment to teaching and learning. There is an increasing demand for new strategies to develop and support pre-service teachers’ critical thinking, problem-solving, and communication skills (Instefjord & Munthe, 2017), especially in the areas of computer science and technology that bring together aspects of computer literacy, educational technology, information technology, and digital citizenship (VDOE, 2020). Research indicates that educators need to be introduced to computer science content, computational thinking, and proven strategies to incorporate them into their core content lessons (Yadav et al., 2014; Yadav et al., 2016a; Yadav, Gratter, Good, & McLean, 2017a; Yadav, Stephenson, & Hong, 2017b) starting in their education certification programs. The experience that pre-service teachers get with the integration of computer science skills and

standards is a crucial factor in how they interpret and implement them professionally and for their perceived ability and attitudes regarding use (Instefjord & Munthe, 2017). Modeling by teacher mentors and educators is found to have a significant impact on student teachers' views and practices in their future classrooms (Lunenborg, Korthagen, & Swennen, 2007).

Unfortunately, many current teacher mentors may also be unfamiliar with computer science and the associated skills and practices, much less, successful strategies for incorporating computer science activities and terminology, for example, into their lessons. It is important, then, to understand how pre-service teachers might consider and eventually incorporate computer science into their future classrooms using their own pre-existing knowledge. Thus, the results of this study will add to the growing body of research on elementary pre-service teacher education and professional development practices in computer science.

### **The Virginia Computer Science Standards of Learning**

In 2016, the Virginia General Assembly declared computer science an essential part of the K-12 curriculum (VDOE, 2020). In November of the following year, Virginia became the first state in the country to require computer science in all grades, beginning in the 2020-2021 academic year, when it passed the new Computer Science Standards of Learning (CodeVA, 2020, VDOE, 2020). The associated documents published on the VDOE website state “these standards are intended to provide students with a detailed understanding of the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society” (2020). Questions such as, “What is computer science?” and “What is computational thinking?” are addressed within the written standards, as well as seven computer science practices for students (VDOE, 2020). Each grade, K-12, has individual standards laid out and organized into six strands: Algorithms and

Programming, Computing Systems, Cybersecurity, Data and Analysis, Impacts of Computing, and Networks and the Internet. Unlike some of the other states that have also adopted computer science standards, Virginia added the cybersecurity strand on its own due to the high number of cybersecurity jobs in the state (CodeVA, 2020). To date, there is not a required SOL test for computer science instruction. Due to the nature and recent adoption of the VA CS SOLs, many in-service teachers have yet to receive professional development in the area or include them in their current lesson plans, especially at the elementary level. Similarly, many pre-service teachers finishing their core methods classes required for licensure may not have experience incorporating or planning for the CS SOLs unless exposed to them during student teaching. Thus, this study aims to explore how pre-service teachers think about and plan for computer science in their future lessons, and if at all, pre-service teachers' perceptions of the VA CS SOLs changed while completing student teaching.

### **Overview of Methodology**

This qualitative multiple case study (Stake, 2005) examines how elementary pre-service teachers enrolled in their final student teaching practicum perceive their ability to teach the VA CS SOLs in future content area instruction, and what, if any, shifts in elementary pre-service teachers' perceptions occurred as a result of their student teaching practical experience.

Conducting qualitative research helps explore a phenomenon or explain an experience (Grbich, 2013) while focusing on the processes and participants involved in the phenomena (Bogdan & Biklen, 2007). A multiple case study approach (Stake, 1995, 2005) was chosen because it allows research to be focused on a target phenomenon or "quintain" where distinct but bounded cases are examined using multiple types of data (Mills, Durepos, & Wiebe, 2010). Participants in this study included five cases (Merriam, 1998; Stake, 2005) selected from a purposive convenience

sample (Merriam & Tisdell, 2016) of student teachers working in elementary classrooms. The cases represent pre-service teachers placed in SPED 3<sup>rd</sup> grade, SPED 4<sup>th</sup> -5<sup>th</sup> grades, Kindergarten, 2<sup>nd</sup> grade, and 3<sup>rd</sup> grade, all enrolled in their final student teaching practicum experience in different elementary schools seeking either an undergraduate degree in Elementary Education PK-3 or Special Education: General Curriculum K-12. Inclusionary criteria for participants consist of completed coursework required to start student teaching, a local placement within a school system (within a 20-mile radius), and the ability to attend two scheduled face-to-face meetings outside school hours. The purpose of the face-to-face meetings was to introduce the topics of computer science and computational thinking, relevant terminology, and to allow the students the opportunity to see and discuss the published VA CS SOLs and subsequent curriculum framework provided on the Virginia Department of Education Website. Also, in line with case study research, which relies on multiple sources of evidence for triangulation (Stake, 2005; Yin, 2018), pre, middle, and post questionnaire responses, transcribed individual phone interviews, and recorded and transcribed face-to-face meetings will serve as primary sources of data and will be analyzed using inductive coding (Thomas, 2006) and cross-case analysis to highlight similarities and differences between cases while conveying the most important findings from each (Stake, 2005).

### **Significance of Research**

Much of the responsibility for student success is placed solely on classroom teachers (Vandevoort, Amrein-Beardsley, A., & Berliner, 2004) who influence what students learn and their attitude toward course content. Educators with positive attitudes toward technology and computer science are more likely to incorporate them into daily activities (Instefjord & Munthe, 2017). To better support in-service teachers and gain a firmer grasp on where we must start with

computer science knowledge and skills in teacher preparation programs, educational leaders, pre-service teacher educators, and school administrators need to have a better understanding of the experiences and challenges that are typically faced in a classroom (Yadav, Gretter, Hambrusch, & Sands, 2016). As new skills and standards in areas like computer science are being introduced into curricula around the world, pre-service teachers' perceptions of and perceived ability with the standards should be addressed to ensure they are able to meet the needs of their future students and the school system. Research indicates past problems regarding elementary teachers' comfort and perceived ability, integrating digital tools, technology, and computer science subject-matter (Hutchison & Reinking, 2011; Yadav et al., 2016a). This study provides a better understanding of elementary pre-service teachers' perceptions of computer science standards as well as their perceived ability to incorporate these standards into future instruction. Additionally, this study speaks to the influence of the placement experience and clinical faculty, and the ways in which pre-service teachers understand the benefits and challenges to incorporating computer science content and associated skills and practices, as well as their anticipated integration of the standards, into their future classrooms. Results of this study may prove beneficial to teacher educators and educational researchers by providing insight to improve the teaching and learning of pre-service teachers.

### **Key Terms and Concepts**

**Computational thinking** is defined as a problem-solving approach that yields a solution by identifying an obstacle, analyzing data, determining possible solutions, and applying these practices to other situations (Chang & Peterson, 2018; CSTA & ISTE, 2011; ISTE, 2016; Wing, 2006) and must be included when considering computer science pedagogy (Sentence & Csizmadia, 2016) in any context. Computational thinking can be used across all disciplines to

help solve problems and make connections between what is learned in school and daily life (Google Inc. & Gallup Inc., 2016). For this study, computational thinking is defined as an “approach to solving problems, designing systems and understanding human behavior that draws on concepts fundamental to computing” (Wing, 2008, p. 3717).

**Computer science** may be defined as the study of how we use computing technology to solve human problems. More specifically, it is “the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society” (Tucker et. al, 2006, p. 2).

**Educational technology**, essentially, is when technology – devices, applications, smartboards – are used in educational settings combined with educational theories of both teaching and learning. The goal of including educational technology in content area instruction is to improve academic performance (U.S. Department of Education, 2020a).

A **clinical faculty member**, also referred to as the assigned “mentor teacher” to a student teacher within a placement school, is most often the lead classroom teacher where the student is assigned. The clinical faculty is responsible for supervising and providing guidance, modeling lessons, and offering support and feedback to the pre-service teacher as he/she/they take over the responsibilities of running a classroom. Clinical faculty for the university within this study must meet the following minimum criteria outlined in the Teacher Candidate Internship Handbook (2020) before being assigned a student teacher:

- a. A “continuing contract” licensed teacher
- b. Willing to participate in workshops and meetings held for clinical faculty.
- c. Have a valid, renewable teaching license.
- d. Have a minimum of three years of successful teaching experience.



- e. Willing to accept the responsibilities of the clinical faculty position.
- f. True desire to mentor pre-service teachers.

A **pre-service teacher** is an undergraduate or postgraduate student that is majoring in education (Kennedy-Clark, 2011) and/or pursuing a certification in education. In this study, all participants are pre-service teachers working toward a degree in elementary education.

**Student teaching** is a classroom-based capstone experience that typically occurs near the end of a student's teacher educator program with the intent of bridging the theories, contents, and strategies learned in core classes with classroom practical experience (Washut Heck & Bacharach, 2015).

## **CHAPTER II**

### **REVIEW OF LITERATURE**

In the United States and around the globe, there is pressure to integrate digital technologies and 21<sup>st</sup>-century skills throughout K-12 curricula (Depta, 2015; Yadav et al, 2016a) to better prepare students for a digital world. Currently, there is an influx of technology in every aspect of society, from education to the workforce, that requires students to have an understanding of, and experience in, aspects of computer science and computational thinking (Barr & Stephenson, 2011; Depta, 2015; Yadav et al, 2016a; Yadav et. al, 2016b). Programs to introduce computer science ideas in all grade levels highlight the need for trained teachers with computing experience to meet the growing demand in education (Cuny, 2012; Yadav et al, 2016a). These programs include CS for All, created under the advisement of a steering committee that included the Association of Computing Machinery (ACM), the College Board, the Computer Science Teachers Association (CSTA), and the National Center for Women & Information Technology (NCWIT) and Computing at School (CSforALL, 2019), part of the BCS Academy for computing, that work to provide resources and support to students and educators interested in computer science. Although efforts have been made to train in-service teachers on aspects of digital technologies, computational thinking, and computer science (Depta, 2015; Watson, 2006), a number of researchers have suggested that training in these skills should begin with pre-service teachers (Adler & Kim, 2017; Chang & Peterson, 2018; Chigona, 2015; Kay, 2006; Whipp et al, 2005; Yadav et al, 2014). However, without an understanding of the experiences and perspectives of pre-service teachers regarding computer science, it is challenging to provide them with the necessary supports to integrate it into instruction (Sentence & Csizmadia, 2017; Srikoom, Hanuscin, & Faikhamta, 2017), especially at the elementary level

where computer science instruction is a relatively new subject. Furthermore, because relevant literature suggests that in-service training and school experiences have a profound influence on the way pre-service teachers think about and integrate content (Harbin & Newton, 2013), it is necessary to consider the impacts of required student teaching experiences on the perceived benefits and challenges to integrating new material and standards like the VA CS SOLs. Hence, the purpose of this study is to examine elementary pre-service teachers' understanding of and intent to integrate the Virginia Computer Science Standards of Learning (VA CS SOLs) into future classroom content area instruction, as well as to determine if and how their student teaching experience influenced what they see as benefits and challenges to adding the VA CS SOLs to their lessons. This study is informed by the theory of cognitive constructivism that allows for a focus on the ways individuals learn and actively construct knowledge and meaning through the assimilation of new information to existing ideas (Perry, 1999; Piaget, 1968).

In this chapter, I present a review of literature on pre-service teacher training and student teaching, computer science, and the theories that inform the way we construct knowledge. First, I review the research surrounding cognitive constructivism and beliefs about teaching and learning. Next, I provide an overview of computer science and computer science standards of learning in the contexts of elementary education, teacher training, and perspectives of pre-service teachers. Finally, I present a review of literature on teacher education programs, including student teaching practicum experiences, and pre-service teachers' perspectives on teaching and learning.

### **Theoretical Lens**

This section provides an overview of the constructivist theory with an emphasis on cognitive constructivism. Information is presented on constructivism in teaching and learning in classroom settings as well as teacher education programs.

### **Constructivism**

The theory of constructivism holds that humans apply meaning to information presented to them, thus constructing their own body of knowledge through personal experiences and reflection (Ackermann, 2001; Powell & Kalina, 2009; Solvie & Kloek, 2007; Sutton et al, 1996). Within this context, learners must be active participants in the construction of knowledge instead of recipients of information provided by resources, the environment, and those around them (McLeod, 2019; Sutton et. al, 1996) including teachers and peers. Constructivism is most often thought of in two different categories – social constructivism and cognitive constructivism. Social constructivism, based on the work of Lev Vygotsky, emphasizes learning as a social activity, influenced by language and culture, created through interactions with other people (Dewey, 1938; Vygotsky, 1978). Cognitive constructivism, based on the work of John Piaget and the theoretical basis for this research, suggests that learning is a personal process that occurs in the mind through the inductive discovery and processing of information (Ackermann, 2001; Piaget, 1953; Powell & Kalina, 2009). Cognitive constructivists believe the knowledge created by an individual is directly related to the way they consider and understand information and past experiences (Brau, n.d.).

Within the field of education, cognitive constructivism emphasizes the personal role of each student to construct knowledge within their minds. This occurs when a learner works to make sense of new information by applying existing knowledge and experiences to new information considered, and the continual testing of hypotheses created during this construction

(Brau, n.d.; Kasemsap, 2015). Although social and cognitive constructivism are fundamentally different, both are grounded in the idea that learning is an individual process and no two people have the same understanding or personal connection to the experiences from which it was formed (Ertmer & Ertmer, 1998; Powell & Kalina, 2009; Sutton et al, 1996). This research is grounded in the theory of cognitive constructivism, specifically, as a means to better understand the individual perceptions of elementary pre-service teachers faced with constructing an understanding of what computer science is, what the standards say, the benefits and challenges, and how to best implement the VA CS SOLs in their future content area instruction.

### ***Constructivism in teaching and learning***

Constructivism is often considered one of the most useful theoretical frameworks for teaching and learning because of the opportunities for both cognitive and social scholarship (Powell & Kalina, 2009). In a constructivist learning environment, information is passed or provided to the learner, but understanding and knowledge are created individually through meaningful connections and personal beliefs and points of view (McLeod, 2019; Sutton et al, 1996). This process allows students to build on what they already know through questions and discussion that aid in the personal construction of knowledge. In constructivism, student interest is valued and often students work cooperatively to learn more about the topics that interest them the most resulting in a sense of ownership in their education (McLeod, 2019; Tam, 2000).

It is suggested that for constructivism to be successful in a classroom, teachers need to have an understanding of the theories, pedagogies, strategies, and tools to explicitly explain concepts and allow students to make connections (Powell & Kalina, 2009). Activities and situations must be provided that promote individual learning, that acknowledge the specific needs of each learner, and that support the different ways in which students may view their

learning environments (Fosnot, 2005). According to Piaget (1953), simply providing students with information and expecting them to immediately understand what it means is not realistic. For the construction of knowledge to occur, opportunities for reflection and application must be available. For example, when considering the teaching and learning of computer science, teachers and students must combine the skills they have already acquired through personal and professional experiences, with hardware and software to expand their knowledge in the area. This aligns with constructivist learning where existing skills are combined with sensory data – what they see, hear, and experience, for example - to construct new knowledge and understanding. Similarly, the theory of constructivism places value on students being able to evaluate their own progress (McLeod, 2019), as in this study, to promote reflection on the part of the participants to evaluate their own comfort with integrating computer science standards of learning into elementary classroom environments. Thus, this study uses a cognitive constructivist perspective to better understand the perspectives of pre-service teachers regarding the VA CS SOLs. Specifically, how elementary pre-service teachers who are presented with information, provided with opportunities to both integrate and observe the information in an educational setting such as a classroom, and then given time to reflect on the information, individually understand, consider, and intend to use the information provided – the VA CS SOLs – in practice.

### ***Constructivism in teacher education***

The theory of constructivism posits that people are active seekers of knowledge, learning through discovery and connections to past experiences and information (Nicaise & Barnes, 1996; Piaget, 1954). Teacher education programs, namely elementary licensure programs, support constructivist principles in both theoretical and practical elements to aid in the development of

educational beliefs and dispositions by pre-service teachers. These elements included the exploration and application of interdisciplinary studies, opportunities for collaboration and discussion, problem-solving, and the freedom to create their own learning through reflection on past experiences combined with new ideas and theories found in course work, hands-on activities, and observations (Kauffman, 1996; Vygotsky, 1978).

Indeed, teacher education programs often use authentic tasks and methods that support the construction of knowledge through constructivist processes in content areas courses. Student teaching and field placements, examples of practical experiences found in most teacher education programs, serve as opportunities for students to participate in real-life teaching scenarios and practice problem-solving. Opportunities such as these may change pre-service teachers' initial beliefs and ideas (Nicaise & Barnes, 1996; Tarman, 2012) allowing for personal reflection and the reshaping or construction of knowledge. The benefits of such environments in educational settings on academic and professional growth have been well documented (Fosnot, 2005, Kauffman, 1996; Sutton et al, 1996; Kroll, 2004). Kroll (2004), for example, conducted a case study to better understand how pre-service teachers in a graduate education program develop their ideas about teaching and learning in the context of a course that was taught using constructivist principles. Participants in the study included 20 graduate students in a master's and credential program in early childhood education and teacher preparation, and the advanced seminar course used as the background for this study provided students with opportunities for reflection about their teaching practices and observations during practicum experiences. Results of the study determined, among other findings, that each student showed "growth and development in her ideas about her own learning and the learning of the students with whom she worked, and developed a complex definition of learning, teaching and knowledge construction

grounded in the variety of readings and theoretical perspectives experienced during the semester” (Kroll, 2004, p. 210).

Constructivism can also be seen in pre-service teacher education to help develop the necessary skills to teach in environments that support technology, digital skills, and problem-solving consistent with computer science. Seifert (2017) conducted research in an online learning environment aimed at preparing pre-service teachers to implement and integrate Information and Communication Technology (ICT), including computer hardware, and web 2.0 tools into their future classroom instruction. Although this research emphasized a social constructivist approach to learning, pre-service teachers independently constructed their own knowledge regarding teaching methods, enhancing their sense of ownership of the discourse and information they created. Results of this study support authentic learning opportunities for pre-service teachers, and the researcher suggests both mentoring and practicum experiences to help understand and improve attitudes toward integrating and teaching with technology.

To continue the focus of providing pre-service teachers with successful strategies and opportunities to learn about, and ultimately thrive, as educators, it is necessary to consider their beliefs, ideas, and theories (Ng et al., 2010) regarding content area instruction. Furthermore, it is especially important to gain insight into the ways in which elementary pre-service teachers perceive areas such as computer science that are still being introduced into curricula to determine if they see it as valuable and a topic they will attempt to integrate into future instruction. Thus, this study aims to address the limited focus in past research given to the way elementary pre-service teachers perceive the VA CS SOLs based on their constructed knowledge and beliefs.

The sub-theories above highlight the role of the cognitive constructivist lens used to frame this research. The following sections discuss empirical perspectives related to the core



areas of focus in this study: (a) computer science; (b) pre-service teacher education and perceptions.

### **Computer Science**

Computer science is defined as “the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society” (Tucker et. al, 2006, p. 2). Computer science is no longer seen as an elective for students as it encompasses basic skills needed for all students spanning the grades (Ozogul et al., 2018; Tabesh, 2017; Yadav et al., 2016a) to help them succeed socially and economically (The White House, 2016). Computer science and computer science standards in education, specifically in the Commonwealth of Virginia where this study was conducted, integrate aspects of computer literacy, educational technology, information technology, and digital citizenship (VDOE, 2020). Specifically, seven practices of computer science have been identified as essential for students to be exposed: (a) fostering an inclusive computing culture, (b) collaborating around computing, (c) recognizing and defining computational problems, (d) developing and using abstractions, (e) creating computational artifacts, (f) testing and refining computational artifacts, and (g) communicating about computing (K12 Computer Science, n.d.; VDOE, 2020).

Relatedly, computational thinking, a concept that can be found throughout the VA CS SOLs, is a fundamental skill for everyone, not just for computer scientists that is becoming increasingly important in our technologically driven society (Tabesh, 2017; Wing, 2006). Seymour Papert (1980) first introduced the idea of computational thinking as a way to interact, create, and discover with computers. Today, computational thinking is defined as a way of solving complex problems by breaking them down into smaller, more manageable problems

(Wing, 2006). It combines critical thinking skills with computing skills such as decomposition, pattern recognition, abstraction, and algorithm design, to solve real-world problems (Tabesh, 2017). A recent study on computer science and pre-service teachers in the United States by Campbell and Heller (2019) indicated that only 10% of participants in their study reported having an understanding of computational thinking. As the push to incorporate these skills into K-12 education grows, the need to prepare pre-service teachers to understand and incorporate these concepts in lessons and activities across disciplines increases (Yadav et al., 2017a). Understanding the perceptions and beliefs of pre-service teachers, especially elementary pre-service teachers preparing to integrate computer science and specific computer science learning standards into content area lessons, is the first step to providing the necessary training opportunities.

### **Computer Science in K-12 Education**

It is estimated that there will be 1.4 million coding, engineering, and data mining jobs available by 2020 in the United States (Code.org, 2019). Thus, there is a need for the integration of computer science education in all content areas spanning grades K-12 (Barr & Stephenson, 2011; Yadav et al, 2014) as the associated skills impact daily lessons and activities and prepares students to be successful in future endeavors. Students worldwide are studying coding, computational thinking, decomposition, and algorithms as schools continue to add elements of computer science into their curricula (CSTA & ISTE, 2011; Webb, Davis, Bell, Katz, Reynolds, Chambers, & Syslo, 2017; Yadav et al., 2016a) with the intent on providing students with exposure to 21<sup>st</sup>-century skills (Depta, 2015). Within classrooms, the use of technology can be used in a multitude of ways, from collaboration to communication to mimicking real-world

problems and scenarios, that support social learning and teach computer science and 21<sup>st</sup> century skills (Change & Peterson, 2018; Polly, Allman, Casto, & Norwood, 2017).

Computer science lessons and applications provide students with opportunities for computational thinking and collaboration and can be applied to many subject areas (K12 Computer Science, n.d.). Indeed, these problem-solving and logical thinking skills can generalize to areas such as science, math, reading, and writing (Wing, 2006) and can be developed in a multitude of ways. Educators arguing for the inclusion of computer science in all areas of education highlight the economic, social, and cultural rationale (Webb et al., 2017) of introducing these skills to students as early as primary school and advocate for the use of coding and programming environments that encourage students to use abstractions and other computing mechanisms along with creativity (K12 Computer Science, n.d.). Webb and colleagues examined the way that computer science has been developed as part of the curricula in five different countries including the United Kingdom, New Zealand, Poland, Australia, and Israel to determine common themes and differences in their approaches. One major finding of the review is the emerging consensus that computer science education should start in primary education, as early as five-years-old, and is beneficial for the development of learning, self-esteem, and motivation. This finding by Webb and colleagues is directly connected to the study outlined here that investigates elementary pre-service teachers and their perceptions of computer science and the VA CS SOLS as it specifically outlines benefits to incorporating computer science into elementary school curricula.

### **Considerations Regarding Computer Science in Educational Settings**

There are certain aspects of computer science education that should be considered when planning for activities, lessons, and training, for both teachers and students. First, there is

confusion among those in the field of education about what computer science and computational thinking are (Yadav et al., 2017a, 2017b) and about the best practices for incorporating them into classroom activities (Yadav et al., 2016a; Yadav et al., 2017a). Unfortunately, many teachers are unsure what computer science practices entail, and therefore are not able to promote the skills and processes in their teaching (Adler & Kim, 2018). Adler and Kim (2018) reported on two studies conducted to determine if the use of computational thinking helped pre-service teachers learn science content by helping them learn to tackle challenging puzzles and questions. They also sought to determine if the pre-service teachers then wanted to incorporate these same skills in their future classrooms after becoming more familiar with this approach to problem-solving. After working with a certain coding program and web-based simulations, the pre-service teachers participating demonstrated they effectively learned the material and believed that computational thinking and other computer science strands, such as programming, can be effective in learning core content and useful in engaging students in lessons.

Second, teacher educators need to be provided with the necessary training to successfully incorporate computer science content and pedagogies into their classrooms (Yadav et al., 2014; Yadav et al., 2016a; Yadav et al., 2017b). Educators are being asked to teach specific concepts related to computer science without being introduced, much less properly prepared, to integrate them into instruction, and without being provided with appropriate support and guidance to effectively learn and teach the content (Chang & Peterson, 2018; Yadav et al, 2016b). Research indicates that teacher training is a key factor in the successful implantation of educational technology and computer science (Depta, 2015) and should be provided as either professional development or within teacher preparation programs (Yadav et al., 2016a; Yadav et al., 2017b).

Finally, it is necessary to consider the inconsistencies in computer science education within individual schools, between teachers, and across districts, and the ways in which we train our teachers to handle these situations and present content to students. Differences in the way curriculum and materials are introduced and delivered by classroom teachers combined with bias and stereotypes regarding computer science and knowledge of digital tools keep students who may excel in this area from gaining the digital skills they need (Smith, 2016). Indeed, teacher beliefs and understanding of material may impact their classroom practices (Mansour, 2013) and teachers may be less effective in teaching concepts they do not feel comfortable with (Brighton, 2003) or believe in. Thus, this research aims to gain a better understanding of the ways elementary pre-service teachers understand, plan for, and intend to implement computer science and the VA CS SOLs into content area instruction. Additionally, this study is designed to help understand the perceived challenges and benefits of incorporating the VA CS SOLs into future content area lessons as described by pre-service teachers completing their teacher education program. Results of this study can be used to better inform teacher educators as they plan instruction and activities that support pre-service teachers' construction of knowledge and beliefs about computer science.

### **Pre-Service Teacher Education and Perceptions**

Teacher education is an area of continued inquiry and debate as policymakers and practitioners alike work to ensure that the quality of teacher preparation, assessment of practices, and accountability for programs evolve with educational standards and student needs (Darling-Hammond, 2016). Much research and preparation go into educating pre-service teachers as it involves student beliefs, attitudes, identities, practices, and the transformation of knowledge needed to be successful in the classroom (Chang & Peterson, 2018), and traditional approaches

to teacher education have been criticized for not meeting the needs of pre-service teachers (Korthagen, Loughran, & Russell, 2006). As a result, it is necessary to have a comprehensive understanding of the way pre-service teachers learn as well as the experiences and challenges faced by new and pre-service teachers in their classrooms and student teaching practicum (Sentence & Csizmadia, 2017; Srikoom et. al., 2017; Yadav et. al., 2016a) in order to provide them with necessary and appropriate opportunities to construct knowledge and form concepts and beliefs about teaching and learning.

Teacher preparation programs are most often comprised of two different types of experiences, on-campus coursework and school-based practicum experiences that provide opportunities for students to observe and interact in real classroom situations (Jita, 2018) that allow students the opportunity to learn through the intersection of theory and practice. Research conducted by Naylor, Campbell-Evans, and Maloney (2015) shows us that learning to teach is a complex process that is constantly evolving and most often involves “influences of a personal nature, influences from the context, and influences of a professional nature” (p. 123). Pre-service teachers should be open to engaging with new ideas and practices that often arise from experiences provided during their teacher preparation programs. Unfortunately, other research, such as that conducted by Jita (2018), suggest that students, even within the same program or cohort, may not receive the same opportunities to learn and make connections within their program. This is especially true in areas surrounding educational technology and computer science elevating the need for a better understanding of how experiences, such as student teaching, influence the perceptions of pre-services teachers.

The student teaching practicum is often described as the most informative and beneficial experience in teacher education as it is the time when one brings together the theories, contents,

and strategies learned in core classes (Washut-Heck & Bacharach, 2015). Immersing students in authentic learning experiences, such as student teaching, is noted to increase the problem-solving skills of teacher candidates and aid in the application of pedagogies and content learned in core classes (Meyers & Lester, 2013). Traditionally, student teaching experiences are a time for pre-service teachers to observe lessons, ask questions, and refine their skills and practice under the supervision of a clinical faculty member, also known as a cooperating or mentor teacher. In fact, pre-service teachers may develop their beliefs about teaching and learning methods through their own experiences as students, and that the perceived quality of education that they experienced leads to preconceived notions regarding methods to best reach students (Lortie, 2002), which is often displayed during student teaching. This notion is confirmed in a study conducted by Ozogul, Karlin, and Ottenbreit-Leftwich (2018) that demonstrated the importance of field experiences on the development of pre-service teachers' practical and theoretical knowledge. Their results show a connection between content knowledge created through coursework and practical skills that can only be developed in field experiences (Zeichner, 2010). Unfortunately, due to the availability and limited training of cooperating teachers, the student teaching experience is not the same for all candidates and many complete the experience without being introduced to new content and standards or without receiving necessary feedback or training (Washut-Heck & Bacharach, 2015). This indicates the need for a better understanding of student teacher perceptions regarding training in content areas. This study seeks to contribute to research in student teachers' perceptions by exploring their recognized understanding of and intent to incorporate the computer science standards for elementary educators, as well as what they see as benefits and challenges.

### **Preparing Teachers to Integrate Computer Science Content**

Historically, in the field of education, the use of digital and educational technology for everyday activities, has been confused with content, concepts, and practices associated with computer science (K12cs.org, 2020) that requires a basic knowledge of what computers can do and how they work. In many cases, teachers place students on computers for activities that can be accomplished without the use of technology and believe they are incorporating computer science. Thus, as computer science standards and practices become part of school curricula, it is critical that teacher educators and school administrators consider the role of digital technology in the classroom, how it is introduced to students and within teacher education programs, and as part of computer science and computer science learning standards, to help teachers overcome common misconceptions. With the incorporation of federally mandated standards such as the Common Core State Standards (CCSSI, 2019) and Next Generation Science Standards (2018), it is becoming increasingly important for classroom teachers to have a basic understanding of the practices proven to help students learn to work collaboratively and creatively through the integration of problem-solving and performance tasks. This is specifically outlined in the Virginia Standards of Learning which reads, “Beginning with the elementary school grades and continuing through grade 12, students should develop a foundation of computer science knowledge and learn new approaches to problem-solving that captures the power of computational thinking to become both users and creators of computing technology” (VDOE, 2020).

There is a reciprocal relationship between content and technology that teachers should understand in order to integrate digital skills and tools in meaningful ways (Colwell, Hutchison, & Woodward, 2020; Hutchison & Colwell, 2015;). With the emergence of computer science standards in K-12 education around the world, educators, both in-service and preservice, should



be given the tools they need to incorporate technology while at the same time increasing the digital skills and disciplinary literacy of their students (Davies, 2011; Ertmer & Ottenbreit-Leftwich, 2010). Yet, research suggests that many teacher preparation programs have not adequately trained teacher candidates to incorporate technology and digital tools into their teaching practices (Chang & Peterson, 2018; So & Kim, 2009; Yadav, Stephenson, Hong, 2017) often limiting computer science content beyond basic computer applications.

Effective integration of technology into classroom instruction requires teacher training, access, and technical support (Crompton, 2017) as simply providing the teachers with a heightened awareness without opportunities to practice with the technology is not always enough to create a change in perspectives or pedagogy. Classroom teachers need to understand not only how to use these technologies, but also the best practices for integration to help enhance lessons (Seifert, 2017) and meet specific standards. Most teachers, however, are not familiar with the methods associated with building these skills within their students (Chang & Peterson, 2018), and research indicates past problems regarding the ability and comfort, especially teachers in grades K-5, integrating digital tools, technology, and computing subject matter (Hutchison & Reinking, 2011; Yadav et al., 2016a). Mouza and colleagues (2017), for example, studied the design of an educational technology course with the focus of incorporating computational thinking in K-8 classrooms offered in a teacher education program as this problem-solving process is linked with computer science and has been identified and integrated into learning standards and curricula. Findings indicated that teachers left the class with a better understanding of computer science-related concepts, practices, and dispositions but still faced challenges regarding their comfort level and self-efficacy. Similarly, research conducted by Johnson, Jacovina, Russell, and Soto (2016) showed that internal challenges to integrating educational

technologies into classrooms, such as teacher attitudes and beliefs that contribute to confidence in skills and knowledge, often influence the amount of technology included in content lessons. The present study addresses the need for continued research in the areas of pre-service teacher education and computer science as indicated by Mouza and colleagues (2017) and Johnson and colleagues (2016) by examining the perceptions of pre-service teachers concerning how they understand, plan for, and intend to integrate computer science and the VA CS SOLs, in addition to perceived comfort level and identified challenges and benefits, as a result of both coursework and student teaching experiences.

Further, it is recommended that pre-service teachers not only learn about educational technologies and Web 2.0 tools available, but also have authentic opportunities to practice with and plan for computational thinking and computing skills (Chang & Peterson, 2018) as they are fundamentally connected and often improved by having a better understanding of the other (k23cs.org, n.d.). Further, researchers have suggested that it would be most beneficial for pre-service teachers to begin their careers already understanding different ways to integrate computer science and computational thinking across content areas (Barr & Stephenson, 2011; Chang & Peterson, 2018; Yadav et al., 2014) and to provide experiences that help them understand misconceptions about computer science (Duncan, Bell, & Atlas, 2017). Recent research stresses the importance of integrating computer science and computational thinking skills and experiences into methods courses to help pre-service teachers develop the necessary understanding to use and apply these skills in future work (Yadav et al., 2017b). Yadav and colleagues (2014) conducted a study in which they developed modules on computational thinking to help increase understanding in pre-service teachers and impact attitudes toward implementing it in classrooms. Results of this study support the integration of authentic

experiences in computational thinking pedagogies and content development to increase understanding and affect attitudes toward implementing these and other computer science-related skills and processes.

Similarly, it has been argued that for pre-service teachers to develop the competencies needed to translate computer science concepts and related skills to students in multiple subject areas, courses must be adapted to help teachers develop their own professional understanding (Chang & Peterson, 2018; Yadav et al, 2017a, 2017b) of the practices and concepts. This is especially important to consider as it has been noted that as one's understanding of computational thinking develops, one's interest and attitude toward computer science improves (Scharber, Peterson, Chang, Barksdale, Sivaraj, Constantine, & Englund, 2019). Chang and Peterson (2018), for example, conducted research using two separate course designs in educational technology to determine how pre-service teachers perceive and plan for computational thinking within K-12 education. Despite the course design provided to the students, researchers determined that pre-service teachers have several misconceptions about computational thinking, as both a problem-solving process and an aspect of computer science, before being provided with learning opportunities focused on the topic (Chang & Peterson, 2018). The current research project aims to address these misconceptions by considering both how and why elementary pre-service teachers understand computer science and the VA CS SOLs, and how, if at all, authentic learning opportunities influence their understanding and perceived challenges and benefits.

### **Teacher Beliefs and Perceptions**

Considering teacher beliefs about instruction and student learning may influence changes and improvements in pre-service teacher education. Ng and colleagues (2010), for example,

tracked the beliefs and perceptions of 37 pre-service teachers over a 30-week period to determine if their perceptions about teaching and learning were influenced by their student teaching experiences. Data from this study shows evolving beliefs about teaching and learning as a result of practicum experiences and opportunities to construct knowledge through authentic learning and reflection, as in this current research project. Similarly, Dağ et al. (2019), investigated the use of active learning environments that support authentic learning experiences on pre-service teacher perceptions and experiences for learning. Results of the study indicate positive learning experiences for the participants that support cognitive awareness, individual responsibility for learning, and active participation in their own education. Because pre-service teachers often teach using the same methods they experienced as students (Yildirim, 2000), pre-service teacher education programs should design and implement learning activities that enhance pre-service teachers' perspectives on content and pedagogy while supporting the construction of knowledge. This includes the use of technology and computer science, as well as standards of learning that will need to be included in future content area lessons.

Furthermore, understanding the perceptions of teachers in regard to content area information and standards of learning is an important first step to understanding how, if at all, they plan to incorporate and introduce the information into daily content area lessons, as well as the challenges and benefits they see to including specific information (Sentence & Csizmadia, 2017). This understanding is especially important when considering newer areas of education, such as computer science, that are being incorporated into curricula around the world resulting in a change in both practice and subject knowledge for educators. In an effort to prepare teachers to integrate computer science, Sentence and Csizmadia (2017) conducted a study to determine how computing teachers in the United Kingdom recommend teaching computer science, as well as

challenges they face. Results of a study that surveyed 339 computing teachers spanning grades K-12 show both intrinsic and extrinsic challenges to introducing computer science, with many of the intrinsic challenges resulting from personal beliefs and perspectives about subject knowledge and pedagogy related to incorporating technology, computational thinking, and computer science into already full classroom curricula. At the school level, understanding these challenges may help the administration plan for and address items such as support and professional development provided to teachers. For teacher educators, having a better understanding of the challenges faced by in-service teachers may inform the information and training provided to pre-service teachers preparing for future content area instruction.

Finally, it is critical to examine the perceptions of elementary teachers, specifically, as they are tasked with providing both disciplinary instruction as well as developmental and age-appropriate activities for children that can shape their views of different content areas for years to come. Technology, a critical component of computer science, has proven to be an area that many teachers are hesitant to incorporate into content area instruction (Ertmer, 2005) at any grade level. However, elementary pre-service teachers are now tasked with incorporating it into all content areas in their future classrooms and research shows it is important to understand pre-service teachers' knowledge and use of technology for instruction as well as with their own use to help policymakers and teacher educators shape instruction (Rehmat & Bailey, 2014; Tezci, 2011). One such research study by Rehmat and Bailey (2014) was conducted to better understand elementary pre-service teachers' beliefs and attitudes toward incorporating technology into science lessons. Data collected from this study shows that pre-service teachers' intent to use technology in the classroom is directly influenced by their knowledge and beliefs, and those perceptions and beliefs can be changed through technology-enriched activities

provided within university methods courses. Thus, understanding what pre-service teachers think about technology, computer science standards of learning, and associated computer science concepts and skills in elementary classrooms may provide insight into how, if at all, it is used to enhance student learning and provide a window for teacher educators into the needs of their students. This current study aims to further this line of research by providing insight into elementary pre-service teachers' perceptions of computer science, the VA CS SOLs, and any perceived challenges and benefits to incorporating them into content areas instruction.

### **Conclusion**

As this chapter outlines, it is important to gain a better understanding of the experiences and perspectives of elementary pre-service teachers regarding computer science and the associated skills and terminology in order to provide them with the necessary supports to successfully integrate it into content area instruction (Sentence & Csizmadia, 2017; Srikoorn, et al., 2017). With the increased emphasis on computing expectations in education and helping students understand computer science concepts and skills in several countries around the world (Mouza et al., 2017), it is necessary to provide pre-service teachers with access to hands-on experiences to facilitate learning, especially in the areas of computer science and computational thinking (Ertmer & Ottenbreit-Leftwich, 2010) starting in elementary grades. Having insight into the ways that elementary pre-service teachers understand and perceive computer science, consider the benefits and challenges, and intend to incorporate them into content area lessons, is the first step to providing them with these meaningful learning experiences. Additionally, with the introduction of the VA CS SOLs into school curricula, it is necessary to determine what, how, and where elementary pre-service teachers see computer science fitting into content area lessons, as well as their perceived ability to teach the content successfully. Thus, the purpose of

this study is to examine elementary pre-service teachers' understanding of, ability to teach, and intent to integrate computer science, computational thinking, and the VA CS SOLs into future classroom content, and what effect, if any, their student teaching experience has on the way they view computer science in elementary education. Hence, the research questions guiding this study are:

RQ1) How do elementary pre-service teachers perceive their ability to teach and integrate the Virginia Computer Science Standards of Learning in future content instruction?

RQ2) What shifts, if any, occurred in these pre-service teachers' perceptions in response to their student teaching experience?

The method of study used to address these questions through research will be the focus of Chapter 3.

## **CHAPTER III**

### **METHODOLOGY**

This qualitative multiple case study (Stake, 2005) examined the way elementary pre-service teachers perceive their ability to teach and integrate the VS CS SOLs in future classroom instruction. Additionally, the researcher sought to determine what, if any, shift occurred in their understanding of and intent to implement computer science into future classrooms as a result of their student teaching experiences. The research questions guiding this study are as follows:

RQ1) How do elementary pre-service teachers perceive their ability to teach and integrate the Virginia Computer Science Standards of Learning in future content instruction?

RQ2) What shifts, if any, occurred in these pre-service teachers' perceptions in response to their student teaching experience?

#### **Qualitative Multi-Case Study Research Design**

Qualitative research is often used to examine the beliefs, experiences, and attitudes of a certain group of people or to help better understand a problem or topic from the perspective of those involved (Denzin & Lincoln, 2008; Merriam & Tisdell, 2016; Pathak et al., 2013). With the current global need for elementary teachers with computer science experience, there is a need for researchers, school administrators, and teacher educators to consider the perceptions of pre-service teachers concerning computer science standards to best prepare them to enter the classroom, as well as to provide them with continuing professional development in the area during their first years in the classroom. This qualitative study employed a multiple case research design (Stake, 2005) investigating the perceived ability of elementary pre-service teachers to incorporate the Virginia Computer Science Standards of Learning into content area instruction,



as well as their perceived benefits and challenges to incorporating computer science as a result of their teacher preparation program and student teaching practicum experience.

Qualitative case study research, according to Stake (1995), is a “study of the particularity and complexity of a single case, coming to understand its activity within important circumstances” (p. xi) such as the preparation of new teachers or the adoption of new standards of learning. Simmons (2009) elaborates on this and suggests a benefit to case study research is that it can “document multiple perspectives, explore contested viewpoints, demonstrate the influence of key actors and interactions between them in telling a story of the programme or policy in action. It can explain how and why things happened” (p. 23). This qualitative study focused on understanding how and why pre-service teachers perceive the VA CS SOLs, aims to explore multiple perspectives from a specific group of people to inform teacher training in the area. By looking at multiple cases within the bounded system, I was able to identify any variations and similarities across the cases. The benefits to this include enhanced external validity and a more compelling and robust interpretation of the results (Merriam, 1998). Within this study, five specific cases are considered, representing multiple perspectives and views, allowing me to better understand commonalities and discrepancies between the perceptions of, and intended integration of, the computer science standards and associated skills.

Stake’s (1995) approach to multiple case study research was selected for this study. First, this approach aligns with the theoretical framework that this study is situated in about the development of beliefs and construction of knowledge (Merriam, 1998; Stake, 1995). Next, this study utilizes multiple data sources such as observations, interviews, and other documents to gather data from each distinct case within the phenomenon (Mills, Durepos, & Wiebe, 2010; Stake, 1995). To best understand the perceptions of pre-service teachers, I collected a variety of

data including phone interviews, pre- and post-questionnaires, and individual phone interviews. More information on the data collection procedure follows. Finally, this study meets the criteria for case study research as described by Merriam (2009) that states a case study is an “in-depth description and analysis of a bounded system” (p. 40) and is supported by Stakes (1995) definition of a case as “an integrated system” which “has a boundary and working parts” and is purposive (in social sciences and human services) (p. 2). Thus, this multiple case study was designed to focus on what Stake (2006) calls a “quintain”, “an object or phenomenon or condition to be studied—a target, but not a bull’s eye. In a multicase study, it is the target collection” (p.5). Within this research, individual cases were analyzed to allow for an in-depth investigation into the perceptions of five pre-service teachers faced with implementing the VA CS SOLs into future content area instruction. I then looked across all cases to determine the similarities and differences between cases to help better understand the target phenomenon.

### **The Quintain**

A multiple case study design was chosen for this research. Multiple case studies entail “a special effort to examine something having lots of cases, parts, or members...to understand better how this whole...[or] ‘quintain,’ operates in different situations. The unique life of the case is interesting for what it can reveal about the quintain” (Stake, 2006, p. vi). The quintain, or “object or phenomenon or condition to be studied” (Stake, 2006, p.6), in this research is that of the perceptions of elementary pre-service teachers, completing their student teaching practicum, in regard their ability to incorporate, as well as the benefits and challenges of incorporating, the VA CS SOLs into their future content area instruction. The cases in this multiple case study were chosen because they are categorically bound, share a common thread, and allow different aspects of the quintain to be considered.

To obtain a clear understanding of the quintain, or perceptions of the pre-service teachers, many different data points were considered. Participants were asked about prior knowledge of computer science in general, associated skills, and any training for incorporating computer science into content areas offered within their education programs that may impact their perceptions. Further, participants were encouraged to express their opinions about the necessity, benefits, and challenges to incorporating computer science and the VA CS SOLs into elementary school curricula. To enhance understanding of participants' perceptions of teacher use and support in schools for integrating the VA CS SOLs into content areas, participants reflected on their student teaching placement, how often (if at all) their assigned clinical faculty member and other faculty and staff in their placement school used computer science, and if they felt as though the VA CS SOLs were valued and supported by the school administration. By examining all of these parts on a separate case by case basis, I was able to look across cases for themes that accurately represent the quintain. I elaborate on these themes in Chapters 4 and 5.

### **Participants**

This multiple case study was set in a large, public research university in the Mid-Atlantic region of the U.S. The university offers programs in both undergraduate and graduate teacher education and across a variety of endorsement areas with the purpose of preparing future educators with the content knowledge, pedagogical knowledge, and dispositions that reflect a commitment to both the field and lifelong learning. All pre-service teachers graduating from the university and applying for a state teaching license must complete a student teaching internship, traditionally in a 14-week placement in a local school district, as a culminating experience. University students participating in the student teaching internship must have completed all

coursework as listed in the curriculum and met or exceeded the GPA and grade requirements of their program of study.

I engaged in purposive convenience sampling (Merriam & Tisdell, 2016) and invited 10 groups of elementary pre-service teachers completing their final semester of student teaching to participate in the study. Participants were selected through purposeful sampling to ensure information rich-cases, or “those from which one can learn a great deal about issues of central importance to the purpose of the inquiry, thus the term *purposeful sampling*” (Patton, 2015, p.53). Qualities I was looking for in the cases included a demonstrated or verbal commitment to their education and that of their future students, a willingness or desire to consider computer science education at the elementary level, and enrollment in the full 14-week student teaching experience. Additional requirements for the cases included placement in a local PreK-5 classroom within a school or district that expressed, in some way, a commitment to the inclusion of computer science and/or educational technology, as well as the completion of all education methods courses at the university supporting the research. The use of purposive convenience sampling allowed me to identify and select cases that could provide the most useful information to obtain a comprehensive understanding of the quintain out of a limited number of easily accessible participants (Patton, 2002). The invited groups, consisting of anywhere from 2-6 elementary pre-service teachers, were previously assigned by the university’s Office of Clinical Experiences in charge of both placing student teachers in school systems and assigning university supervisors. Within this setting, university supervisors are responsible for holding seminar meetings for their groups outside of student teaching hours to answer questions and discuss current topics in education, in addition to observing them in the student teaching classroom placements and providing feedback and suggestions. Because I needed to meet with

the participants during two of their scheduled seminar meetings to introduce computer science and computational thinking concepts and provide background on the VA CS SOLs, initial contact with the pre-service teachers had to be made through their university supervisors. In response to personal emails and phone discussions with the university supervisors, four groups - 12 pre-service teachers – initially agreed to participate in the study. After two brief introductory meetings with each group to introduce the study more thoroughly, sign consent forms, and collect initial data via pre-questionnaires, ten participants agreed to continue. More information on the meetings and questionnaires can be found under “Data Collection”. Finally, an email was sent out to six participants whose experiences would address the quintain to participate in a second round of data collection in exchange for a \$10 Amazon gift card. Five participants responded and each one became a separate case for cross-analysis.

### **The Cases**

Each case in the study represents a pre-service teacher completing student teaching in an elementary school setting. All participants had completed required coursework as defined by the university and specific program, were placed within a local school system (within a 20-mile radius), and assigned different schools and mentor classroom teachers. Of the cases, all were traditional degree-seeking students with 60% working towards a master’s degree in Early Childhood Education and the other 40% seeking Bachelor of the Arts degrees in Interdisciplinary Studies with a focus in Special Education: General K-12 Curriculum. All cases self-identified as female with 20% representing ages 20-25 with the remaining 80% identifying as 18-24 years of age. When asked to self-identify ethnicity, 20% identify as Black or African American, 20% Hispanic or Latino, 20% Asian / Pacific Islander, and 40% White. These cases met Stake’s (1995) criteria for case study selection by (a) providing diversity across multiple contexts (b)

providing opportunities to learn about different contexts, and (c) being relevant to the quintain (p. 23).

### ***Jayden*<sup>1</sup>**

Jayden was one of the first participants to agree to be part of this research study. In fact, she reached out to me to find out more about it as she felt like it was lacking in her pre-service teacher training. Seeking a master's degree in Elementary Education PK-3, Jayden was placed in a Kindergarten classroom in Willow Park Elementary School, Oceanside Public School System, for student teaching. When asked what her experience was with the VA CS SOLs prior to student teaching, she indicated that she was not at all familiar with them but saw computer science as a way to approach problem-solving using technology. Jayden shared that she felt like students of all ages could use and understand technology and was excited to see how her clinical faculty member incorporated aspects of computer science into her content area lessons.

### ***Bella***

Completing her student teaching in a 3<sup>rd</sup>-grade classroom in Central Elementary School in the Westwood Public Schools, Bella was working toward a master's degree in Elementary Education PK-3. Like the other participants, Bella reported no familiarity at all with the VA CS SOLs prior to her student teaching experience but, according to the pre-questionnaire, understood the concept of computer science to include processing and sequencing. Bella was one of just two students who had worked with young children before in a classroom or camp-like setting before completing any required practicum hours toward her degree and indicated she was ready to learn and introduce computer science to her students as soon as her clinical faculty member would allow her.

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<sup>1</sup> Pseudonym used for all participants in the study in accordance with IRB guidelines.

***Maggie***

Similar to Jayden and Bella, Maggie was also completing student teaching as the final step toward earning a master's degree in Elementary Education PK-3. Although Maggie was assigned a 3<sup>rd</sup> grade classroom in Sunnyside Elementary, Westwood Public Schools, for student teaching, she requested to also spend time working with a 2<sup>nd</sup> grade classroom within the school to see the differences in grade levels, student age, and curriculum. Although Maggie had experience working with students in a classroom setting prior to working toward her degree, she indicated was very nervous about taking over a classroom of her own during student teaching, much less incorporating new material that she had not worked with during her core education classes. She looked forward to observing how all teachers in her assigned school, not just her clinical faculty member, planned lessons to meet the needs of all students. Maggie noted that she was not at all familiar with the VA CS SOLs before starting student teaching (post questionnaire).

***Yudi***

Unlike the prior three participants, Yudi was enrolled in student teaching under the umbrella of *Teacher Candidate Internship for Special Endorsement* as she was completing her bachelor's degree in Special Education: General Curriculum K-12. Her elementary placement was in the Oceanside Public School System working with students in both 4<sup>th</sup> and 5<sup>th</sup> grades through a classroom pullout program in Pinehill Elementary School. Yudi entered the study and student teaching with what she called "minor knowledge" of computer science, but no experience with the VA CS SOLs (pre-questionnaire). She attributed the knowledge she did have about computer science to living with a spouse serving in the United States military. When asked about her familiarity with the VA CS SOLs prior to student teaching, Yudi wrote on her

Perceptions of Computer Science post questionnaire, “I was not familiar at all in the sense of understand[ing] them and being able to utilize them in a classroom. I knew of the standards but have not spent much time looking at them and trying to implement them.” On her pre-study questionnaire, Yudi identified the need to teach computer science to all students to help them look at real-world problems and figure out a way to solve them. Yudi was the only participant that was entering the field of education from another career path.

### ***Kim***

Kim, like Yudi, was also completing her bachelor’s degree in Special Education: General Curriculum K-12 and was completing her student teaching through the *Teacher Candidate Internship for Special Endorsement*. Her placement was in a 3<sup>rd</sup>-grade classroom as a full-time in-class teacher assigned to students with disabilities in Hawking Elementary School in Westwood Public Schools. Kim, while very willing to participate in the study, seemed hesitant to discuss computer science and wrote on her post questionnaire, “Prior to my student teaching experience, I was not familiar with the VA CS SOLs other than they were new” (post questionnaire) when asked. During the two seminar meetings, Kim was the most reserved and only spoke up when prompted or asked a question directly. Although she acknowledged the need for computer science and the VA CS SOLs at the elementary level, she initially appeared the most hesitant about taking up valuable core content time with computer science lessons.

Information on each participant can be summarized in Table 1. More information on each school system, including access to technology and faculty education and experience, will be presented in Chapter 4.



**Table 1***Case Descriptions*

Pseudonym	Degree Seeking	School System / School Name	Grade Level(s)
Jayden	Master of Science in Education; Early Childhood, PreK-3, Initial Licensure	Oceanside / Willow Park Elementary School	Kindergarten
Bella	Master of Science in Education; Early Childhood, PreK-3, Initial Licensure	Westwood / Central Elementary School	3 <sup>rd</sup>
Maggie	Master of Science in Education; Early Childhood, PreK-3, Initial Licensure	Westwood / Sunnyside Elementary School	2 <sup>nd</sup>
Yudi	Bachelor of Arts in Interdisciplinary Studies; Special Education: General Curriculum K-12, Initial Licensure	Oceanside / Pinehill Elementary School	4 <sup>th</sup> -5 <sup>th</sup> SPED - Pullout
Kim	Bachelor of Arts in Interdisciplinary Studies; Special Education: General Curriculum K-12, Initial Licensure	Westwood / Hawking Elementary School	3 <sup>rd</sup> SPED - Inclusion

*Note.* School systems and elementary school names have been changed.

### **Data Sources and Collection**

Data collection occurred in two different phases over a 14-week period that followed the student teaching schedule established by the university. The first phase occurred in February and March 2020 with the second phase taking place in early May 2020 after the participants

completed their student teaching practicum. In order to follow Merriam's (1998) approach to qualitative case study data collection, multiple sources of data regarding elementary pre-service teachers' understanding of and planning for the VA CS SOLs were collected. Primary sources of data include multiple questionnaires, transcriptions from two recorded face-to-face meetings, written exchanges between participants from an online group discussion board, and transcriptions from semi-structured individual phone interviews occurring during each phase of the data collection process. I used the *Rev* iPhone application for all recorded and transcribed data. A descriptive overview of the data collected can be found in Table 2.

**Table 2***Data Collected*

Type of Data	Phase(s)	Description
Questionnaires (pre)	1	Open-ended questions to determine familiarity with computer science (terminology, skills, principles) and the VA CS SOLs, as well as perceptions of computer science in elementary school classrooms prior to student teaching. Completed by hand during the first face-to-face meeting. (Appendix A)
Questionnaire (mid)	1	Open-ended questions to determine perceptions about computer science and the VA CS SOLs as part of the elementary school curriculum. Additional questions focused on likelihood to incorporate computer science into future lessons and perceived ability to incorporate the VA CS SOLs effectively. Completed via email following the second face-to face meeting, approximately one month after data collection began. (Appendix B)
Questionnaire (post)	2	Open-ended questions presented via Google Forms to determine participants' perceptions of computer science and the VA CS SOLs after working with clinical faculty and completing student teaching with elementary students. Questions were presented to prompt reflection on personal knowledge and beliefs regarding computer science at the beginning of student teaching to their overall impressions and plans to incorporate computer science and computational thinking into their future teaching. Participants were asked to identify specific computer science standards they felt prepared to integrate and ones in which they felt less comfortable integrating. Finally, participants were asked to reflect on their student teaching placement and the perceived impact, if any, it had on their personal views of computer science and the VA CS SOLs. (Appendix C)
Meeting transcriptions	1	Face-to-face meetings (2) were recorded and transcribed to explore participants' understanding and perceptions of computer science (terminology, skills, principles) and the VA CS SOLs prior to student teaching. During the meetings, participants were given the opportunity to browse and discuss the Virginia Department of Education website, published Standards of Learning, and documents associated

**Table 2 (continued)**

		with the SOLs such as the framework for integrating computer science into content area lessons. Additional information / resources shown to the participants during the meetings included the Code.org, CodeVA.org, and Barefoot Computing websites as these are reputable resources for educators of computer science. Each meeting lasted approximately one hour. (Appendix D)
Semi-structured individual phone interview transcriptions	1	Semi-structured individual phone interviews were conducted after participants had completed approximately half of their student teaching practicum experience to allow participants to respond to questions regarding their views of computer science and the VA CS SOLs in elementary classrooms as well as their perceived ability to integrate the standards into future lessons. Additional questions were asked to determine perceived benefits and challenges and current (at the time) use of computer science and integration of the standards by the clinical faculty and placement schools as overall. This round of phone interviews took place just before Virginia schools closed for face-to-face instruction as a result of the Covid-19 pandemic. (Appendix E)
Semi-structured individual phone interview transcriptions	2	Semi-structured individual phone interviews were conducted at the end of each participants' student teaching experience. These interviews were conducted to explore how, if at all, perceptions of the VA CS SOLs changed over the period student teaching, how the VA CS SOLs were incorporated into classrooms lessons, and any benefits and challenges that the participants could see to incorporating computer science and the VA CS SOLs into elementary lessons. Additionally, because this interview was conducted at the end of the school year after participants had been working with school faculty and connecting with students virtually due to the COVID-19 -19 pandemic, questions were included to explore if the restructuring of lessons had any effect on their views of computer science in elementary schools and perceived future use in classroom instruction. (Appendix F)
Written / posted exchanges – online discussion board	1 and 2	Participants were given access to and encouraged to participate in an online discussion board via Google Classroom to share experiences and resources with computer science and the VA CS SOLs. Posts on the discussion board included participants asking peers about lesson planning and shared resources, as well as providing

**Table 2 (continued)**

support for each other with online teaching during the Covid-19 pandemic. These posts were examined to determine if there was a change of personal perspectives of computer science over time during student teaching.

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**Data Collection: Phase 1**

Elementary pre-service teachers should be introduced to computer science skills and concepts within their teacher education programs (Yadav et al., 2014) to help them gain an understanding of computer science content and effective teaching methods. In the Commonwealth of Virginia, this also means addressing the VA CS SOLs and corresponding documents available on the Virginia Department of Education website (2020). Thus, I met with each group of pre-service teachers and their university supervisors at an off-campus location during their first two seminar meetings in February and March 2020, to provide a space for the participants to explore and discuss computer science and the VA CS SOLs with their peers in a judgment-free space away from the university and their respective placement schools. It is important to note here that I did not attempt to train the pre-service teachers in computer science concepts; I simply provided the VA CS SOLs, along with documents associated with these SOLs, to them as a means to prompt discussion.

I wanted to ensure the participants knew how to find and access the VA CS SOL documents published by the Virginia Department of Education, as well as to give them the chance to engage in conversations about their beliefs and perceptions of computer science and the VA CS SOLs at the elementary level in general and within their placement schools. All participants had their own laptop computers and cell phones during the meetings to use to take notes, communicate, and access information. My role in these meetings was to ensure all

participants had access to and the chance to read the VA CS SOLs and other prominent state resources on computer science in education and to generate discussion. To help achieve this, I created a few slides for each meeting as well as an outline that could be referenced at a later date and emailed them to the participants when we met. See Figure 1 for an example slide from the first face-to-face meeting with participants and Appendix D for the full meeting outlines and slides. During the first seminar meeting, consent forms were signed, and each participant filled out a questionnaire about prior knowledge, experience, and beliefs regarding computer science and the VA CS SOLs for elementary students and teachers. Meetings were recorded and transcribed to help determine each participants' perspectives and prior understanding of computer science and the VS CS SOLs prior to being part of the study, as well as what changes, if any, occurred in the participants' perceptions as a result of student teaching. Each meeting lasted approximately one hour, and participants had roughly one month between each face-to-face meeting.

## COMPUTER SCIENCE

- What is it?
- Quietly, reflect on your experiences and beliefs –
  - In schools in general
  - In elementary schools
- Definition from the VDOE
- Definition from [Code.org](#)
- VDOE –VA CS SOLs can be found [here](#)

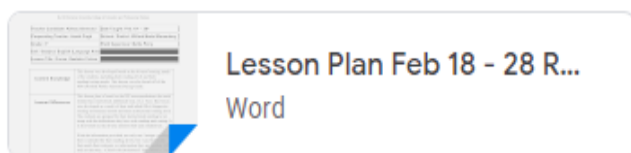


Figure 1: Example slide from the first face-to-face meeting with participants.

Additionally, during this first phase of data collection, participants were encouraged to post and respond to peers in an online discussion board created in Google Classroom to extend their conversations about the VA SC SOLs and their experiences in student teaching related to the standards. This platform was chosen because it is a free web-based site that all participants could easily access. Before participants were given the code to connect on the discussion board, I posted links to the VDOE so they could easily find the VA CS SOLs and state-provided resources, as well as links to CodeVA, Code.org, and Barefoot computing as they are reputable sites for computer science education and were introduced in the face-to-face meetings. I continued logging on to the discussion board weekly to monitor the posts and interactions. Participants used the discussion board throughout the semester to ask peers questions about resources, to discuss what they saw or did not see in their placement classrooms or schools, to

post pictures, and to work together on lesson planning specific to computer science and the VA CS SOLs (see Figure 2 for an example of a discussion board post). Because the discussion board was open and utilized during the entire study, participants also used it to ask each other questions about computer science and lesson planning for virtual lessons as a response to the Covid-19 pandemic and to organize times for gatherings and phone calls outside of scheduled seminar meetings. Participation in the online discussion board encouraged reflection about understanding and beliefs around the use of computer science in elementary classrooms, as well as a place to help participants make connections and construct knowledge for use in future lessons.

Recently, I have incorporated computer science into my lesson plan for guided reading. The lesson covers realistic fiction and is intended for 3rd grade (special education). The computer science SOLs correlate with the assessment portion of the lesson, in which students have to be able to sequence the events in order, from the beginning to the end of the story they have read. Below I have attached the lesson plan.



I think that providing flexible seating when reading with peers is important! I loved that you had students use reading strategies when trying to figure out a word because then they will know how to decode these unfamiliar words when they are outside of the classroom. Lastly, I love graphic organizers! It's a great way to map out all of you thoughts and ideas and prioritize your writing. I think you did a great job with incorporating this into you CS standards. Great Job!

Figure 2: Sample post and response on the online discussion board.

The last data collected during this phase was in the form of semi-structured individual phone interviews and questionnaires emailed to the participants. This was an important step in the data collection procedure as the end of March typically marks the time when student teachers begin to take more control of the classroom they have been assigned and are expected to create



and teach their own lessons. Similarly, by this time, participants should have been participating in team or grade level meetings and parent conferences to add to their understanding of the school climate and overall integration of the VA CS SOLs and computer science in general. The questionnaire, completed via email by the participants, consisted of six questions about perceived comfort with and likelihood to integrate computer science into future content area lessons as well as how important they believe computer science and the VA CS SOLs to be in elementary education. Similarly, the individual phone interviews had seven critical questions asked of all participants to help better understand how they felt computer science was or was not used in their placement school and classroom, examples of how they plan to or can see computer science being integrated into content area lessons, and any challenges or benefits that they saw to incorporating computer science as they moved forward with student teaching and classrooms of their own.

### **Data Collection: Phase 2**

The second phase of data collection occurred in May 2020 after the participants completed student teaching and prepared for graduation from the university. This phase included a second semi-structured phone interview and a final questionnaire completed as a Google Form in addition to continued participation in the online discussion board. Again, I sought to better understand how and where participants thought computer science could or should fit into elementary education, their perceived challenges and benefits, and personal comfort with specific standards and the VA CS SOLs as a whole. Additionally, because this second half of the participants' student teaching practicum experience was completed in the form of online instruction with lesson plans created and sent out by both school systems as a result of the Coronavirus Disease (COVID-19 pandemic), I felt that it was important to consider if and how

their views of computer science and the VA CS SOLS changed in light of the way schools chose to instruct their students remotely after campus closures.

### **Protection of Participants**

All participation in this study was voluntary and non-compulsory. Participants were assured that they may rescind their participation at any point throughout the study. All interviews were semi-structured to allow participants to ask questions and help guide the discussion by responding directly to questions or providing new views or alternative ideas on a topic (Merriam & Tisdell, 2016). I allowed the participants to select the time and date of the interviews within a specific time frame to ensure they were comfortable and had enough time to answer questions thoroughly and ask questions if needed. Each participant was offered time to review the transcripts from the interviews to allow for member checking and additional information to ensure the interview data is representative of their voice and constructed knowledge (Birt, Scott, Cavers, Campbell, & Walter, 2016). All questionnaires were sent to university email addresses that are both password-protected and two-factor authenticated, and participants were encouraged to discard the emails after the study. All efforts to ensure privacy were observed. Pseudonyms were assigned to protect the participants' identities, and school names, locations, and districts were changed to ensure participants could not be linked to their classroom assignments. Finally, data is currently stored on the researcher's university H: storage drive, which is a secure, password-protected storage site. Five years after the study is complete, all data collected will be destroyed by deleting it from the researchers' H storage drive and external hard drive.

### **Data Analysis Procedures**

A qualitative general inductive approach (Thomas, 2006) was used to analyze data for each case (see Table 2). This approach was used because it allows for raw data to be condensed

into a summary format that can be used to show links between the data and research questions in an efficient and straightforward manner (Thomas, 2006). Following the coding process, as outlined by Thomas (2006), I first collected and read the data sources for each case without coding, allowing me to gather a holistic understanding of the data before I began. Next, I reread data sets for each participant, or case, to determine trends. For each case, sections of data were highlighted, and notes were made in the margins when I came across keywords and phrases that occurred frequently (see Figure 3).

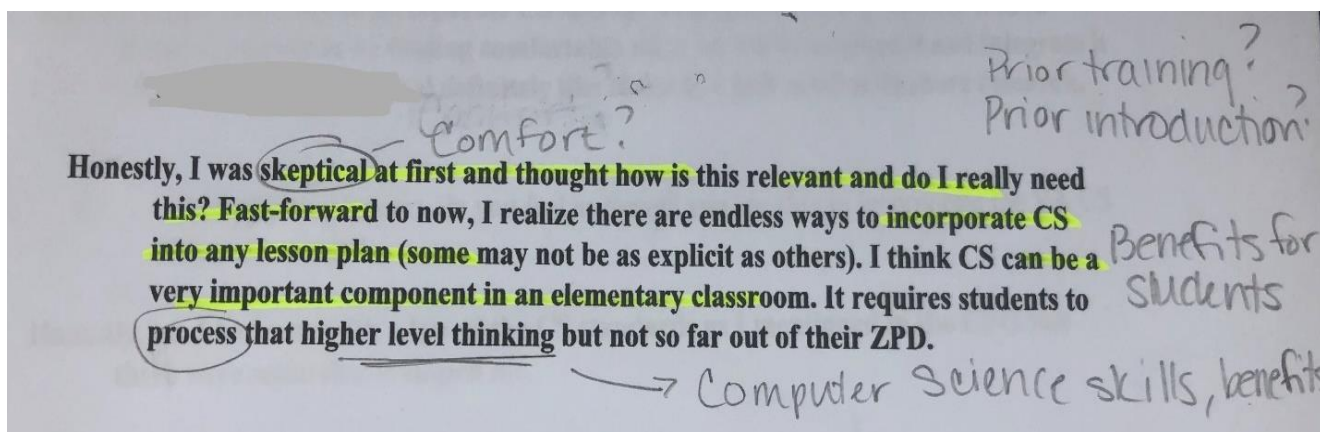


Figure 3: Example of notes made from a participant's raw data.

From these notes, I collected and coded sample selections of meaningful text segments and placed them into categories created by identifying shared commonalities (Thomas, 2006). This was done manually using a reflexive journal that easily allowed me to revise my codes and notes. To better ensure I determined themes that accurately represented the case's beliefs and perspectives about computer science and the VA CS SOLs, I entered the data sets into NVivo qualitative data analysis computer software created to organize large amounts of texts. Not only did results from NVivo support the themes I came up with manually, but this process also provided me with sentiment results that I ultimately use when presenting individual case results

in Chapter 4. Figure 4 provides an example of raw text and categories identified from a sample of Bella's raw data.

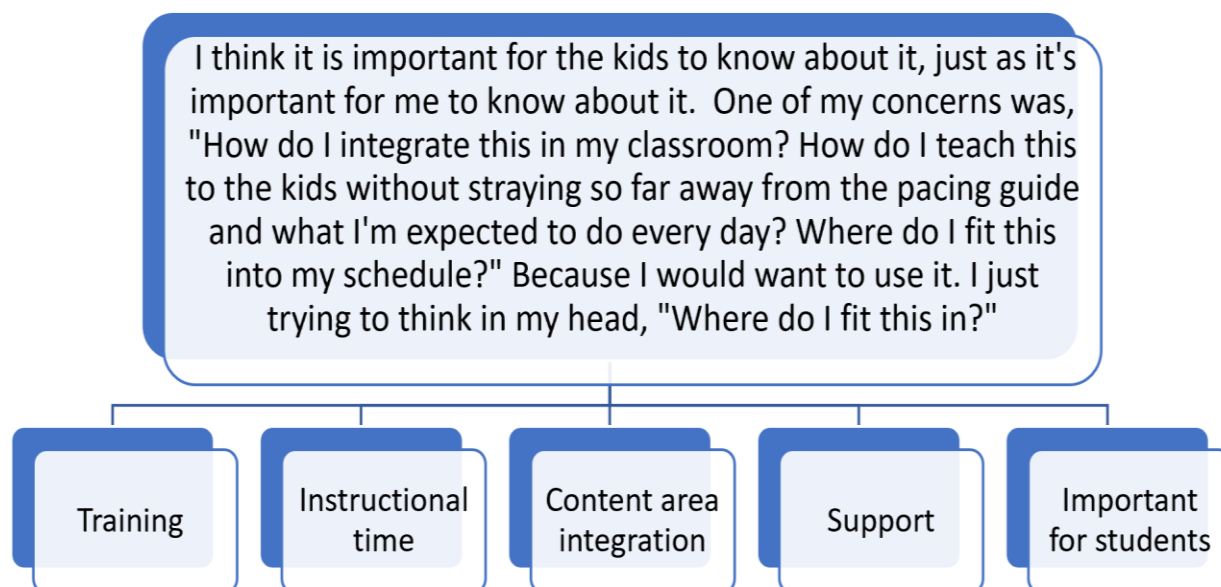


Figure 4: Example of raw text and subsequent categories created.

I revisited my data several times using NVivo. Multiple iterations of coding were performed to better support a clear and reflective representation of data and to determine a relevant set of central themes. Some codes fell into multiple categories while other sections of text did not feel relevant to the research and were left out. Codes were then collapsed or linked based on similar themes or subthemes that represent the participants' perceptions of and ability to incorporate the VA CS SOLs into future lesson plans, as well as the influence, if any, their student teaching placement had on these views. I continued this process until all cases were coded and I had identified the main categories for each case. The within-case analysis (Stake, 1995, 2006) is presented in Chapter 4.

### **Cross-Case Analysis**

A cross-case analysis (Stake, 1995, 2006) was then performed using NVivo to determine similarities and uniqueness within the quintain. To do this, I first selected all of the data sources that I had loaded into the program by case. I then ran the program to identify codes across cases with both nodes and sentiment. Through the use of the paragraph analysis option and pre-determined codes from the individual case analysis, I was able to identify common themes across cases. The findings for the cross-case analysis are discussed in Chapter 5.

### **Validity, Reliability, and Trustworthiness**

Numerous steps were taken to strengthen the validity, reliability, and trustworthiness of this study as this analysis process is often seen as highly subjective (Thomas, 2006). First, a triangulation of data was used to reduce researcher bias when analyzing questionnaires, interviews, and artifacts. Specifically, multiple sources of data were collected and analyzed to capture the perceived challenges and benefits of computer science, as well as the perceived ability of each participant to integrate the VA CS SOLs into content area lessons. Next, I verified initial categories and codes through the use of the NVivo qualitative data analysis computer software to ensure they best represented the cases and quintain. Additionally, I provided opportunities for member checks through prompts and chances for clarification during interviews as well as time to review transcripts to check for accuracy of intended responses. No participant requested to review or modify their transcripts when provided the opportunity.

### **Conclusion**

In summary, this qualitative study was designed to investigate pre-service teachers' perspectives of the VA CS SOLs in elementary schools and classrooms. I chose to focus my research on five elementary pre-service teachers completing their final student teaching practicum, placed in different schools and grade levels comprised of varying groups of students,

each comprising one case. The in-depth analysis provided rich data to help understand the viewpoints of each participant in regard to integrating the VA CS SOLs and computer science in general into future content area lessons. In addition, using multiple cases allowed me to look across their experiences to determine common characteristics and unique perspectives. In the next chapter, I will outline the findings of the individual case analysis highlighting perceived challenges and benefits to incorporating computer science as described by each participant. The results of the cross-case analysis will be presented in Chapter 5 as the results of a multiple case study cross-case analysis can be discussed in terms of themes that provide a better understanding of the quintain (Stake, 2006).

## **CHAPTER IV**

### **FINDINGS**

This study was designed to explore the perspectives of elementary pre-service teachers regarding their understanding, planning, and integration of the VA CS SOLs into content area instruction. Additionally, I sought to investigate what, if any, effect student teaching had on these perspectives as we prepare teachers to take on the roles and responsibilities that come with running a classroom. In this chapter, I will first present information about the school districts where the participants completed their student teaching to provide more context for their experiences. I will then present the findings of the individual cases comprising the quintain in this multiple case study. The findings are described to address the following research questions:

RQ1) How do elementary pre-service teachers perceive their ability to teach and integrate the Virginia Computer Science Standards of Learning in future content instruction?

RQ2) What shifts, if any, occurred in these pre-service teachers' perceptions in response to their student teaching experience?

#### **Context**

When considering the perspectives of preservice teachers concerning computer science and the VA CS SOLs, it is necessary to acknowledge the background and makeup of the school systems in which they complete their student teaching placements. As mentioned in an earlier chapter, there is a link between the amount of exposure to and use of technology in classrooms with the integration and interest in computer science by teachers and students (University of California, Irvine, 2020). Having an overview of the student body and environments in which the preservice teachers were learning and working with computer science and technology is a

necessary step to understanding how or why their individual perspectives may have evolved during this time.

### **Westwood Public Schools<sup>2</sup>**

Westwood Public Schools (pseudonym) is a large, urban school district that serves approximately 30,000 students each year spanning pre-kindergarten through grade 12. The elementary schools alone serve over 16,000 students, a little over half of the total number of students registered. Overall, roughly 84% of students missed less than 10% of school days in each of the past three school years and over 83% of the class of 2019 graduated with at least a standard diploma. In 2019, 63.3% of students in Westwood Public Schools were labeled “economically disadvantaged” with more than 75% of the student body eligible for the free or reduced meal program. Additional information about the breakdown of the student body during the time of this study is shown below (Table 3).

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<sup>2</sup> Pseudonyms are used for both school districts to ensure adherence to IRB guidelines.



**Table 3***Membership by Subgroup – Westwood Public Schools*

Subgroup	Percent of Students
American Indian	Less than 1%
Asian	2.1%
Black	57.9%
Hispanic	11.3%
Native Hawaiian	Less than 1%
White	21.3%
Multiple Races	6.6%
Students with Disabilities	14.3%
English Learners	4.8%
Homeless	1.2%
Military Connected	14.9%
Foster Care	Less than 1%

*Note.* This information is collected from the Virginia Department of Education School Quality Profiles, 2019.

At the time of this study, all schools within the Westwood Public School district were either fully accredited or accredited with conditions.

***Teacher Population***

Additionally, student teachers work very closely with their clinical faculty members, otherwise known as their mentor teachers, when planning lessons and discussing resources and

tactics to help all students learn. Thus, it is necessary to have at least a basic understanding of the teaching staff within the school district when considering the influence they may have on the perspectives of the participants. According to a 2018 – 2019 school quality report, Westwood Public Schools currently has 3.8% of teachers who are not fully endorsed for the content they are teaching (out of field), 5.5% with less than one year of classroom experience (inexperienced), and less than 1% who are both inexperienced and teaching out of field. Additionally, 9.3% of all teachers are working on a provisional license. Over 43% of the instructional staff in Westwood Public Schools hold a master’s degree or higher and have an average of 10 years of experience. In 2019-2020, the student-teacher ratio for grades K-7, the grade range for participants in this study, was about 12:1.

### ***Student Access to Digital Technology***

The use and availability of technology in Westwood Public Schools has been an ongoing issue recently addressed and published in a division-wide educational technology plan aimed at keeping the public abreast of changes and educational initiatives within the district. Although there are other conditions identified by researchers as necessary to “effectively leverage technology for learning” (ISTE.org, 2021) in addition to access, it is beneficial to have a clear picture of the technology available across the district to students and pre-service teachers as they are both working with and learning from these resources and the veteran teachers who have had access to them for longer periods of time. Further, because educators have often thought of computer skills and practices as something that can only be taught through the use of digital technology (K12cs.org, 2020), access to digital tools in educational environments may influence the use of computer science in elementary classrooms and content area lessons.

As in many school districts like Westwood, older facilities lack the space, power, and cable and Internet capabilities to provide the same exposure and use of technology as in the newer buildings. However, at the time of the study, almost all classrooms across the Westwood school district had an interactive whiteboard, a set of classroom computers (either desktop or classroom set of Chromebooks), and at least one printer. Many classrooms offered much more in the way of digital technology to students based on location, age of the building, and grants/funding obtained by individual teachers, but this varied across the district. Specific to this study, at the primary grade levels, many students were also exposed to STEM activities and KIBO Robotics. The COVID-19 pandemic and response by the state governor to close schools to face-to-face learning during the study changed the availability of technology to students. The district provided Chromebooks, iPads, or laptops for students PreK-12 who did not have access to a device for online learning. Wireless hotspots were also ordered for students who needed them. Classroom teachers were also provided with the digital technology needed for virtual learning when necessary.

### **Oceanside Public Schools**

Oceanside Public Schools (pseudonym), located about 20 minutes from the Westwood School district, is a large, suburban school district serving approximately 41,500 students PreK-12. Approximately 42% of the students were enrolled in elementary grades during the time of this study. Overall, absenteeism is not a problem for the district with only 6.9% of students missing more than 10% of total school days; roughly 94% of students graduating in 2019 received a standard diploma or higher. In 2019, about 35% of students in the district were categorized as “economically disadvantaged” with roughly 48% qualifying for free and reduced

meals – about half of Westwood Public Schools. Table 4 below shows a breakdown of student enrollment by subgroup.

**Table 4**

*Membership by Subgroup – Oceanside Public Schools*

Subgroup	Percent of Students
American Indian	Less than 1%
Asian	2.8%
Black	32.2%
Hispanic	10.7%
Native Hawaiian	Less than 1%
White	45.8%
Multiple Races	7.9%
Students with Disabilities	17.1%
English Learners	4.8%
Homeless	Less than 1%
Military Connected	20%
Foster Care	Less than 1%

*Note.* This information collected from the Virginia Department of Education School Quality Profiles, 2019.

***Teacher Population***

Similarly to Westwood Public Schools, the student-teacher ratio for grades K-7 is moderately low at about 14:1. The school quality report published by the state for the year in

which this study took place shows that less than 1% of all teachers were teaching content they were not fully endorsed to teach and only 2.9% of all teachers had less than one year of classroom experience. None of the teachers in Oceanside schools were both inexperienced and teaching out-of-field.

### ***Student Access to Digital Technology***

The Oceanside Public School district, although located just a short drive from Westwood, has some distinct differences in technology and computer science. According to the district website, both teachers and administration are committed to “accelerat[ing] innovation in education and improv[ing] the opportunity to learn for all through technology and research” (cpschools.com, 2020) by providing equitable opportunities for students. While in classrooms, students are provided with laptops and Chrome Books as part of a one-to-one initiative. Further, and pertaining to this study, the district has launched STEAM (science, technology, engineering, and math) initiatives in elementary schools where students as young as Kindergarten are exposed to coding and programming. Additionally, the district is working to provide professional development in computer science and computational thinking to teachers.

In response to school closures in Virginia during the time of this study due to the COVID-19 pandemic, Oceanside Public schools devised a plan to ensure each student has access to technology. Like Westwood Public School district, Oceanside provided, and continues to provide, hotspots to students who needed them to ensure all students had the same access to the Internet. This was done through an educational foundation associated with the school system. There is also a device loaner program in place for students needing access to a device at home. Findings related to the COVID-19 pandemic will be reserved for the cross-case analysis and discussion in Chapter 5. In summary, although both the Westwood Public School district and the

Oceanside Public School district are similar in size and in fairly close proximity to one another, there are differences that may influence the way computer science is viewed and used by staff, including student teachers, and students.

In the following section, I present findings for each case in the quintain that addresses preservice teacher perceptions of the VA CS SOLs. Findings will be presented to show each participants' perceived benefits and challenges to integrating the VA CS SOLs into content areas instruction throughout the semester, as well as any shifts in their perceived ability to teach computer science and associated skills outlined in the standards of learning, including computational thinking. The results will also highlight any shifts that occurred in the participants' perceptions of the VA CS SOLs in elementary education due to their student teaching experience.

### **The Cases**

#### **Jayden**

Jayden, like all participants, joined the study enrolled in her final semester of her teacher preparation program. Placed at Willow Park School, a fully accredited primary school with just a little less than 1,000 students in the Oceanside Public School district, Jayden was assigned a Kindergarten classroom with 13 students and a clinical faculty member who had been teaching for 14 years. From the beginning, Jayden appeared excited to be part of a study that focused on computer science at the elementary level, jumping at the opportunity to be part of the discussion and being the first participant to commit to the study. In fact, in our first group meeting, Jayden said she knew from the first day of student teaching in a Kindergarten classroom that computer science had a place with even the youngest students. "These kids are great with computers and technology. I see them using their parents' phones before and after school and I know they

understand some of the concepts” (Jayden, meeting #1 transcript). Although she indicated in our first face-to-face meeting that she was not familiar with the VA CS SOLs specifically, she did explain that she believed “sequencing, repeating patterns, and problem-solving were all components of computer science” (Jayden, meeting #1 transcript) when asked specifically about her familiarity with computer science at that point in time. When asked about the integration of computer science and specific topics such as computational thinking in the elementary classroom on her pre-study questionnaire, Jayden wrote that she felt as though “computational thinking can be integrated in science and math” and that “[she] would use computer science in writing and reading” (pre-questionnaire). Although she appeared unsure of her answers while completing the pre-questionnaire, shaking her head, shrugging, and looking up while she wrote, Jayden quickly answered the questions and described computer science as “problem-solving using technology skills” and computational thinking as “solving or analyzing problems as a computer would” (pre-questionnaire).

During my first face-to-face meeting with my participants, which occurred in February 2020, the participants discussed information outlined on the Virginia Department of Education website and Code.org having to do with computer science in elementary classrooms. During this first meeting, Jayden was one of only two participants who started the study feeling as though she had a rudimentary knowledge of computer science and the associated skills and practices as described in the standards of learning, although she readily admitted that she did not feel confident in her understanding of the concepts at the time. Jayden stated,

“I think I know what computer science is. I mean, I know it includes using computers and computer skills for education. However, I assume there is much more to it and I do not

really feel comfortable with all of the different parts written in the SOLs” (Jayden, meeting #1 transcript).

However, after a brief discussion with the other participants about the VA CS SOLs and the definition of computer science and many of the core skills, concepts, and practices, Jayden seemed to feel more comfortable with the content going as far as to point out what she saw as a major benefit of integrating computer science at an early age. She commented that computer science can, “help engage students in multiple ways and prepare them for life skills like critical thinking and a basic understanding of the step-by-step process[es] used to solve a problem” (Jayden, meeting #1 transcription).

This acknowledgment of the need for computer science in elementary lessons sparked a discussion about the integration of the VA CS SOLs in Willow Park School. Jayden stated that she did not think many veteran teachers understand exactly what computer science is or the benefits of incorporating any aspect of it into content area lessons. She said,

“I have seen teachers during my practicums doing what they are told to do in respect to technology and computers and the SOLs. They may even try something that has to do with computer science, but only because they are told to, and even then, they do not really understand it. I have heard some teachers say they do not know why they have to incorporate it at all because they have too much to fit in already” (Jayden, meeting #1 transcription).

Jayden followed this up by saying she felt as though veteran teachers in her placement school, specifically, “[they] list the VA CS SOLs at the top of their lesson plans because they are a required component of lesson plans in her district, but they do not really teach them” (Jayden, meeting #1 transcription). This sentiment carried over into our second face-to-face meeting when



Jayden went into detail about what she saw as a specific challenge to implementing computer science in her classroom.

“My [clinical faculty] teacher was like ‘I do not do technology. I am not going to be able to do that when we spoke about computer science. Then, when I brought the SOLs up to my teacher and how they could be taught and she was like, ‘oh, that’s interesting, but they really don’t care. She was like, ‘you’re going to have to teach me this stuff.’ And I think they are easy to incorporate – the sequencing and that kind of stuff. But for me, it is just remembering to put them in” (Jayden, meeting #2 transcription).

In spite of this perceived lack of understanding and enthusiasm for the VA CS SOLs and computer science in general by her clinical faculty member, Jayden conveyed that she was still eager to learn more.

The next time I spoke with Jayden was for the first of two individual phone interviews. The interviews were scheduled so that the first interview took place at about seven weeks into student teaching, or halfway through the university semester. When asked about any perceived benefits that she saw to incorporating the VA CS SOLS specifically, as well as computer science in general, into elementary education at this point in her student teaching practicum, Jayden said,

“I think that by incorporating computer science standards into other lessons we are providing students the opportunity for innovative thinking. Our future revolves around technology and the mindset in which a computer can demonstrate. Humans can also demonstrate this kind of thinking with practice and support” (Jayden, phone interview #1).

This statement demonstrates Jayden’s shift in thinking about why and how often computer science should be included in elementary lessons, as well as her belief that it can be used across

content areas to help students connect new ideas and information. Jayden went on to explain how she saw herself integrating the VA CS SOLs into her future classroom and content area instruction.

“I will incorporate these standards during pattern sequencing activities. I may have the students create a pattern on Sketch Jr. using various shapes and objects. Students will be able to discuss and predict what shape or pattern may come next” (Jayden, phone interview #1).

One noteworthy difference at this point in student teaching from when the study first began is the fact that Jayden was taking notice of the VA CS SOLs being integrated into daily lessons around her placement school as she understood them. She pointed out that while working with her students on site words, she heard herself and her mentor teaching using vocabulary and skills she believed to be related to computer science. “I heard myself telling the students to do things like decode, predict, and try again, words I think go with computer science” (Jayden, phone interview #1). Jayden revealed that her clinical faculty had started integrating computer science into some of her lessons and hearing her use computer science terminology encouraged her to think more about incorporating the topic into other areas in the classroom. A significant challenge Jayden discussed at this time had to do with differentiating instruction for students with disabilities, although she did not provide any examples specifically related to computer science. She said,

“I am not sure how to create lessons that meet the needs of all students, especially students with IRBs. How do I know they can do what I am asking them to? I am sure I need other resources and help with this. I have not had practice in this area in class or in schools” (Jayden, phone interview #1).

I spoke with Jayden again for a second individual phone interview just after she completed her 14-week student teaching experience. She expressed that after spending the time working with students at the elementary level, she saw more ways to incorporate computer science as she understood it into different content areas. Jayden explained,

“I just see now how I can include it into other content areas. So, it doesn’t necessarily just need to be writing in English or language. It is in math and science, too. Some of it, like computational thinking and problem-solving, can be taught by just talking about the steps needed to get ready for school and what you need to do first” (Jayden, phone interview #2).

This was the first time that Jayden spoke about her understanding of computational thinking and her ideas toward it being a skill that students should be exposed to in a variety of ways, outside of just reading and math as she previously mentioned, as well as providing what she believed to be a practical and age-appropriate lesson/connection to the real world. Jayden continued by pointing out what she saw as benefits that came to her mind at the time when thinking about integrating computer science standards of learning into content area lessons.

“I just think it is beneficial when they’re able to do hands-on activities where they can actually see [computer science]. Ever since the video was shared on the discussion board of students using robots for decoding, I’ve seen it everywhere. It’s in all the schools! I definitely think it is beneficial for engaging them and helping them retain that information and apply it later to other aspects of their life” (Jayden, phone interview #2).

It was during this second phone interview that Jayden really opened up about the challenges she felt personally during her student teaching experience in terms of incorporating computer science into content area lessons. She expressed that her main concern was simply

having time to think about the different aspects of computer science so she could apply it in a meaningful way for her students. She commented,

“I think with experience, it’ll get easier. But it is kind of like a critical thinking period for me to be like, ‘Okay, how can I add this into an engaging lesson when [the students] will enjoy it as well as learn it? I want to feel comfortable teaching it so that they feel comfortable learning it, you know?’” (Jayden, phone interview #2).

The other challenge Jayden highlighted was accessibility to prepping and planning for content areas lessons. She stated,

“The way my school works is that one teacher is assigned to plan for all science for the grade, one teacher to plan for all math for the grade, and so on. I don’t really get to change or add too much to the lessons given to me by team members” (Jayden, phone interview #2).

Jayden felt like this not only limited her control over how she planned for incorporating the VA CS SOLS and general computer science topics in other content areas, but also limited what she planned for the grade level because it had to work for different experience levels in regard to computer science and digital technology.

Jayden entered this study already enthusiastic about integrating computer science concepts and practices as she understood them into her future classroom, a sentiment that remained constant throughout her student teaching experience. She expressed on her post-study questionnaire that she looked forward to teaching her future students about the topics addressed in the VA CS SOLs and could easily see herself integrating it into both content area lessons and life lessons for the younger students. She wrote, “I feel very comfortable integrating them now that I have learned the meaning and purpose behind it. I think they’re useful standards that help

students make real-life connections” (post-questionnaire). Jayden also wrote on her post-questionnaire that some standards, such as K.4 (*The student will a) count forward to 100 and backward from 10; b) identify one more than a number and one less than a number; and c) count by fives and tens to 100, felt natural for her to combine with computer science*), “seem to go well with math standards. It feels natural to combine it with computer science” (post-questionnaire). She went on to write that she felt as though computer science standard K.1 (*The student will construct sets of step-by-step instructions (algorithms) either independently or collaboratively including sequencing that emphasize the beginning, middle, and end.*) had been “demonstrated throughout the year as kindergarteners are always learning different process and ways of thinking” (post-questionnaire).

Overall, Jayden wrote on her post-questionnaire, “I ended my student teaching experience feeling very comfortable in my overall ability to integrate the VA CS SOLs into my future classroom after having had the opportunity to think about them” (post-questionnaire). She did not believe her student teaching placement had an impact on her views toward computer science because, “[her] clinical faculty did not highlight the standards a lot in class” (post-questionnaire), but she felt as though the discussions and exchanges with peers around the VA CS SOLs contributed to how she viewed computer science in elementary classrooms. Of note, Jayden was the only participant who did not mention working with the students as a reason for a shift in perspectives.

### **Bella**

Bella, a Master of Science student with an early-childhood PK-3 education concentration, completed her student teaching experience in a 3<sup>rd</sup>-grade classroom at Central Elementary School in the Westwood Public School district. Central Elementary School was built in 1925 as a

neighborhood school and is one of the oldest schools in the district. Over the years it has gone through major renovations and remodels and now claims to have an inviting instructional climate with state-of-the-art technology. Situated in an urban-neighborhood community, Central Elementary serves an ever-changing population of over 800 students in grades PK-5. The clinical faculty Bella was assigned to work with had been teaching for eight years at the time of the study, five in that specific school. There were 14 students enrolled in the class.

Bella joined the study with what she described as “a minor knowledge” of computer science (pre-study questionnaire). Although she wrote on her pre-study questionnaire that she was, “not at all familiar with computer science and the VA CS SOLs” (pre-study questionnaire), Bella included words such as “processing” and “sequencing” when asked to describe computer science on the pre-study questionnaire, terms also included in the VA CS SOLs. This was, however, the extent of Bella’s knowledge of what the VA CS SOLs at the time, noting,

“I cannot explain computer science in education past using and understanding computers. I have no idea what computational thinking is or why it is important, and I have zero familiarity with coding or coding applications for school, especially applications to use with younger students (Bella, meeting #1 transcription).

Nonetheless, even with this self-described minor knowledge, Bella was excited to explore computer science and the VA CS SOLs stating, “I love all tools and applications that can be used to help students relate content areas to real-world scenarios! There is so much out there!” (Bella, meeting #1 transcription). She went on to indicate that although she had only been working in the school for a short time, she saw technology in the building and was looking forward to seeing how it was used to demonstrate “plugged” computer science activities.

When we came back together for a second face-to-face gathering in March 2020, Bella's perceptions of computer science integration within Central Elementary School had changed. When asked if she had observed anyone in her school incorporating computer science standards into lessons, either generally or explicitly, she responded, "I know for sure my school does not use them. I brought it up to my teacher and she was just like, 'Oh, okay, cool.' but I [Bella] am the only one who uses [the VA CS SOLs]" (Bella, meeting #2). Nevertheless, Bella went on to express increased comfort in her perceived ability to integrate many of the VA CS SOLs into her content lessons.

"I've used [the VA CS SOLs] with my intro and review questions with the kids. The ones that are more computer-based I have found more challenging to incorporate. The ones that are sequencing or algorithm, they were easier to include in my lessons" (Bella, meeting #2 transcription).

These statements did not seem to align with the published mission statement of the school. The district-created website for Central Elementary School claims to have technology available to all students with a commitment to incorporating technology in classroom lessons. I was curious to know if the student was having trouble identifying or incorporating the VA CS SOLs because she did not understand them or because the school/teacher did not use technology often with content area lessons. Thus, I followed up by asking more about the use and availability of state-of-the-art technology in the classroom she was assigned. Bella responded that the students "use the computers, but not in a way that seems to support the standards" (Bella, meeting #2). She went on to add,

“[M]y school seems to be technologically challenged as far as what the teachers are able to do. My teacher didn’t know how to use Google Classroom, and she’s a younger teacher, too! I thought everyone knew how to use that” (Bella, meeting #2).

Bella’s comments speak to the often-preconceived notions that younger educators inherently know how to use and incorporate computer science as well as the need for training and professional development for all teachers on computer science and the VA CS SOLs. In addition, the lack of computer science integration in the classroom could impact the way Bella understands and integrates the standards in her future content area lessons.

I spoke with Bella again during our first individual interview. After working in her assigned 3<sup>rd</sup>-grade classroom for about 7 weeks, Bella was excited to say that she believed her students were learning about computer science after all. She reported seeing the students in her class learning and engaging in what she believed to be computer science during content area lessons and was able to speak to what she saw as benefits. Bella said,

“I feel like a benefit that I personally see, especially merging [the VA CS SOLs] into different content areas are the chance for kids to start using those higher-order thinking skills. When they are coding and they’re sequencing and all that, they are doing [computer science] kind of already, and so they’re not really thinking about it. But once you start applying [computer science skills] to maybe like more difficult concepts, then they still have to use those same strategies they learn and apply it forward” (Bella, phone interview #1).

Bella went on to explain that she especially saw benefits in math and spelling and used the example of looking for and creating patterns, as well as science with the life cycle and different systems. However, in her opinion, a major challenge at this point was allowing enough



instructional time to introduce some of the new information and allow students to explore computer science concepts and associated technology. Bella said, in a flustered manner,

“There just isn’t enough time for all of this. I worry that I am using all of the instructional time to let the kids play on the computers, just so they understand what I am talking about. I wish they already knew some of this computer stuff before they got to my class” (Bella, phone interview #1).

Not only does this sentiment speak to the need for computer science lessons to begin in early elementary grades, but also to the continued concern about getting all content in that is required during the school year. Bella felt as though this “lack of time” also contributed to why her clinical faculty and their grade level team did not explicitly discuss computer science with the students.

“Everyone is worried about getting the required content in and passing SOL tests for accreditation and having students ready for next year. I know many things are cut out daily because there just is not time. I think the teachers do not see it as a priority” (Bella, phone interview #1).

This sentiment regarding a lack of computer science integration within her placement school was reiterated by Bella in her final phone interview with me that took place after her student teaching practicum was completed. When asked if her assigned clinical faculty intentionally incorporated the VA CS SOLs into content area lessons, Bella responded,

“Not to my knowledge. As far as I know, I’m the only one who was using it, at least on my grade level. Obviously, there might have been other teachers who were using it within the school, but I was not aware of it. And, because I really have not had training in it, it was never a direct lesson about computer science” (Bella, phone interview #2).

Bella's response points to the lack of, or perceived lack of training in computer science and the associated VA SOLS for educators. Hence, it is increasingly important to provide training and support to teacher candidates throughout their educational programs and during their practicum experiences so they can integrate computer science topics into their future classrooms.

Over the course of this study, Bella's perceptions about the VA CS SOLs for elementary students did not vary. She continued to discuss what she felt was the importance of using computer science within other lessons as a tool or building block to help students learn and connect concepts. Bella consistently expressed *some* comfort regarding integrating the standards into future classrooms, interpreting her ability as a "6 / 10" (no formal scale was used) and citing her lack of training and instruction on specific VA CS SOLs and unplugged activities, as well as the lack of direct instruction or demonstration of the standards by her clinical faculty. On her post-study questionnaire, Bella wrote, "I am less comfortable integrating CS SOLs 3.8 - 3.17...I was not sure how to use these effectively without a computer or device" (Bella, post questionnaire). The standards noted by Bella, VA CS SOLs 3.8 - 3.17 fall under the following categories: computing systems, cybersecurity, data analysis, impacts of computing, and networking and the Internet. Although some of these standards may be met through discussions and simulations, such as discussing information that may be sent using computing devices (VA CS SOL 3.17), others, like creating an artifact using a computing system (VA CS SOL 3.13) would be much harder for a novice teacher to meet without proper training and the use of computing technology. These topics were some that Bella initially thought she would see integrated when the study began because of the technology available in her placement school and the advertised commitment to "state of the art technology and instructional climate" on the school's webpage. Nevertheless, Bella noted that she liked the idea of using computer science

and looked forward to continuing to use it in the future. Specifically, Bella, like Jayden, expressed comfort with the VA CS SOLs related to algorithms and programming when completing her VA CS post-questionnaire.

“They are a great tool to integrate into the lessons - given you know how to do this effectively. I would say I am 85% likely to work on this on my own and use computer science and specific standards in the future” (Bella, phone interview #2).

Finally, when asked if she thought her student teaching placements had an impact on her perceived ability to integrate the VA CS SOLs into her future lessons, she indicated that it had a profound influence because she was able to see how the students responded to different types of lessons. She said,

“What had the most influence on me was just interacting with the students and watching them work in different content areas. After seeing how they responded to different lessons, what they liked and didn’t, and what they had a hard time with, I am able to think more about how I would to plan execute all lessons, especially those with newer material like computer science” (Bella, phone interview #2).

Bella felt it was important to add that professional development trainings within the school while she could watch her students use the skills being discussed would be useful in the future as it would allow her to discuss, reflect, and see computer science in action at the same time.

### **Maggie**

Maggie joined the study as a student teacher assigned to Sunnyside Elementary School, a school in a diverse urban environment originally built in the early 1900s located in the Westwood Public School district. Although she was assigned a clinical faculty member and placement working with 3<sup>rd</sup>-grade students, Maggie also spent some time in a second-grade

classroom as this was the only grade where she had not previously observed or completed a shorter practicum experience, and she was curious to see the difference in grade levels. The clinical faculty member to whom Maggie was assigned had been teaching at the school for six years at the time of the study. There were 14 students enrolled in her assigned 3<sup>rd</sup>-grade classroom. Maggie was one of two participants who worked closely with students in multiple grade levels during this study.

When Maggie agreed to be a participant in this research, she indicated she was very nervous about leading an entire classroom despite having multiple hours and placements leading up to this experience.

“Leading the classroom and being in charge of everything from lesson planning to discipline kind of scares me. Before, we had the classroom teachers there to help and jump in when needed and do the planning. I know my clinical faculty is technically there, but she really is just there as support and not as a teacher. This is all my stuff and I do not want to mess up and tell [the students] or show [the students] something wrong”

(Maggie, meeting #1 transcription).

Thus, Maggie wanted to learn as much as she could about everything that may help her in a future classroom. In fact, she mentioned several times in our first face-to-face meeting that she wanted to learn from her clinical faculty member and see, “how [her clinical faculty] plans and executes lessons that all students are able to complete, especially lessons that span different subjects” (Maggie, meeting #1 transcription). Indeed, although Maggie reported being unfamiliar with the VA SC SOLs, she was interested in learning more about the standards and how she might be able to integrate them in her future teaching. Maggie explained that this was one of the reasons she agreed to participate in this research, as she believed that “computer science could be

incorporated into every subject area” (pre-questionnaire). She went on to write she had no familiarity with the VA CS SOLs at the beginning of the study (pre-questionnaire; post-questionnaire).

Maggie began the study explaining that her concept of computer science included, “problem-solving, organizing data, etc., through programming” (pre-questionnaire). She seemed confident in her answer, jotting the words down quickly and without hesitation. It appeared that although she was not familiar with the VA CS SOLs specifically, she had prior knowledge of computer science and, unlike other participants, understood some of the associated concepts outlined in the VA CS SOLs. Maggie followed this by explaining her concept of computational thinking to be, “understanding that there is more to using computers: analyzing, sequencing, etc.” (pre-questionnaire). In contrast to when she answered the previous question, Maggie took a moment to think about her definition of computational thinking, appearing more unsure of her answer and clearly trying to recall any information she may have learned, even looking up at the ceiling as she thought about it. Lastly, Maggie wrote that she had never heard of using coding or coding applications in a classroom environment when asked about them on her pre-questionnaire. She stated, “I had not thought of all of that as computer science stuff for elementary school, but more for older kids in computing class.” (Maggie, meeting #1 transcription) when she handed me her pre-questionnaire. This, however, was not what she was most worried about at the time. Maggie said her biggest concern was incorporating computer science content at all in a way that would make sense to the students because she “was not very good with computers and had not had training in the specific SOLs” (Maggie, meeting #1transcription) although she had not mentioned needing computers to teach computer science in her earlier definition. This statement not only illustrates an unfamiliarity with computer science

and the thinking skills and processes that can be achieved without hardware, but also a lack of confidence and comfort with using computers.

This sentiment of not wanting to incorporate computer science at all due to a lack of comfort or confidence in her own abilities began to slowly change after meeting with the other participants for a second face-to-face discussion in March 2020 where computer science and, specifically, the VA CS SOLs were discussed. Maggie expressed that her perceptions of the VA CS SOLs had changed because she realized,

“...how easy and fun computer science can be. It makes me excited to start using it, but I am still nervous that I'll do it wrong because no one really showed me how. I feel like I would at least try to incorporate computer science and the SOLs into future lessons, though, especially with the right resources and support” (Maggie, meeting #2 transcription).

This sentiment echoes that of other participants and speaks directly to the lack of training, or perceived lack of training, in the area of computer science for elementary pre-service teachers. It also highlights the need for support from peers and administrators for teachers, both in-service and preservice, working to incorporate the VA CS SOLs into content area lessons. Additionally, during this second face-to-face meeting, Maggie identified what she felt was a second challenge to adding the VA CS SOLs to her future content area lessons. Outside of not being trained in or shown different ways to incorporate computer science into her elementary classroom - the first challenge-, she indicated that she was “concerned about the time it takes to do this stuff in the classroom” (Maggie, meeting #2 transcription). This concept of time as an identified challenge came up again during a later interview.

By the midpoint mark of Maggie's student teaching experience, she was able to discuss why, if at all, she thought the VA CS SOLs were important to include at the elementary level and how her idea of computer science had changed. She was also able to provide more insight into what she saw as challenges and benefits to introducing computer science to young students. On her mid-questionnaire, Maggie wrote about including the VA CS SOLs and identified computer science skills into elementary content area lessons:

“It is important that children today have [computer science] skills. More and more jobs are becoming available having to do with technology and no one is filing them.

Everything today seems to be becoming online and if children have these skills, they will have a better opportunity to take some of these jobs” (mid-questionnaire).

She made a similar remark during our first phone interview conducted at the end of March, not only discussing her perceived benefits of incorporating the VA CS SOLs, but also indicating she was feeling more comfortable identifying what she believed to be computer science. Maggie said,

“A lot of [the VA CS SOLs] are already in the lesson plans. It's a matter of you identifying which ones are already being addressed. But I think some of the benefits are, they help kids be able to work on their problem skills and being able to analyze things. I think they fit in almost every subject.....and, almost everything I do in my classroom, a lot of the assignments and stuff, are on computers and students need to understand how to problem-solve and analyze and use critical thinking skills. That's where I see computer science overlap with other subjects. So, I think it is beneficial for them to learn because it applies to what they are doing in the classroom already” (Maggie, phone interview #1).

Indeed, by simply observing and working with students in the classroom combined with spending some thinking about the VA CS SOLs, Maggie determined not only that elementary students could do computer science, but that they were already doing many of the things outlined in the standards in daily content area lessons. These were two of her concerns coming into the study; Maggie was able to identify what she saw as benefits to incorporating computer science in all content areas after just a few weeks. Furthermore, at this ‘midpoint check-in’, Maggie modified her previous definition of computer science and computational thinking and now explained that in her opinion, “[C]hildren developing computer skills, coding skills, and creativity skills is all computer science. Computational thinking can basically be defined as problem-solving and the different steps needed to solve the problems” (mid-questionnaire). Although Maggie’s definitions were evolving based on her experiences and conversations with peers and mentors, in her opinion, additional training in the area would have been beneficial prior to entering the classroom for student teaching. She went on to write,

“I barely knew anything about computer science before and what it actually meant to implement it and the SOLs into the classroom. Now, I have a greater understanding of how easy it can be to implement it into my lessons after being able to read over them and stuff. I wish I had known some of this before I started” (mid-questionnaire).

Maggie continued by identifying specific content areas where she believed she could implement computer science.

“I think definitely math, and I think also reading when you’re sequencing events and stuff of a story you’re reading. Oh, and then we can analyze the story. I know right before we left school, we were doing poetry. I think computer science could fit in with that, too” (Maggie, phone interview #1).



Yet, despite indicating a greater comfort with computer science and the VA CS SOLs, Maggie continued citing her lack of computing knowledge as a challenge with integrating all aspects of the VA CS SOLs into her future lessons. When asked specifically what challenges, if any, she saw to integrating the VA CS SOLs into content area lessons during our first phone interview, Maggie responded,

“I think the main challenges that I had when I was learning about [the VA CS SOLs] was even though not all of them are directly, have to be a computer, is that I’m not very good with computer stuff. So when we were discussing coding and that kind of thing on the discussion board and during our meetings, I was stressed about how I would be able to teach my kids properly how to use it” (Maggie, phone interview #1).

This feeling of being underprepared and not having a clear understanding of computing knowledge highlights the increasing need for reform in teacher education to ensure students are entering the classrooms with the skills and knowledge needed to be and feel successful.

Maggie’s perceptions of and comfort regarding computer science and the VA CS SOLs in elementary content area instruction continued to evolve during the second half of her student teaching experience. When we spoke a second time for the final interview in May 2020 after Maggie’s student teaching semester had completed, she spoke about computer science and the VA CS SOLs in a manner that indicated she had invested time in learning more about what they said and required. She said,

“I definitely think my understanding of the VA CS SOLs changed for me. At the beginning of student teaching, I didn’t really have any understanding of what they were, and I kind of only thought of it as having to do with computers. Obviously, that part does

play in, but just understanding that they can be applied to every subject in the classroom in different ways is new to me” (Maggie, phone interview #2).

Maggie continued by disclosing that she did not feel as though her clinical faculty member or any teacher that she worked with directly at Sunnyside Elementary explicitly taught computer science or the VA CS SOLs. However, she now felt as though she could identify elements of computer science in their planned content area lessons, indicating growing confidence and understanding of computer science constructed through experiences, discussions, and personal connections. Maggie remarked, “Oh, I saw computer science in a couple of lessons that my cooperating teacher taught, like having students comparing and contrasting and finding patterns. We did a lot of that, especially in math” (Maggie, phone interview #2). When I asked Maggie why she thought her clinical faculty member did not directly reference the VA CS SOLs when working with students or writing lesson plans since she was clearly, at least to Maggie, integrating them, she responded,

“I don’t think she understood it, because I remember I told her when I first started learning about it and stuff, she was like, ‘I have no ideas what that even is.’ I just did my own thing after that” (Maggie, phone interview #2).

Although Maggie’s clinical faculty did not appear to see the value in teaching computer science and reportedly dismissed her when she brought it up, Maggie did not seem discouraged when speaking about it. She had a cheerful tone to her voice while speaking and sounded as though she had brushed it off, commenting, “[My clinical faculty] was comfortable with her lessons and didn’t really want to change them for anything. She liked walking in and just teaching and not having to do too much outside of her normal routine” (Maggie, phone interview #2). I continued our conversation by asking if she felt as though there were any benefits that came to mind when

thinking about incorporating the VA CS SOLs. Maggie's response confirmed that throughout her student teaching experience, she continued to believe that there were, indeed, benefits to incorporating the VA CS SOLs into elementary education.

“I think there are a lot of benefits. I think the main one that I noticed was that it helps my students critically think and have a deeper understanding of what we are learning about in all subjects. And I think it also helps open them up to more the computer stuff that I struggled with; you know? How that kind of stuff works” (Maggie, phone interview #2).

One area that was steadfast throughout Maggie's student teaching experience was her ideas related to incorporating computer science in general and the VA CS SOLs. She indicated the same challenges at the end of the semester as she did in the beginning - a lack of training for classroom teachers, little time to find resources and study the standards, and even less time in the school day to spend teaching students new material. Specifically, Maggie continued to note her lack of confidence in using technology and thus meeting the standards that specifically mentioned computers and coding, emphasizing again,

“I am not really good at computers. I do not want to tell the students something wrong, so it would take me a second to understand what those standards were saying about using them before I could try to teach it” (Maggie, phone interview #2).

At this time, Maggie did not note any specific instructional challenges for the students, even commenting that they used computers for everything and would probably pick-up computer science skills more quickly.

Overall, Maggie's perceived ability to incorporate and intention to integrate computer science and the VS CS SOLs into future content area coursework grew over her student teaching experience. She indicated the most comfort with the VA CS SOLs that required students to work

on problem-solving skills and sequencing. When asked on the post questionnaire if she thought she would explicitly teach the VA CS SOLs in her future classroom, she wrote, “Yes, I feel pretty comfortable with them because I have come to understand how they can be used in different areas and I know I can take what I saw the students doing here and apply it later” (post-questionnaire). Maggie felt as though her student teaching placement had an impact on her perceived ability to integrate the VA CS SOLs because she was able to read through the standards while her clinical faculty member taught and identify skills and practices already being presented in the lessons. Additionally, she indicated on her post questionnaire that she learned the most about computer science, and teaching in general, from watching the students work in class and interact with their friends.

### **Yudi**

Yudi was one of two participants in the study working toward licensure in Special Education, General Curriculum K-12. Her elementary student teaching placement was in Pinehill Elementary School in the Oceanside Public School district, a neighborhood school that opened in 1959. Yudi was not assigned one specific classroom in Pinehill. Instead, she was assigned to a clinical faculty member with 14 years of classroom experience who worked with students in both 4th and 5th grade through a pullout program. Essentially, a pullout program involves removing students from their classroom at different points during the school day for individualized or small group instruction that is designed to meet the students’ specific needs (Fernandez & Hynes, 2016). Due to the nature of this pullout program, Yudi agreed to participate in this research as a way to gain a better understanding of how to integrate the VA CS SOLs into the content area lessons provided by the students’ homeroom teachers.

When Yudi started student teaching, she thought she had at least “minor knowledge” of computer science. She believed computer science to be “critical thinking on the computer and the skills [students] need to do this” and specified computational thinking as a “skill that lets people look at real-world problems and solve them with assistance” (pre-questionnaire). This skill, the ability to consider and solve “real-world” problems, is especially important for special education students accessing the general curriculum in schools. Often, according to Yudi, (Yudi, meeting #1 transcription), students with special learning needs may not be able to easily work through the general thinking strategies taught in most classrooms and may benefit from thinking about things differently. One such way is in terms of “computational steps or algorithms” as identified in the VA CS SOLs (2020). Additionally, because “some computational thinking practices can be developed with or without technology” (VDOE, 2020), students who find working on a device challenging due to mild disabilities can still improve these skills. Yudi wrote on her pre-questionnaire that computer science could and should be included in daily lessons at all levels, especially for students who needed extra help breaking down problems and solving them. At this time, Yudi noted that she was not at all familiar with coding or coding applications for education, or the specific skills outlined in the VA CS SOLs although she had read them and did know they were required.

While meeting the first time with the other participants for a face-to-face discussion about the VA CS SOLs and computer science in general in elementary schools, Yudi began to speak about specific content areas where she believed computer science would be a great addition to her lessons. She was reading through the VA CS SOLs on her iPhone and stopped and said,

“I see how the SOLs build off of each other and I can use them with all my students. [Computer science] can help students think about the big picture - this is what we want, but how do we get there? I can see using this type of thinking in math with fractions. Like, here is the big picture. How do we break it down? What can we use to get this result as a whole? I guess this is really more of a thinking process than something that needs a computer all the time” (Yudi, meeting #1 transcription).

This statement was the first time that Yudi identified her own shift in what and how she thought about computer science. After reading through and considering what the VA CS SOLs included for the first time, she moved from thinking of computer science as something that needed a computer to be taught, to a way of thinking and a set of skills that could be developed in multiple subjects. Yudi went back to her students and lessons with this mindset about computer science until we met again.

During our second face-to-face meeting, Yudi seemed encouraged about integrating computer science into her lessons. When asked if she had a chance to review the VA CS SOLs or try specific ones out in any lessons, she replied,

“I did look at them a few times. I think they are very direct and to the point and not at all confusing. They seem age-appropriate and I like how they have the same topics included throughout. So, I think if everyone got on board, we could start with the Kindergarten SOLs with students who need to go back this far and then just keep progressing” (Yudi, meeting #2 transcription).

This type of gradual progression is especially important for the students that Yudi was working with at the time and will be working with in the future. As students develop their computer science skills, they can move on in the same strands as other students but at their own pace,

something that special education students working in a general curriculum environment could benefit from trying. Yudi went further in her discussion about the VA CS SOLs and took the opportunity to speak about her growing comfort with them.

“I think at first I was like, ‘Computers. How do you teach this if you don’t have computers in your classroom?’ but now I feel much more comfortable knowing that you can apply [computer science] in various settings. So, I feel very comfortable that [the students] don’t necessarily have to have a Chromebook sitting in front of them, but we can still apply the same skills” (Yudi, meeting #2 transcription).

Indeed, this shift in thinking about computer science as a way to prepare students to work on and with computers to a set of skills that helps students solve tasks and identify the impacts that computing has on society, echoes Yudi’s increased comfort with the VA CS SOLs and perceived ability to integrate them into content area lessons.

Additionally, Yudi took this time to identify some of what she believed to be benefits to including computer science in lessons with elementary students, especially the students she worked with regularly. She noted that skills associated with computer science can be used in all content areas and have the ability to be used on a very simple level or with more detail as the students advance in their understanding and application of the skills. Yudi mentioned the ease at which they can be included in lesson plans as the skills are already being taught in the simplest terms in many of the content area lessons. “The students are already working on creating and following instructions, drawing conclusions, trying to figure out what went wrong in a math problem, et cetera. I am pretty sure these are all aspects of computer science after reading the SOLs” (Yudi, meeting #2 transcription).

A notable challenge Yudi identified during this meeting was the lack of training she had received in her content courses on exactly what computer science is and how to specifically incorporate it into lessons created for students with very different learning styles. A second challenge she saw at the time was the lack of support and urgency for implementing the VA CS SOLs within her placement school. Yudi did not think that the classroom teachers she worked with intentionally left computer science out of her lesson plans, she just did not think that they had been formally introduced to them at the time.

“I think some of the teachers would use them or add them in if they knew more about them. No one likes to try new things in front of the students the first time, so without training and practice they probably just don’t put them in” (Yudi, meeting #2 transcription).

The next communication I had with Yudi was for her mid-questionnaire and first individual phone interview. She was excited to share that some of the lead classroom teachers in her placement school had started a robotics club and many of her students signed up to participate. Thus, Yudi had been able to see robotics and coding in action with elementary students. Yudi was the only participant in the group who discussed coding and programming specifically as important topics and skills for her students. She deliberately spoke in our first phone interview about watching her students working with programming and problem solving and being amazed at how quickly they picked it up and their excitement when what they created worked.

“[The students] just did it. They jumped right in – they didn’t hesitate at all! They listened to some basic instructions and then just went from there. They had some



problems, but once they made it work, they were all so excited” (Yudi, phone interview #1).

Yudi went on to say how delighted she was to be able to relate what they were working on in this club with content area lessons, such as math, when speaking one-on-one with her students in their pullout programs. “Having something the students can relate to, that they have just done, is very important to the students I work with when I am trying to help them understand a concept” (Yudi, phone interview #1). While describing different aspects of the robotics club to me during our phone interview, Yudi also took the time to discuss several challenges she saw that came with starting a club like this, especially with students who may not have traditional learning styles. The challenges included following instructions, teamwork, and the introduction of new material. However, Yudi admitted that these challenges may be increased due to the nature of the student population with whom she worked and not as much of a problem with other students. When asked if she sees herself integrating the VA CS SOLs specifically into her future classroom and content area lessons, she responded,

“Yes, absolutely. They have such an important place in the curriculum regardless of what the subject is. They impact the way students think. Some students might not get it right away but might be perfect for another student to think like that, so I think it is important to include them even though some schools, it seems, are not using them” (Yudi, phone interview #1).

Based on Yudi’s experience working in her placement school, the VA CS SOLs were not being integrated or discussed as far as she knew. However, because she was able to see the benefits of incorporating different aspects of computer science into content area lessons with her students, Yudi feels as though she will continue to use them in the future.

Throughout the course of this study and Yudi's student teaching experience at Pinehill Elementary School, the perceived challenges and benefits she identified with including the VA CS SOLs evolved as did the way she interpreted computer science and the VA CS SOLs. In her post student teaching interview with me that took place in May 2020, Yudi said,

“My perspectives of the VA CS SOLs have definitely changed. I knew the standards existed, but I had never implemented them....So just learning about it in general, my perspective changed because it can be utilized in every subject. I think people hear computer science and they assume a topic that solely relies on using a computer, but that is not exactly what it's about. So, yeah, it is definitely changed” (Yudi, phone interview #2).

Throughout the semester, Yudi's ideas about and understanding of computer science continued to evolve based on her experiences working with her students while staying committed to learning more about the VA CS SOL's strands for each grade level. Yudi further explained her comfort level integrating the VA CS SOLs into her future classroom and content area lessons on her post-questionnaire. She wrote,

“I would not say I am 100% comfortable integrating the standards into my future classroom but it is something I definitely will use in my classroom, and as my students learn the standards, I will learn alongside them as a new teacher just like I would do with anything else. I feel more comfortable now implementing them than I did before” (post-questionnaire).

Indeed, because Yudi was able to see and discuss what she felt at the time as benefits to including the VA CS SOLs in lessons with her students, her comfort level trying them with her students grew enough that she feels she will use them in the future. Had she had more of an

introduction to them before entering the classroom as a student teacher, Yudi may have felt this comfort level earlier on in the semester. Still, Yudi also felt comfortable enough at this point to discuss specific VA CS SOLs that she felt she would and could use with her future students. She wrote on her post-questionnaire,

“Depending on my students’ grade level and understanding of the computer science standards, I may change the ones I use often. I believe in special education implementing the algorithms and programming standards - they would work excellently because it allows the students to understand and create step by step instructions and can be used across various subjects” (post-questionnaire).

The VA CS SOLs that Yudi reported feeling less confident incorporating into future content area lessons fall under the headings of computing systems, cybersecurity, data and analysis, impacts of computing and networking and the Internet. She cited a lack of training in computers and digital technology as reasons for not being as comfortable with these specific standards and ways to incorporate them into lessons. Not only does this sentiment speak to the importance of providing pre-service teachers with training in computer science skills and concepts to use in classrooms, but also highlights the misconception that preservice teachers are more comfortable with computers and technology -especially technology in the classroom – than some seasoned teachers. Although many preservice teachers may be savvy with technology such as tablets and cell phones, they may not have a clear understanding of strands such as computing systems and data analysis.

Finally, like many of the other participants reported at the end of the study, Yudi remarked that she felt as though many of the teachers in her placement school were including computer science skills in their lessons with the students, they just did not know they were doing

it and did not include the specific standards in their lesson plans as a result. She did, however, feel like the teachers in her school were going toward using more technology in their classrooms leaving her encouraged that they would include more computer science in the future. Still, Yudi expressed that student teaching had a major impact on how she viewed computer science and the VA CS SOLs citing her experiences with her students as the major contributor to her positive view of incorporating them into content area lessons. “Watching how my students responded to different ways of approaching problem solving and the way they took to everything in the robotics club made all the difference for me” (Yudi, phone interview #2).

### **Kim**

Kim, like Yudi, was completing her final semester toward a degree in Special Education, General Curriculum, K-12. She joined the study to gain a better understanding of what computer science is and how others planned to incorporate the VA CS SOLs into future lesson plans. Of all the participants, Kim was the most reserved and most hesitant to speak about computer science when the study began, writing, “I am not at all familiar with the computer science standards and am not sure how to use it in the classroom” (pre-questionnaire). Still, she was interested in participating in the study to learn about a “topic that can possibly help [her] students learn” (Kim, meeting #1 transcription), especially because of the educational focus of her student teaching placement. Kim was assigned to Hawking Elementary School, a “model school” in the Westwood Public School district. The school received this designation because of its’ commitment and focus on teaching and learning based on the latest research, technology, and enrichment activities to help students succeed (NPSK, 2020). Kim wanted to be able to meet these expectations when working with her students; thus, she agreed to participate in this research. At the time of the study, Kim’s clinical faculty had been teaching for 9 years; there

were 15 total students in this classroom, 5 identified as needing special education services. As a preservice teacher seeking endorsement in Special Education, General Curriculum K-12, Kim directly assisted those five students but also helped with the other students as needed.

Kim began the study by identifying computer science as “the use of technology to create things such as programming for a robot” (pre-questionnaire). She was unable to identify any associated skills or concepts at the time and reported being unfamiliar with coding and coding applications. However, when asked if she felt as though computer science can be integrated into elementary instruction on her pre-questionnaire, she wrote, “Yes, it could be used, because it could be used for a math lesson where [the students] have to solve a problem or use code patterns to create a final product” (pre-questionnaire). These conflicting statements emphasize Kim’s lack of comfort with computer science but basic, although unrealized, understanding of some of the processes and skills associated with computer science principles. She easily identified what she saw as useful areas to integrate computer science in content area lessons at the elementary level but apparently did not have enough exposure or training in them to put the concepts together. These ideas of wanting to integrate computer science and feeling as though they would be beneficial in content areas but uncertainty in her ability to do so without training continued into the semester.

After meeting with the other participants in February and March 2020 for two face-to-face meetings, Kim reported that she was very likely to incorporate computer science into her content area lessons but would feel more comfortable doing so with training. Kim was fairly quiet in these meetings, listening to what others had to say and nodding in agreement, but she did not add much to the conversation unless specifically asked. One such time was regarding the outline of the VA CS SOLs. Kim reported that she likes that “the VA CS SOLs are written in a

manner that is straightforward, easy to follow, and pretty easy to understand” (Kim, meeting #2 transcription). She continued,

“I wish I had more time to really study them and try to work them in with the kids, but I have to do the lessons the teacher asks me to help with and rarely have time for that with my students” (Kim, meeting #2 transcription).

This was the first of several times throughout the study that Kim mentioned the concept of time when talking about computer science and the VA CS SOLs.

By the midpoint of her student teaching practicum, Kim was able to discuss more of the benefits and challenges she saw to integrating the VA CS SOLs into her lessons. During our first phone interview, Kim said,

“I think a benefit of incorporating these standards into lessons with young students is that they need to learn to use technology. A benefit specifically for special education would be that [computer science] helps students see different content like math and reading, in different ways to help them learn” (Kim, phone interview #1).

This sentiment of computer science helping students with disabilities think and see in alternative ways echoed that of Yudi, the other participant working toward an endorsement in Special Education, General curriculum. Kim also wrote about her perceived benefits on her mid-questionnaire reiterating her view of computer science being a tool to help struggling students learn.

“The students I work with often need more help with concepts than others. They might not see or understand things like the rest of the class. Teaching students to follow steps and do some of the other skills listed in the SOLs may help my students” (mid-questionnaire).

However, this idea of using computer science with students who identify as requiring accommodations is also where she saw most of the challenges to integrating computer science and the specific topics outlined in the VA CS SOLs. Kim reported in her phone interview that,

“With special education students, integrating computer science would depend on each student’s disability because the disability could interfere with them participating in lessons that incorporate computer science. This would almost have to be a one-on-one thing to make it work” (Kim, phone interview #1).

It is because of this belief that a student’s disability could interfere with participation in a lesson that included computer science that Kim indicated during our first phone interview that her use of computer science in her future content area lessons would depend on the student or students she is working with and the specific disabilities.

“Some content areas are harder for some of my students than others. I would have to be really creative when writing the lessons to make sure it all fit together. I do not want the computer science part to make it harder for them” (Kim, phone interview #1).

Kim did, however, say that she felt comfortable enough with what the VA CS SOLs said that she was confident she could teach the skills and practices associated with computer science to elementary students if she needed to. Yet, Kim did not think that her clinical faculty member, or any teacher working at Hawking Elementary School during her student teaching experience, integrated computer science, and certainly did not list the VA CS SOLs on their lesson plans. She said in her mid-semester phone interview,

“I really did not see it – no one made a point to include computer science or list them on lesson plans. I think I could see opportunities for it to be integrated, but I never specifically saw it taught in the main content areas” (Kim, phone interview #1).

Like most of the cases in the study, Kim's perceived challenges and benefits to integrating the VA CS SOLs into elementary content area lessons did not change during the last half of her student teaching experience. When I spoke with her in May for our final phone interview, Kim reiterated that she believed there are many benefits to integrating computer science. She went into more detail on her post-questionnaire, writing,

“I think that computer science helps all elementary students enhance their computational thinking, because it assists students, especially special education students, strengthen skills such as problem - solving and teamwork skills. It helps students be able to make progress towards independently finding solutions and to learn to work with others to meet goals such as programming a robot. These are skills that are important for all students, particularly special education students, because they will need these skills for when they are living independently and may have a position where they will need to appropriately work with others to complete tasks” (post questionnaire).

Still, Kim once again reported that she thought she would not have enough time to incorporate the VA CS SOLs into lessons for many of the students with whom she worked. She noted that depending on the disability, most of the lesson time would need to be spent on the content tested by the state and keeping the student focused on that material.

“Most of my job is to help my students understand the lessons the lead teacher writes. Most, if not all, of those lessons revolve around passing the SOLs. Sometimes I spend a week working on the same skill. I just do not know if there would be enough time in the day to try to teach anything else” (Kim, phone interview #2).

By the end of the study, Kim was more comfortable and willing to discuss the benefits of teaching computer science to her students but unwilling to vary from the lessons or traditional



ways of working with her special education students as demonstrated in previous practicum experiences or her education courses. Thus, she had not incorporated the VA CS SOLs into her lessons. However, unlike the beginning of the study, Kim was able to go into detail about the VA CS SOLs she felt the most comfortable integrating into her content area lessons with her future students after completing student teaching. She wrote on her post questionnaire,

“I think that the Algorithms and Programming standards would work best for my future elementary special education students, because of their different levels of reading. If they were to learn from creating animations, or if only visuals for sequencing were used to demonstrate comprehension, then it would allow them to fully participate with their general education classmates. Also, it would allow my students, especially those with Autism, to be able to express themselves and understand not only their own thoughts and feelings, but other students' thoughts and feelings” (post-questionnaire).

This clear outline of perceived benefits and potential ways to incorporate the Algorithms and Programming strand into content area lessons and assessments demonstrates Kim’s evolving understanding of and comfort with the skills outlined in the VA CS SOLs. However, this was not the only strand of the VA CS SOLs that Kim saw as a benefit to her students. She added,

“Another standard that I think would work best with the elementary special education students I will be working with would be the Computing Systems standards, because not only would it strengthen my students' problem - solving skills at a basic level, which may very well be one of their IEP goals but will teach my students how to appropriately work with others if they had to work on a computer together. Also, it could help students who may have trouble articulating their ideas appropriately strengthen their communication

skills, especially when presenting, if they had to demonstrate what they were doing” (post-questionnaire).

This strand of the VA CS SOL that Kim was referencing reads,

*The student will identify, using accurate terminology, simple hardware and software, problems that may occur during the use, and apply strategies for solving problems (e.g., rebooting the device, checking for power, checking network availability, closing and reopening the app).* (VDOE, 2020).

Again, as demonstrated by this statement, Kim is able to identify how she thought integrating the VA CS SOLs could help her special education students succeed. Further, she was the only participant who identified this strand of the SOLs as one that she would feel comfortable using. When replying to the questionnaire on the post-questionnaire asking if there are any VA CS SOLs that the participant feels less comfortable integrating, Kim wrote,

“The one computer science standard that I would not be comfortable integrating into my instruction would be the Impacts of Computing standards, because I may have a large group of students with Autism, who may still not be able to understand how others may feel or be impacted positively or negatively by technology. They themselves may not be able to understand how technology impacts them. The instruction would then have to be differentiated in a manner where they will be able to understand in their own way how others may feel about technology, but even then, it could take an extensive amount of time for the mentioned students to be able to understand“ (post questionnaire).

Here, once again, Kim noted time as a reason to not integrate or at least introduce a skill outlined in the VA CS SOLs to her student in addition to her lack of comfort with the strand.

Overall, Kim's perceived comfort integrating and knowledge regarding the VA CS SOLs changed over the 14 weeks she was in student teaching. She went from stating that she was not familiar at all with the VA CS SOLs to discussing how computer science activities could help teach her students to be more independent and wanting to participate and being able to identify specific SOLs that could help with these things. Although she never saw her clinical faculty member or any teacher in her placement specifically integrating the VA CS SOLs into lesson plans, she thought she could identify aspects of computer science in their lesson plans and hoped to find a way to use those same concepts with her future students.

### **Conclusion**

This chapter provided detailed information about each school district where the participants completed their student teaching internship. In addition, each case was outlined describing the perceptions of each participant at different points during the semester. In the next chapter, I will discuss the similarities and differences between the cases as a result of the cross-case analysis, the perceived challenges and benefits to integrating the VA CS SOLs into content area lessons as described by each case, and the themes that emerged from the cross-case analysis. Finally, I will discuss and the limitations and implications of the research.

## **CHAPTER V**

### **DISCUSSION AND IMPLICATIONS**

In this concluding chapter, I start by presenting an overview of the purpose of the study including the research design and guiding research questions. I then present the challenges and benefits of incorporating the VA CS SOLs as outlined by the participants. Next, I include the results of the cross-case analysis including the three themes that emerged along with similarities and differences between the cases. Finally, I explain the implications of the findings of this study, the limitations to the study, and opportunities for future research.

#### **Overview of the Study**

As the need for computer science skills and a basic understanding of computing processes increases in all areas of the workforce around the globe, there is a growing need for students to be exposed to all aspects of computer science during their PK-12 education. Thus, we are seeing an increasing number of schools integrating computer science activities, lessons, and learning standards into their existing curricula spanning the grade levels (Depta, 2015; Leonard, Mitchell, Barnes-Johnson, Unertl, Outka-Hill, Robinson, & Hester-Croff, 2017; Yadav, Hong, & Stephenson, 2016). However, with the integration of computer science content comes the need for more educators with exposure to and basic knowledge of computer science to implement lessons in meaningful ways.

The integration of computer science into content area lesson plans at the elementary level is essential for students to create a solid foundation of computer science skills and concepts that they can build on throughout their educational careers. Unfortunately, at the time of this study, there are not enough teachers at the elementary level that have both the content and pedagogical knowledge to effectively integrate computer science and associated skills and processes, such as

computational thinking (Ozturk, Dooley, & Welch, 2018) into elementary content area lessons. It is because of this need for more highly qualified teachers with experience incorporating computer science that there is a call for teacher educators to look at and improve the ways computer science is introduced to pre-service teachers during their content area coursework (Whipp, Eckman, & van den Kieboom, 2005; Yadav et al, 2014) and practicum experiences required of their educational programs, especially those seeking licensure in the elementary grades.

Thus, the purpose of this study was to gain a better understanding of how elementary pre-service teachers understand and consider computer science and the VA CS SOLs, and to determine if their perceptions of the VA CS SOLs changed as a result of their student teaching placement. Results of this study will aid teacher educators in preparing pre-service teachers for their future classrooms and school administrators working with and supporting student teachers within their buildings. Hence, data for this study were collected to determine the perceived challenges and benefits of including the VA CS SOLs into elementary content area lessons, as well as each participant's perceived comfort understanding, identifying, and ability working with and integrating the VA CS SOLs into future content area instruction as a result of their student teaching experiences. The research questions that guided this study are:

RQ1) How do elementary pre-service teachers perceive their ability to teach and integrate the Virginia Computer Science Standards of Learning in future content instruction?

RQ2) What shifts, if any, occurred in these pre-service teachers' perceptions in response to their student teaching experience.

Participants were selected through purposive sampling and then invited to be part of the study. To find participants who represented a range of elementary grade levels, who were open

to discussing and considering computer science at the elementary level, and who would provide me with the best information to help explore and understand the quintain (Patten, 2002), I held two face-to-face meetings with twelve elementary pre-service teachers who agreed to be part of the study. I then sent an email to six of the participants who represented different schools and grade levels in nearby districts to recruit them for the second round of data collection. Five participants agreed and each became a separate case. See Chapter 4 for the full description of the findings by case.

### **Perceived Benefits and Challenges**

Each of the cases in this study identified different challenges and benefits to including the VA CS SOLs in their future content area lessons. It is important to understand the apparent benefits and challenges as understood by each participant as they are often linked with perceived comfort and knowledge of computer science and may influence the way computer science is introduced, taught, and used (Wang, et. al., 2016) in their future lessons. The perceived benefits and challenges of each participant are outlined in Table 5 and Table 6.

**Table 5***Perceived Benefits to Integrating the VA CS SOLs into Content Area Instruction*

Perception /Participant	Jayden	Bella	Maggie	Yudi	Kim
Benefits	Provides essential life skills  Easy for the students to relate to computer science and technology  Allows for hands-on exploration of skills	Helps students use and exchange content area facts and skills from one subject to another  Teaches higher-order thinking skills  Second-nature for most students  Allows for creativity	Elementary students already work and learn through technology  Second-nature for most students  Knowing about computer science will help them get jobs in the future	Many students already use computer science skills both with and without technology  Easily simplified to meet all learning needs  Aspects already included in most lessons - easy to integrate  Helps with problem-solving skills	Elementary students already work and learn through technology  Helps with problem-solving skills  Allows for creativity

*Note.* This information is collected from all data sources.

**Table 6***Perceived Challenges to Integrating the VA CS SOLs into Content Area Instruction*

Perception /Participant	Jayden	Bella	Maggie	Yudi	Kim
Challenges	Teacher buy-in  Not a tested subject area  Time to learn and practice for both students and teachers  Little training	Time to learn and practice for both students and teachers  Teacher buy-in  Support	Time to learn and practice for both students and teachers  Training  Teacher lack of comfort with technology  Support	Time to learn and practice for both students and teachers  Few resources  Lack of training	Students have different learning needs and abilities  Time to learn and practice for both students and teachers  Few resources  Training

*Note.* This information is collected from all data sources.

Overall, many of the same recognized benefits and challenges to incorporating computer science and the VS CS SOLs were shared by all participants. Every participant recognized computer science as an area that many of the students can easily relate to even if they are unfamiliar with the specific concepts and terms, even suggesting that many of the skills may be second nature to the students depending on grade level and based on experiences outside the classroom. Additionally, all participants noted that some students and/or lessons presented within content areas already involve computer science, making the processes, skills, and practices easily



integrated and interchangeable across subjects. Four of the five participants pointed out that integrating the VA CS SOLs into elementary curricula can help teach students life skills, such as problem-solving, that will be beneficial to them throughout their educational years and into future careers. This belief aligns with work done by Wilson and Moritz (2015) where they write, “[e]arly exposure to CS educational experiences is necessary to help diversify the CS, technology, and innovation workforce” (p 74). Finally, three of the participants identified that incorporating the VA CS SOLs supported hands-on learning that may be beneficial for many students as they work to make connections between what they already know and what they are learning. Incorporating the VA CS SOLS allowed students to be creative through design, coding, cooperation, and provided situations for problem-solving skills to be applied. These examples identified by the participants support cognitive constructivist learning methods as outlined by Powell and Kalina (2009), McLeod (2019), and Tam (2000) by providing opportunities for scholarship and through meaningful connections made by the individual students.

As expected with any newly introduced topic, the participants also identified what they see as challenges to integrating computer science and the VA CS SOLs into their future classrooms and content area instruction. All participants identified the need for time to learn about computer science and the VA CS SOLs for both students and teachers as a barrier to integrating computer science into future lessons. This is consistent with the findings of Keengwe, Onchwari, and Wachira (2008) and Dinc (2019) that reported lack of time as one of the biggest barriers to technology integration and skills associated with computing. Because of the extra stress and responsibilities that come with being a new teacher without the addition of unfamiliar content, this specific challenge was highlighted by the participants for all pre-service teachers. Further, time was highlighted as a challenge for the students because of the short class periods

and lack of extra time to work on content, such as computer science, that is not a tested standard of learning in the state of Virginia. Four of the five participants recognized that the lack of training received on the VA CS SOLs in their teacher education programs resulted in a lack of comfort, and therefore would make planning and executing lessons containing computer science much more difficult for them going forward. Lastly, four of the five participants suggested that they would need support with and access to resources on the VA CS SOLs by their future team members and administrators in the schools in which they will be employed. Based on their experiences in their student teaching placements, this was identified as a challenge. Ultimately, the perceived challenges identified by the participants were revealed early on in the study and influenced the overall themes that occurred as a result of the cross-case analysis.

### **Cross-Case Analysis**

The cases presented in Chapter 4 allow for different aspects of the quintain to be examined. Three common themes were found across all cases as a result of the cross-case analysis: time, training, and experience. In addition, several subthemes emerged under each category that helps to better define each topic. These themes emerged from the examination of similarities and differences within the quintain, and through the exploration of nodes, sentiment, and paragraph analysis options in the NVivo Qualitative Data Analysis Software. Further breakdown of the themes can be found in Table 7.

**Table 7***Breakdown of Themes and Subthemes*

Theme	Subtheme
Time	Time for instruction
	Time for training
	Time for exploration
Training	Availability for pre-service teachers
	Availability for in-service teachers
	Availability for students
Experience	Student and educator experience with computer science and the VA CS SOLs
	Student and educator experience and comfort with technology
	Experience leading to teacher “buy-in”
	Experience for pre-service teachers and the impact of the student teaching placement

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An explanation of the themes and subsequent subthemes are outlined below.

**Considerations of Time Constraints**

The concept of time, or a perceived lack thereof, was mentioned by all participants repeatedly and in multiple contexts throughout the course of the study. This is consistent with findings of previously conducted studies that suggest time is one of the largest barriers to technology integration and computer science for both in-service and pre-service educators (Dinc, 2019; Outlier Research and Evaluation, 2021). Figure 5 outlines the different aspects of time as

discussed by the participants as described as an aspect directly affecting their perceived intent and ability to integrate the VA CS SOLs into future content area instruction.

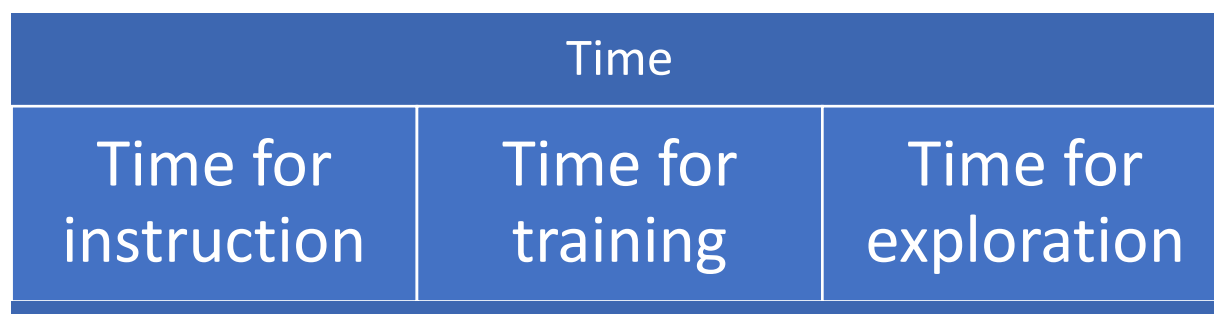


Figure 5: Subthemes of Time.

### ***Time for Instruction***

Instructional time has been a topic of discussion in education for many years. According to Barak Rosenshine (2015), students in elementary classrooms divide their day between academic activities, non-academic activities, and non-instructional activities, with academic time representing just 57% - 60% of the total hours in a school day. Because of this, many teachers maintain tight schedules and even struggle to meet the curricular demands set forth by individual districts and the state. Indeed, with the incorporation of pacing guides and monthly planners that many teachers must follow, the idea of adding anything additional, especially content that many teachers may not be comfortable with, that could take time away from provided lessons and activities seems daunting. Student teachers working in classrooms and learning from clinical faculty see the push to get all required content covered before the end of the year standardized tests given in certain content areas and may even experience the same stress as the clinical faculty for students to pass. Because in-service training such as student teaching has been shown to be one of the greatest factors on future instructional practices (Harbin & Newton, 2013), it is not surprising that the participants in this study responded similarly to their clinical faculty and

felt as though there is a lack of instructional time during the day to add new material or integrate new content such as computer science that is not a tested standard of learning in the state of Virginia at the time of this study. This aligns with research conducted by Outlier Research and Evaluation at the University of Chicago (2021) linking time to teach computer science that is not a tested requirement or standard as a barrier to scheduling and incorporating it into lessons. For pre-service teachers, especially those working to better understand material such as computer science and the associated standards of learning, there are two main implications as a result of lack of time for instruction. They are: 1) a reduced amount of time to observe and work with students on the topic while in their student teaching placement, and 2) limited exposure to methods and practices for including computer science content into lessons provided to them from other sources. Participants in this study noted both of these as contributing factors to their perceived growth and comfort with the VA CS SOLs, as well as the formation of what they perceive to be instructional challenges.

**Instruction Challenges Linked to Instructional Time.** The limited time for instruction noted previously influenced the participants' view of instructional challenges that come with integrating the VA CS SOLs into content area instruction. Most notably is the freedom to modify or write lesson plans to include computer science and the VA CS SOLs. While time for instruction was not the initial reason that this challenge was identified, it was later determined by all to be the main cause and underlying concern leading to this instructional challenge. This finding supports Veenman's (1984) finding that identified reduced planning time and time to work on and modify lesson plans as two of the 24 most perceived problems of teachers working to incorporate computer science. However, similarities and differences between the cases emerged as to how and why they were influenced.

Kim, for example, noted that the nature of her student teaching assignment limited her time and ability to integrate the VA CS SOLs into many of her lessons. Kim worked in an inclusive classroom and directly assisted specific students throughout the day as they worked through the lessons assigned by the general classroom teachers. Kim noted several that she had to follow what the lead classroom teacher had for the students and that she would not have much ability to vary from what was provided, thus limiting how, how much, and when computer science was introduced. Kim was one of two participants working toward initial licensure in SPED, General Curriculum PK-12, and was adamant that her students would have difficulties or require more instructional time with some VA CS SOLs than other students and pointed out that was not always possible for a number of reasons including instructional time.

Indeed, the two participants working with special education students, Yudi and Kim, both anticipate that they will need to reiterate computer science terms and lessons over and over again with their future students to meet the diverse learning needs where other participants did not specify this as an issue, increasing the amount of time needed for computer science instruction. They also agreed that some aspects of computer science would come more easily to their students than others but saw the importance of incorporating computer science into content area lessons. These observations made by both Kim and Yudi are in line with the results of work done by Sentence and Csizmadia (2016) that determined that a “student’s lack of understanding of content” and “differentiation to meet the different levels of ability” (p.479) are two of the five most commonly mentioned challenges of teachers working to incorporate computing and computer science. Where these two participants differed, however, was how much they thought they should integrate computer science into lessons if the homeroom teacher assigned to the students did not make it an instructional focus of the lessons. Yudi said she would feel

comfortable integrating computer science in areas where it fit and made sense to incorporate it to help students make connections regardless of time. She liked seeing the students get excited about learning new concepts and skills, especially those related to computer science, during her student teaching experience and expressed in a face-to-face meeting that she interpreted part of her job to be using whatever resources and skills she can to support her students and help them succeed (Yudi, meeting #2). Kim, on the other hand, reported being worried about integrating computer science into lessons if the classroom teacher did not include it. She, unlike Yudi, saw computer science and the VA CS SOLs as an area that needed specific time to discuss outside of the lessons with which she assisted her students and felt like she would need to work with students on tested content provided to her from homeroom teachers in the future before attempting to add new information. Of course, this belief may be linked to a lack of experience integrating computer science skills and standards that Instefjord and Munthe (2017) determined to be a critical factor in one's perceived ability and, in turn, attitude toward integrating computer science.

Further, the participants expressed their belief that the amount of instructional time devoted to computer science was directly related to the lesson plans created, and the amount of computer science integrated into content area lessons relied heavily on the person writing the plans. The instructional challenges here identified by the participants is that the responsibility for planning and executing a content area lesson may not fall on the same person and/or may influence how or how many VA CS SOLs are incorporated into content area instruction. Unlike Kim and Yudi who worked mostly with students using the lesson plans provided to them by their students' homeroom teachers, the other participants were responsible for creating lesson plans, executing the plans, and evaluating the success of the lesson. However, the participants reported

that each school had different guidelines and responsibilities for planning or creating lessons. In a normal year, one school had each grade-level team work together to create lessons for all content areas, one school left the execution of each lesson up to the individual teacher but expected them to follow the pacing guide provided, and the other school assigned each teacher within a grade-level team a different content area to plan. This meant that one teacher would plan all science, one all math, and so on. Ultimately, the inclusion of the VA CS SOLs falls on the teacher(s) responsible for creating the lesson plans in all scenarios, but the way it is taught or highlighted is up to the individual presenting the lesson. Thus, the participants reported integrating the VA CS SOLs in various ways, in different content areas, and occupying different sections and amounts of instructional time. Jayden specifically spoke about this instructional challenge during our second phone interview citing accessibility to lesson planning and prepping as her biggest instructional challenge. She said, “without the ability to create my own lessons or modify them as needed to incorporate the VA CS SOLs, there is not enough time left in the class period to teach them” (Jayden, phone interview #2). This difference in lesson planning responsibility ultimately influenced the participants’ perceived comfort with certain SOLs, their anticipated ability to plan for future content area lessons that include the VA CS SOLs, and their intent to include them in future lessons.

### ***Time for Training***

Time for training is the next subtheme that emerged during the cross-case analysis. All participants noted that time will be needed during the school day for both teachers and students to study and learn about computer science terms, processes, and skills to increase comfort and knowledge in the content area. As previously noted, many teachers, both in-service and pre-service, may face challenges to integrating the VA CS SOLS and computer science curriculum



(Sentence & Csizmadia, 2017; Shin, 2018), which may be lessened by increased time for training. The participants in this study suggest that without providing time for training, offering resources and ideas on computer science may not be valued and the resources will go unused. Further, allowing time for training is especially important for pre-service teachers who are juggling being new educators with finishing requirements for their teacher education programs so they can properly use and apply what they learn across content area lessons as well as in experiences outside of the school walls. The participants also expressed that this was important for all new teachers as they will be faced with incorporating the VA CS SOLs into class lessons and activities, in which they have had limited exposure, while trying to manage their classrooms and find their footing in a new school. This finding relates back to the considerations regarding computer science in educational settings outlined in Chapter 2. As noted by Yadav and colleagues (2016a, 2017b), there is often confusion over what computer science content entails and the best practices for incorporating the skills and practices outlined in the VA CS SOLs, enhancing the need for training and practice for pre-service teachers. Finding the time to learn about, explore, discuss, and reflect is necessary for the construction of knowledge that the participants felt was essential to properly integrating the VA CS SOLs.

### ***Time for Exploration***

Results of this data collection show that the participants believe many educators, both in-service and pre-service, are unsure of or feel uncomfortable integrating new materials, content, or resources into their daily lessons. This is consistent with findings from Adler & Kim (2018) and Yadav and colleagues (2016a, 2017) that conducted research surrounding how educators understand and incorporate computer science and the associated skills and practices, such as computational thinking, into their daily curricula and lessons. One of these reasons the

participants in this study believe many educators are unsure about incorporating computer science is because of the short amount of time allotted during the day for teachers to “play with” or “explore” this new content or seemingly unfamiliar technology. This lack of time for hands-on-experience with computer science and the VA CS SOLs does not allow new teachers the chance to engage in cognitive constructivism and develop knowledge and become more comfortable with or see the benefits of including the VA CS SOLs into their planned and structured lessons. As discussed by Vaidyanathan (2018), it is necessary to provide educators the time to “take off their teacher hats” and engage in their own hands-on learning of computer science. As a result, teachers should be provided with scheduled opportunities and time to learn. In turn, the need for and availability of training emerged as the next theme.

### **Availability of Training**

Availability of training was identified as a central component of how, why, and if or when the participants in this research plan to incorporate the VA CS SOLs into future content area instruction. This finding supports previous research highlighting the need to prepare and support both in-service and pre-service teachers, as well as students, in their quest to gain computer science knowledge and experience (Ozogul, 2018) by providing professional development and training opportunities (Outlier Research and Evaluation, 2016). As in the previous theme discussed, three subthemes emerged under the heading of “training” and are outlined in Figure 6.

Training		
Availability for pre-service teachers	Availability for in-service teachers	Availability for students

Figure 6: Subthemes of Training.

### ***Training for Pre-Service Teachers***

Throughout this research study, the cases cited a lack of training and knowledge about the VA CS SOLs prior to entering their student teaching semester and suggested training for pre-service teachers in the area of computer science should start early on in teacher education programs. This sentiment was expressed by the participants at all points during the study as a contributing factor to their comfort, understanding, and intent to integrate computer science into future content lessons. This finding supports previous research stating pre-service teachers should begin their careers with an understanding of computer science (Barr & Stephenson, 2011) and that the best way to ensure they have a clear understanding is to introduce computer science practices, skills, and methods in their coursework (Yadav et. al., 2017a, 2017b). All participants in this research study noted that they felt as if they did not know enough, if anything at all, about computer science and the VA CS SOLs when starting their student teaching practicum to include them in lessons or teach the skills in a way that would benefit the students. Those who did say they had heard of the VA CS SOLs within their teacher education programs said they were discussed minimally in required educational technology courses taken early on in their programs, but that they were not introduced in methods courses that could have provided them with suggestions and examples of proven pedagogical concepts. Yudi, for example, discussed in both

face-to-face meetings that she did not get any training on the VA CS SOLs in her methods courses and would have liked to be able to practice and think about them before entering the classroom. Maggie and Bella echoed this sentiment and spoke of the need for more professional development courses in computer science before they were required to enter the classroom as lead teachers in both their final interviews and on their post-questionnaires.

Many of the participants took this further by saying that more of an introduction to all of the Virginia Standards of Learning, not just computer science, in their methods courses would have helped them feel more comfortable writing lesson plans that cover all required strands. These three cases, Maggie, Bella, and Yudi, shared the same view - that they did not receive enough instruction in the content or pedagogical approaches to teaching computer science in their educational programs and that they did not get to see enough of the VA CS SOLs, if any, integrated by their clinical faculty members during student teaching to mimic their strategies as new teachers. The other two cases, Jayden and Kim, spoke about the time it takes new teachers to create lesson plans and educational spaces for their students during their second phone interviews, and as a result, were proponents for professional development or in-service training that occurred after they had a chance to get started in the classroom. None of the cases said they were fully ready to integrate the VA CS SOLs into their future content area lessons without more training, intervention, and support on the topic, and it was suggested by the participants that the additional opportunities to think about and discuss what they were seeing in their respective classrooms with others in the same situation would help increase understanding and comfort. Although this finding is to be expected, it is important because it not only supports the need for increased training in computer science and the VA CS SOLs during methods courses for pre-service teachers, but it also suggests that alternative or additional opportunities to consider

computer science should be afforded to pre-service teachers during their educational training. Yadav, Gretter, Hambrusch, and Sands (2016a) had a similar finding and suggested the need for pre-service teachers to engage in communities of practice to engage in collaborative discussions about computer science and gain support and mentoring from peers. According to Wenger, McDermott, and Snyder (2002), a community of practice can provide opportunities for reflection to help gain new perspectives and understanding about topics such as computer science, something that the participants in this were seeking to help increase comfort and perceived ability to integrate the VA CS SOLs into future content instruction.

Relatedly, the availability of training and expressed need for more trainings were identified when the participants were asked to specifically identify any computer science standards they felt comfortable integrating, less comfortable integrating, and ones they thought worked best with the content they observed during student teaching. Unsurprisingly, all participants identified the same VA CS SOLs that they felt most comfortable integrating as the same ones that they thought worked best with what they saw being used and taught - either directly or indirectly - during their student teaching experience. Although some participants indicated comfort with one or two additional strands than the other participants, the SOLs that all participants agreed upon fall under the strand of Algorithms and Programming. Algorithms and Programming are defined in the VA CS SOLs (2020) as:

Algorithms and Programming involves the use of algorithms. An algorithm is a sequence of steps designed to accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions for computing devices. Algorithms and programming control all computing systems, empowering people to communicate with the world in new ways and solve compelling problems. The development process to create meaningful

and efficient programs involves choosing which information to use and how to process and store it, breaking apart large problems into smaller ones, recombining existing solutions, and analyzing different solutions.

Reasons for this include the need and ease to incorporate patterns and step-by-step instructions as well as the way they easily translate from one grade to another. Without specific training on the VA CS SOLs to date, Maggie, for example, wrote,

“I think the standards that focus on comparing and patterns will work best for me in the future because as an elementary teacher, I can use these in almost every subject with my students and feel as though I can navigate this SOL without much additional training” (post-questionnaire).

Relatedly, the VA CS SOLs that participants identified as less comfortable integrating are the standards that they felt relied heavily on actually using computers and digital devices rather than skills that relate to computing. Reasons for this include student comfort with and training related to technology, teacher/pre-service teacher comfort with and availability of training related to technology, and lack (or perceived lack) of knowledge, experience, or exposure of the students to social media and networks and available training for educators on how to properly incorporate these topics. Indeed, Jayden, for example, specifically wrote on her post-questionnaire that she felt as though her students are not exposed to social media in Kindergarten because of their young age and that she did not know how to teach it to students so young. As a result, she felt that those specific standards may not be as relatable for her kids as older students contrary to the published organization of the computer science standards written to align with grade-level curricula, be integrated into multiple subject areas, and progress vertically through the grades with students (VDOE, 2020). Indeed, recent research on incorporating computer science

standards, specifically those relying heavily on computing devices and applications, in the early grades supports the inclusion and use of software packages, tools, and technology into core content area lessons to improve student creativity, interest, and engagement (Sentence & Waite, 2018). Nevertheless, pre-service teachers faced with integrating these standards feel underprepared. Maggie, like Jayden, expressed discomfort with the standards that incorporated social media as well as those that relied heavily on digital devices continually citing her lack of training and comfort with technology. This finding suggests that training in computer science practices, skills, and methods is necessary to increase both content knowledge and comfort, but that training on computers and computing technologies is also necessary for pre-service teachers as suggested by Seiferet (2017). Data from her study suggest that understanding and “integrating the technology in an informed pedagogical way in teaching a learning is a professional challenge for the student-teachers” (p29). Indeed, even though pre-service teachers are often seen as digital natives (Gao et. al., 2011), they may still need training in both technology and computer science supporting the need for increased training opportunities.

Finally, none of the participants spoke about the general computer science practices for students outlined in the VA CS SOLs under Collaborating Around Computing or Communicating About Computing, but instead spoke only about grade-specific SOLs linked to their assigned grade level for student teaching. This lack of focus surrounding collaborating and communicating about computer science is not specific to students and educators learning and working in elementary grades. Research shows that all students engaged in computer science, even at the university level, may not understand the importance of communicating about computer science and may benefit from increased training (Blume, Baecker, Collins, & Donohue, 2009) This finding supports that of a recent study conducted by Tsan, Rodriquez,

Boyer, & Lynch (2018) that highlights the need for further explanation and available training for elementary teachers, both in-service and pre-service, regarding the overall impacts of computing, and the culture, practices, skills, and social interactions that develop with increased use, scaffolding, and discussion in the elementary classroom.

### ***Training for In-Service Teachers***

Due to the lack of training provided to the participants on the VA CS SOLs in their teacher education programs or during their student teaching experience, many looked to the clinical faculty for guidance and support with implementing the standards. However, as discussed previously in the chapter, most of the clinical faculty members and staff in schools where the participants were placed often did not include computer science or the VA CS SOLs in their lesson plans or classroom activities or did so without fully realizing skills and concepts were included. The overall feeling by the participants is that, in addition to a lack of time to learn about the VA CS SOLs on their own, there is a lack of training provided to in-service teachers to help them build their knowledge and overcome fears. This finding supports research completed by Wang, Hong, Ravitz, and Moghadam (2016) that shows that teaching computer science effectively requires extensive training that many in-service teachers have not been provided. Maggie specifically mentioned several times throughout the study that one of her perceived challenges to including the VA CS SOLs in her lesson plans was a lack of training for classroom teachers. In addition, the participants noted that they did not see computer science being integrated into most aspects of the school day, and so they suggested that training for all educators in the building, not just classroom teachers responsible for the main content areas. Some in-service teachers, according to the participants, have learned just enough about computer science to be able to include terminology and specific strands in their lesson plans but would



benefit from professional development on ways to incorporate, teach, and work with computer science and the VA CS SOLs in meaningful ways that benefit the students in all content areas. However, as reported in the 2018 Trends in The State of Computer Science in U.S. K-12 Schools conducted by Google, administrators and superintendents report spending money on professional development trainings in tested content areas rather than computer science. This supports data from this study that shows limited availability for in-service teachers on computer science, resulting in limited exposure to computer science for pre-service teachers working and learning in field experiences.

### ***Training for Students***

Lastly, training must be available to elementary students to help them feel more confident engaging in computer science practices like using a computational approach to solving problems, and to help them better understand how and why it is important to develop and apply the skills outlined in the VA CS SOLs such as creating step-by-step instructions, or algorithms, both independently and collaboratively. Further, many of the participants indicated that students need training in basic computing skills before attempting coding or programming lessons integrated into content areas. Some participants, like Yudi and Jayden, admitted in their final phone interviews that they initially had some preconceived notions about how much the students understood and would be able to do initially because of the wide availability of phones, tablets, and other devices and agreed that the clinical faculty they were working with probably felt similarly. Moreover, while in their placements, the participants observed students reading, writing, and engaging with computers, albeit for different amounts of time, but determined after being in the classroom with them for just a short amount of time, that being able to do these activities did not mean that students could create artifacts, code, or use the computer for

problem-solving without specific training, supporting the addition of computer science skills and standards for all grade levels. An interesting finding of this research is that all participants indicated a belief that computer science skills and practices will come easily to students at the elementary level once they have at least some basic training, an idea echoed by Code.org (2019). They felt that it is up to the classroom teacher to provide such opportunities, further supporting the need for professional development and increased training for educators. Finally, the participants believe that for students to learn and work with computer science in an unplugged manner, training needs to be provided to ensure the correct terminology, processes, and skills are taught and able to be used in even the most basic situations. Yudi, specifically, noted in her second phone interview, that she saw many skills repeated across grade levels when she read the VA CS SOLs on her own, and identified the need for her students to have training in computer science available for them daily in order to reinforce the concepts outlined that they will need to build on each year and use in real-world situations, supporting the need to teach and reinforce the necessary skills and practices to live and work in a society that relies on computing principals as described by Yadav, Mayfield, Zhou, Hambrusch, and Korb (2014).

All participants agreed that for anyone to feel more confident with computer science, training is necessary to increase understanding and comfort. This finding supports multiple studies previously conducted including that of Webb and colleagues (2017), suggesting training on computer science skills and concepts should begin in primary grades to help develop motivation, learning concepts, and self-esteem, as well as studies by Davies (2011) and Ertmer and Ottenbreit-Leftwich (2010) that suggest all educators, both in-service and pre-service, need to be given the tools they need through training opportunities to incorporate digital and computer science skills. This leads to the next finding, experience, that comes not only from training

opportunities but also through connections and exposure both personally and professionally over time.

### **Value of Experience**

It is necessary for educators to gain experience in all aspects of their field to increase confidence and gain the knowledge needed to feel successful. The same is true for computer science content, the VA CS SOLs, and the associated skills and processes. Students and teachers alike need a combination of formal training and varied experiences to make connections, enhance knowledge and understanding, and to better identify future needs to feel successful integrating computer science into content lessons. Participants in this research study outlined several different subthemes of the value of experience they felt pertinent to increasing their and other educators' perceived ability to teach and integrate the VA CS SOLs into their daily lessons. These subthemes can be found in Figure 7.

Experience			
Educator and student experience with computer science and the VA CS SOLs	Educator and student experience and comfort with technology	Experience leading to teacher "buy-in"	Experience for pre-service teachers and the impact of the student teaching placement

Figure 7: Subthemes of Experience.

### ***Experience with Computer Science and the VA CS SOLs***

Participants indicated that the clinical faculty that they were paired with had little to no experience working with or teaching with the VA CS SOLs or computer science. Although many were veteran teachers, most had not been expected to engage with or integrate computer science and the VA CS SOLs into their lessons by their school district or administration. Thus, these

clinical faculty members essentially had the same comfort and understanding of the VA CS SOLs as the pre-service teachers they were expected to mentor. Further, the educators in this study did not have experience with computer science and all of the skills, methods, and processes that go with it, resulting in hesitation and even resistance to incorporate them into their lessons. This hesitation supports past findings by Chang and Peterson (2018) and Mouza and colleagues (2017) who determined that educator perceptions and beliefs influence the integration of computer science skills and associated practices like computational thinking. Not only did this hesitation to integrate computer science by the clinical faculty reflect on what the participants in the study learned about computer science pedagogy and practice in the elementary classroom, but it may also be reflected in how and if pre-service teachers use them in their future content area lessons. Similarly, students need experience with the computer science skills and practices outlined in the VA CS SOLs as early as possible in their educational journey to construct knowledge about computer science and support the ability to apply what they have learned in a multitude of situations. The participants in this study believe that practice or experience, in addition to formal training, is required for all students to increase comfort, understanding, and the likelihood of future use. This aligns with Wilson and Moritz's research on teacher advocacy and student experiences in computer science where they note that early exposure to computer science experiences is necessary for all students (2015), and Shin's (2018) research that found most students do not have any experience with programming or coding, for example, and must be given extra time to familiarize themselves with computer science aspects before they can engage with them in content area lessons.

Experience with programs and applications that support computer science, such as coding or programming applications, was also noted by the participants as invaluable to increase

comfort, knowledge, and perceived ability to incorporate these aspects in future content lessons. Thus, while training is an important component of CS instruction, it may also be valuable to provide teachers and pre-service teachers with structured practice and time to explore CS in their instruction, increasing the amount of experience using CS. Coding and programming are aspects of computer science that are often highlighted as important elements to education to cultivate computer science skills and practices but, according to Randles (2020), are often overlooked or not incorporated in elementary level classrooms as they should be. In the VA CS SOLs, block-based programming is specifically outlined under the Algorithms and Programming strand starting at the Kindergarten level. Thus, participants in this study were asked specific questions about their familiarity with coding and coding applications, as well as if they had the opportunity to see or use coding as they understood it while in their individual student teaching placements. At the end of the semester, only Yudi reported using coding with her students. She was also the only one who indicated that she felt as though her clinical faculty member is working toward incorporating coding and coding applications, like Scratch Jr, into future content area lessons. In terms of future use of coding applications to enhance content area lessons, both Jayden and Yudi expressed that they see coding and programming through both plugged and unplugged activities as beneficial to help students learn about, process, and retain information and expressed the desire to incorporate coding applications, like Scratch Jr, into future content area lessons. The other cases shied away from discussing coding and programming specifically and focused more on the development of step-by-step instructions and sequencing as individual concepts, reinforcing the need for experiences and training in all aspects of computer science and the VA CS SOLs.

### ***Experience and Comfort with Technology***

Participants also felt strongly that both educators and students needed experience with technology, noting that many of the educators they worked with during student teaching operated as if any use of classroom technology is computer science, but that they often struggled with the best ways to incorporate it to support learning. Indeed, it is noted that the use of educational technologies and computing tools are fundamentally connected to computer science (k23cs.org, n.d ) and practice is required to increase comfort and knowledge in both to help teachers plan for the incorporation of these skills in lessons (Change & Peterson, 2018). However, because the VA CS SOLs go beyond just the use of technology, providing experiences that help teachers overcome common misconceptions about computer science is necessary, as supported by Duncan, Bell, and Atlas (2017), as well to help educators understand how technology can be effectively integrated into their instruction to support content learning (Carver, 2016) and computer science practices.

Some participants explained that their clinical faculty did not have much experience with technology and therefore stuck to only those applications and devices that they were comfortable with. Others mentioned that their teachers would allow students on the classroom computers or their Chromebooks to read or write, but very few if any provided the students with opportunities to engage in problem-solving, programming, or the creation of artifacts using technology for various reasons. Jayden, for example, noted several times that her clinical faculty, “did not do technology” (Jayden, meeting #2 transcription), thus denying students of the chance to work on computer science skills through plugged activities and Jayden the experience of watching and working with students on this type of activity. Bella also noted that her clinical faculty member and school as a whole did not use technology very often when teaching content area lessons, and wrote on her post-questionnaire that because of this, she is not sure how to integrate the

computing systems, cybersecurity, and networking strands into her lessons. She indicated on both her post-questionnaire and in her second phone interview that planning for these strands would be very difficult if the students could only use technology to type and read. Maggie, on the other hand, cited her “lack of preparedness” (Maggie, phone interview #1) with technology and computers as her biggest instructional challenge. Maggie said, “I do not know how to teach some of the SOLs because I am not great with computers” (Maggie, phone interview #2). As these are valuable skills needed for future education and careers, it is necessary for the students to engage with technology that supports the construction of computer science knowledge and associated skills to gain pertinent experience.

### ***Experience Leading to Teacher Buy-In***

Teacher ‘buy-in’ to the need for computer science and the VA CS SOLs at all levels, but especially elementary, was cited by all participants as a priority at the end of the study. Bella pointed this out early on in the research study, commenting several times, that her clinical faculty did not understand why computer science was necessary at the elementary level, and therefore she did not spend time exploring the VA CS SOLs or including them in lessons. This statement is supported by research conducted by Briggs, Russell, and Wanless (2017) that found that teacher buy-in is a crucial component for any educational change or practice to take place. Educators may be aware of the recently mandated VA CS SOLs, but without the opportunities to see students benefit from learning the skills and processes outlined in the different strands, they may not understand why they should make a point to specifically include any aspect of them into daily classroom activities. The participants in this study believe that without experience engaging in computer science on their own and understanding how students use the skills across content areas, they will never integrate them into content area lessons until they are a tested standard of

learning in Virginia. Not only would this leave elementary-aged students with a disadvantage going into upper grades but would also limit the educational experiences provided to pre-service teachers learning in practicum experiences.

### ***Experience and Impact of the Student Teaching Placement***

Throughout the study, participants were asked if they saw their clinical faculty member or other educators in their placements schools using computer science with students and/or integrating the VA CS SOLs into content area lessons in any way. Because modeling by teacher mentors has been proven to influence pre-service teacher's beliefs and practices (Lunenburg et. al., 2007), I found it necessary to understand if any shifts in student teacher perceptions of computer science occurred as a response to this experience. Participants described differing views of the impact of their clinical faculty members and other aspects of the placements on their perceptions of the VA CS SOLs at the elementary level.

At the end of the study, all participants reported a better understanding of the VA CS SOLs as a result of their student teaching placements and because of the connections they made between what was going on in the classroom with computer science, either directly or indirectly, and their exposure to the standards. One noted reason for this increased understanding is being provided with opportunities to consider, discuss, and either see or think about computer science being used in content area lessons with elementary students, all contributing factors of cognitive constructivism as described by Ackermann (2001), Piaget (1953), and Powell and Kalina (2009). Jayden, for example, said in her second phone interview that she is,

“much more comfortable with the VA CS SOLs now than before being part of this



study. Now that I have had the chance to see and think about how I would use them with these students and talk about [the VA CS SOLs] with others, I feel like I understand them better” (Jayden, phone interview #2).

Other individual responses, although in agreement that their perceptions changed as a result of their student teaching experience, noted other reasons. Yudi identified the students she worked within a pull-out program and a robotics club as having the most impact and influence on her views of computer science. She wrote on her post-questionnaire that “watching the students utilize learning tools in a robotics club and in the classroom made it much easier to understand and definitely made [her] believe the VA CS SOLs are important for all students” (post-questionnaire). Kim also acknowledged that the students in her placement had the biggest impact on what she thinks of as computer science and the benefits to using it but said it is because it can, “help [her] special education students participate in and comprehend the lessons” (post-questionnaire). Both Yudi and Kim discussed watching and interacting with the students in their placements as a result of the challenge presented to them in the face-to-face meetings as being the biggest contributors to their shift in their perspectives of computer science, although for different reasons, but neither identified the clinical faculty member each worked with as a contributing factor. Bella reiterated the sentiment of Yudi and Kim that the students had the greatest impact on her perspectives of computer science but identified on both her post-questionnaire and in her second phone interview that it was because she could see how her students responded, both physically (with smiles, hand gestures, etc.) and mentally (through connections they could make, improved grades, and lessons they could later explain), to lessons that she believed included computer science content and skills. Bella did talk about her clinical faculty when answering questions about the impact of student teaching placements on

perspectives of computer science, but only to say that her clinical faculty did not change her views, but instead added to knowledge and beliefs she already held. Jayden, after reading the VA CS SOLs on her own and interacting with peers on the discussion board, reported hearing her clinical faculty member use computer science terminology with students during some content area lessons and that that simple act helped her realize that computer science can be integrated into lessons, even if it is not the focus of the lesson. This supports research on the impact of educational experiences, such as student teaching, on the perceptions of pre-service teachers and their understanding of the VA CS SOLs.

One participant, Jayden, wrote on her post-questionnaire that, although her assigned placement helped her to better understand the VA CS SOLs, she did not believe that her clinical faculty member changed her understanding of computer science or increased her comfort with the standards because she did not highlight the standards specifically when developing lesson plans and working with students. Also, unlike the other participants, Jayden did not ever specifically mention working with students as a reason for her shift in perspectives. Instead, she focused on the discussions and electronic exchanges she had with peers during student teaching as having the greatest impact on how she now thinks about and will plan for computer science. Although the students only met with me for two face-to-face meetings, they interacted often for other seminar meetings and study sessions as well as on the online discussion board, providing opportunities to make connections and reflect on what they read, saw, and experienced.

Maggie, on the other hand, believed that both the students and her clinical faculty contributed to the way she understands and plans to integrate the VA CS SOLs into future content area instruction. She indicated that her perspectives changed because she was able to watch her clinical faculty member during the school day while reading through the VA CS SOLs

on her own, helping her make connections between what was written and what was being done in the classroom. Maggie also noted on her post-questionnaire that watching how the students worked together and interacted helped her think more closely about the practice of collaborating around computing that she found interesting. “I was able to read through the standards during some of the lessons, so watching the students work at the same time really helped me make connections” (post-questionnaire). This example supports the idea of “practice-based teacher education” (Ball and Cohen, 1999) where pre-service teachers learn while working where connections can be made between theory and practice to better prepare pre-service teachers to take over their own classrooms (Ball & Cohen, 1999; Hamilton & Margot, 2019). Regardless of the reasons for any shift in perspectives about computer science due to the student teaching placements of the participants, all were able to identify perceived challenges and benefits and further experience and consider incorporating the VA CS SOLs into future content area lessons.

### **Implications**

The findings from this study lead to implications in the areas of schooling, professional development, and pre-service teacher training. Ultimately, the implications discussed below support different aspects of cognitive constructivism, the framework of this study, that suggests knowledge is created by each individual by combining existing knowledge and experiences with new information and opportunities for review and reflection (Brau, n.d.; Kasemsap, 2015).

### **Support for Student Training and Opportunities to Work with Computer Science**

All of the participants in this study repeatedly expressed their perceived benefits for students exposed to computer science and the skills and processes specifically outlined in the VA CS SOLs. Benefits discussed include the ability to relate terminology content information to multiple areas and situations both in and out of school, increased problem-solving and higher order thinking skills, and expanded opportunities for creativity and collaboration. Additional

benefits noted by the participants include the ease at which the standards can be simplified to meet the needs of all students as well as the intuitiveness of computer science skills for students growing up in a digital age.

Currently, the VA CS SOLs are being incorporated into classroom assignments and activities as add-ons, afterthoughts, or mini-lessons, if at all, to help meet the requirements as students and teachers struggle to find the time to learn and incorporate the different aspects of computer science according to the participants. They all spoke of the need for more training opportunities for students during the school day to work with and explore computer science methods, processes, and systems to ensure increased knowledge and future application. This may be accomplished by integrating small lessons in computer science, such as puzzles from Hour of Code (code.org, 2021) to spark interest and introduce topics while educators work to increase their own knowledge and comfort on the subject and with the associated standards of learning. The addition of dedicated time during the school day for students to focus on computer science could be an option to explore but would rely on the support from the school administration to make it happen.

### **Professional Development**

Over the course of this study, the participants continually discussed the lack of, or perceived lack of, training in computer science and the VA CS SOLs for their clinical faculty members and other educators in their placement schools. This aligns with research that shows that often, educators believe that they are integrating computer science or educational technologies to enhance student learning, when in actuality they are only incorporating them at the most basic level such as to facilitate or deliver instruction (Gorder, 2008). Through increased professional development opportunities, in-service teachers can strengthen their expertise in

computer science as well as their own content areas by learning how to better incorporate computer science into content area lessons.

Increased professional development opportunities, offered virtually, face-to-face, or even asynchronously through programs offered online that allow educators to work at their own pace, on the topic of computer science with a focus on the VA CS SOLs may also benefit pre-service teachers working in practicum and student teaching placements. Participants in this study noted several times that their perceptions of computer science were mostly influenced by the students they worked with rather than their clinical faculty members due to the lack of computer science that was incorporated into daily lessons. Therefore, the addition of professional development opportunities for in-service teachers may not only impact current teaching staff at the elementary level, but also the new teachers who are working with and learning from them. To the point, support and resources that help increase teacher competency in computer science are needed (Shin, 2018) and are available in many forms. Educators may benefit from being exposed to short, online professional development opportunities via ongoing webinars, or through membership in a professional learning community where educators can interact any time and for any amount of time. Providing teachers the opportunity to connect at any time and for any amount of time helps them learn from each other (Outlier Research & Evaluation, 2016).

### **Pre-Service Teacher Training**

Training in the area of computer science should start early on in teacher preparation programs with methods courses. Participants in this study reported feeling underprepared to incorporate computer science skills and concepts into their content area lessons and expressed their disappointment that more information in the area was not provided in their methods courses. Additionally, participants reported feeling confused and even unaware of the VA CS

SOLs due to a lack of training prior to their student teaching experience. As a result of this study, teacher educators may want to consider adding computer science training and information on the VA CS SOLs to their methods courses to better meet the needs of their students. As demonstrated in this study, simply providing opportunities for pre-service teachers to consider how and why to incorporate computer science and the VA CS SOLs into content lessons impacted their perceptions. However, as indicated by previous research conducted by Grimm (2010), it is important to consider the tendency of the subjects to provide socially desirable responses regarding computer science. Thus, teacher educators may ask students to reflect on their own learning and engage in discussions about computer science in their educational experiences early on in methods courses to help students create their own understanding and avoid social bias. Teacher educators may also require students enrolled in courses requiring shorter practicums to simply observe a teacher in their content area and think about how to integrate the VA CS SOLs as a class to support content learning and help students make the connections they need between content and experiences.

Further, many of the participants spoke of continued training in computer science for pre-service teachers outside of content area classes or in addition to their student teaching experience. They spoke of their desire for chances to reflect on and discuss what they were seeing in their classrooms with what they understood computer science to be. Online discussion boards, cohorts, or the use of communities of practice like Critical Friends Groups (CFG), could present opportunities for extra training and discussions on issues relevant to computer science and the VA CS SOLs. science. Research shows that professional learning and development opportunities can be enhanced by working in communities of practice like a CFG through professional discourse and engagement (Akerson, Donnelly, Riggs, & Eastwood, 2012; Le

Cornu & Ewing, 2008), through instruction and collaboration that enriches the learning process and mimics strategies that are easily transferred into the classroom and enhanced through participation and reflection (Akerson, Donnelly, Riggs, & Eastwood, 2012; Wray, 2007), and by being provided with opportunities to work collaboratively to create lessons that can be used in and out of the classroom (Darling-Hammond, Hyler, & Gardner, 2017; Yoo, 2016).

Opportunities to engage in professional conversations through groups such as these may not only help with cognitive constructivism and collaboration for pre-service teachers but may also help combat feelings of isolation and a lack of background knowledge that often plagues new teachers.

### **Limitations**

One limitation of this study is that it took place during the initial outbreak of the COVID-19 pandemic in the United States. Participants were not in face-to-face environments with their students for the entirety of their student teaching semester, and thus they were forced to work with students in virtual environments using platforms such as Zoom or Canvas for teaching and learning. At this point, many elementary educators, including the clinical faculty members assigned to the participants, had not taught in virtual environments before and may have been less willing to try new activities or add new content to their lessons. Further, to ensure all students were being taught the same material in the same way across school districts while in their virtual environments, many of the lessons the participants taught were provided to both the students and teachers by the district, leaving little area for the participants to modify the lesson plans or planned daily instruction. However, because schools were still open and operating exclusively through computer systems and applications, the participants were able to identify several benefits and challenges to incorporating computer science skills into elementary lessons.

This environment also made it very easy for the participants to watch their clinical faculty members and determine if they understood or included computer science content, skills, or terminology.

A second limitation was the sample size. A larger sample size would have allowed for multiple perspectives from pre-service teachers across all elementary grade levels and in different schools and districts. Although the multiple cases included in the study represented a variety of grade levels and students, additional perspectives may have provided alternative views of how computer science and the VA CS SOLs are incorporated into content area lessons around the state. Furthermore, a larger sample size may have provided the pre-service teachers with additional peers and resources that may have influenced their perceived ability to plan for and incorporate the VA CS SOLs into future content areas and for the construction of knowledge through participation in our online discussions and face-to-face meetings.

An additional limitation to this study is the length of time in which the study took place. This research study was conducted over a 14-week period when the participants were being asked to combine all aspects of their teacher training into their culminating experience. This short time frame proved stressful for at least one of the participants who was worried about simply meeting the needs of her students and working to the expectations of the assigned clinical faculty. Further, the participants were asked to reflect on training and methods courses they had early on in their teacher preparation programs rather than being able to discuss what they learned in their methods courses in real-time. A longer study spanning more semesters of a teacher preparation program may have provided different or additional data.

Lastly, it is important to acknowledge my positionality on the research as a former elementary educator as my perspectives on computer science in the classroom may have



influenced the study. I taught most of my career in a PreK-12 environment that embraced technology and computer science skills, providing students of all ages with a 1:1 device and stressing the importance of skills like problem-solving and decomposition starting in the earliest grade levels. Students were often encouraged to create artifacts, conduct research, and discuss the importance and impact of computing on society before the VA CS SOLs were adopted in the state. My beliefs surrounding computer science as an important aspect of elementary education and the different requirements for educators working to incorporate them into content area lessons drove the study.

### **Future Research**

This qualitative multi-case study shows promising results in elementary pre-service teachers' perceived ability to integrate and teach the VA CS SOLs in future content instruction. It also shows how shifts occur in pre-service teacher perceptions in response to their student teaching experience. Further research could extend these findings to include a focus on computer science and the VA CS SOLs in elementary instruction as a result of the COVID-19 global pandemic, online asynchronous teacher preparation programs, and school administrator perceptions of pre-service and in-service teachers' abilities to incorporate computer science and the VA CS SOLs into content instruction.

As a result of the COVID-19 pandemic, many schools around the world have been forced to close or find alternative methods for instruction across grade levels. Students and teachers are finding themselves navigating a virtual learning environment in which they have had little to no prior experience or training. Future research could investigate the impact of the COVID-19 pandemic on both teachers and students concerning computer science and the incorporation of

the VA CS SOLs in online classrooms or virtual learning environments with elementary students.

Teacher preparation programs that are offered strictly online and in an asynchronous manner is another area for future research. With the rise in online programs being offered in a number of disciplines and across departments in many colleges and universities, extended research into online methods courses and asynchronous learning in regard to computer science may benefit teacher educators working with students in these environments.

Finally, future research to determine school administrators' perspectives of how pre-service and in-service teachers working in their schools plan for and incorporate computer science may influence if and how professional development, support, and resources become available. By examining the perspectives of school administrators, discrepancies between what teachers planning for and integrating and what is expected and identified by school administration may be revealed.

### **Conclusion**

In conclusion, this study contributes to the field of research in pre-service teacher education, elementary computer science education, and professional development. The data from the five cases revealed that pre-service teachers' positively perceive their ability to integrate computer science and the VA CS SOLs into future content instruction after being exposed to the standards and allowed for time to consider and discuss them, but desire more and continued training and support in the area. Data collected through this research also supports shifts in the pre-service teachers' perceptions as a result of their student teaching practicum experience due to their work with students and interactions with peers in the same situation.

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## Appendix A

### Pre-Questionnaire

Thank you for being part of this research and for agreeing to answer the following questions.

There are no right or wrong answers, so please answer the following questions to the best of your ability.

1. How would you explain the concept of computer science?
2. How familiar are you, if at all, the Virginia Computer Science Standards of Learning?
3. Are you familiar with the term / skill “computational thinking”? If so, please describe or define it here.
4. Do you believe that computer science can be integrated into the elementary classroom? If yes, how would you plan to teach it?
5. Explain your familiarity with coding applications (such as Scratch or Scratch Jr.) here.

## Appendix B

### Mid-Student Teaching / Mid-Study Questionnaire

Thank you for being part of this research and for agreeing to answer the following questions.

There are no right or wrong answers, so please answer the following questions to the best of your ability.

1. Do you believe it is important to teach computer science at the elementary level?  
Why or why not?
  
2. Do you see the VA CS SOLs as an important component to the elementary school classroom / curriculum? Why or why not?
  
3. Has your perception of computer science changed since you first started working in your student teaching placement? Why or why not?
  
4. Have your perceptions of computer science and the VA CS SOLs changed as a result of peer discussions or posts on the discussion board? Why or why not?
  
5. What is the likelihood that you will incorporate the VA CS SOLs into your future classroom and content lessons?  
Why?
  
6. When planning lessons, do you feel as though you are able to incorporate the VA CS SOLs effectively?



## Appendix C

### Post-Questionnaire (Google Form)

Perceptions of Computer Science: Thank you for agreeing to fill out this form. Please answer honestly and to the best of your ability. Your identity will not be shared with anyone outside of the research team.

1. First and last name
2. Student teaching placement and grade level(s) – please list all grades you taught in or observed during this time.
3. Degree seeking (BA, MA, etc.).
4. What is your age?
  - a. Under 18
  - b. 18-24
  - c. 25-34
  - d. 35-44
  - e. 45-54
  - f. Over 55
5. How do you identify?
  - a. Female
  - b. Male
  - c. Prefer not to say
  - d. Other (please specify)
6. What is your ethnicity?
  - a. White
  - b. Hispanic or Latino
  - c. Black or African American
  - d. Native American or American Indian
  - e. Asian / Pacific Islander
  - f. Prefer not to say.
7. Prior to your student teaching experience, how familiar were you with the Virginia Computer Science Standards of Learning?

**Appendix C (Continued)**

8. Generally speaking, what are your impressions of the Virginia Computer Science Standards of Learning for elementary students?
9. What is your overall impression of computer science and the associated skills and processes, such as computational thinking, in elementary education?
10. Which computer science standards do you see best aligning with your future teaching and why?
11. Which computer science standards seem to work best with content you have observed during student teaching?
12. Which computer science standards would you be less comfortable integrating and why?
13. Overall, how comfortable are you integrating the Virginia Computer Science Standards of Learning into your future classroom / teaching and why?
14. Do you feel as though your student teaching placement had an impact on your view of computer science and computational thinking? If so, why?
15. Anything else you would like to add or feel is important to the study of pre-service teachers and computer science in elementary grade levels?

## Appendix D

### Meeting Slides and Outlines

#### Meeting #1 - WELCOME

#### Paperwork:

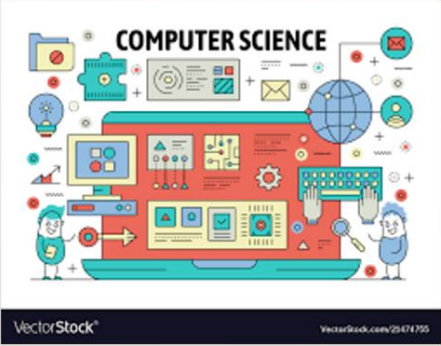
- Intro to study and consent forms
- Pre-Questionnaire

#### Discussion:

## COMPUTER SCIENCE

---

- What is it?
- Quietly, reflect on your experiences and beliefs –
  - In schools in general
  - In elementary schools
- Definition from the VDOE
- Definition from [Code.org](https://code.org)
- VDOE – VA CS SOLs can be found [here](#)



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- What is computer science and the VA CS SOLS? (Slides sent to ODU email addresses)
  - Take a moment and think about your experiences and beliefs.
  - Please share your thoughts and experiences with the group. I am just here to listen – there are no right or wrong answers. What are your perceptions?
- VA CS SOLs – Please tell the group anything you know or do not know about the VA CS SOLs or any experience you have had with them. (Links provided on slide)
  - Feel free to look through them and discuss anything you find interesting with the group.

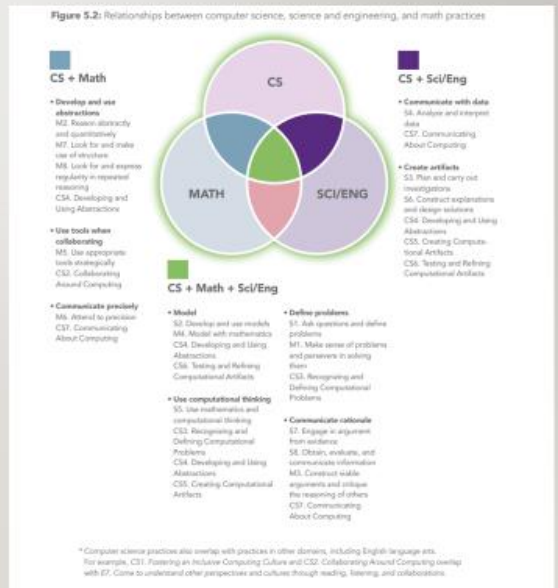
## Appendix D (Continued)

### Computer Science Curriculum Alignment (VDOE, 2020)

The 2017 K – 8 Computer Science Standards of Learning were designed to be integrated into the instruction in multiple subject areas including mathematics, science, history, English, fine arts, and career and technology courses. This document is designed to provide support to K-8 teachers as they integrate computer science into core areas of instruction. The content area connections serve as guidance for teachers and may not be limited to the connections indicated in the table below.

Directly from:

<http://www.doe.virginia.gov/instruction/computer-science/index.shtml>



- The VDOE has provided you with resources like the one on slide 2.
- Other popular resources include:
  - Code.org (<https://code.org/>)
  - CodeVA ([www.codevirginia.org](http://www.codevirginia.org))
  - Barefoot computing ([www.barefootcomputing.org/](http://www.barefootcomputing.org/))
- Thoughts? Comments? Questions? Concerns before we wrap up?

## Appendix D (Continued)

### DISCUSSION BOARD / CHALLENGE

#### Discussion board:

Google Classroom

Chance to connect, discuss computer science, ask questions, get help, reflect, etc

Need to talk to someone in the same situation – reach out to your peers here.

#### Challenges:

Log in to the discussion board at least once a week during student teaching. Post or reply to a friend – this is an opportunity to learn from each other and work together.

Think about any benefits and challenges to using computer science at the elementary level.

Look at the resources provided and take a minute to think about them.

Watch your CF and the other teachers in your school and see how they incorporate computer science and the VA CS SOLs.

- Discussion board
  - Logging on
  - Uses
  - Expectations
  
- Challenges for our next meeting:
  - Log on at least once a week.
  - Make a post or reply to a friend.
  - Any benefits or challenges you see to integrating CS and the VA CS SOLs to content area instruction at the elementary level? Could you do it? Would you?
  - Take the time to read the VA CS SOLs and think about them. Take a look at what the VDOE has already provided you.
  - Talk to your CF about this. Watch lessons and take notes. Do you think computer science present in your placement school?
  
- See you soon!

## Appendix D (Continued)

### Meeting #2 – WELCOME BACK

- How is it going?
- Any comments on computer science before we begin?
  - How did you do with the challenges I put before you?
  - Did you get to use the discussion board? Find it helpful?
  - Anything to talk about before we look at the first slide?

## MEETING #2


After being provided the time to look at the VA CS SOLs over the past few weeks and discuss them with your peers, what is your interpretation or perception of them?

Things to think about:

- How do they read?
- What is included?
- Any surprises?
- Easy to incorporate?
- Do you think your school is integrating them? How or why not?

Questions for your peers?

*Share your thoughts and ideas with the group!*




**The VA CS SOLs:**

[https://www.doe.virginia.gov/testing/sol/standards\\_docs/computer-science/index.shtml](https://www.doe.virginia.gov/testing/sol/standards_docs/computer-science/index.shtml)

- Discussion – During our last meeting I provided you with a link to the VA CS SOLs, the VDOE, and some other resources. I also gave you a chance to talk about them – you had a lot to say! Have you had the chance to look at them or think about them since then?
  - How do they read?
  - What is included?
  - Any surprises?
  - Easy to incorporate?
  - Do you see them in your placement school or classroom?
- Has your perception of the VA CS SOLs changed since our last meeting?
  - What about any of the specific VA CS SOLs?
    - Easier or harder for your students?
    - Have you tried to incorporate them?

## Appendix D (Continued)

## MEETING #2

Thoughts about incorporating computer science concepts and skills across content areas with elementary students?	Think about:	Challenge:
	<ul style="list-style-type: none"> <li>• Any challenges you see?</li> <li>• Any benefits that come to mind?</li> <li>• How you would / could use it in your future classroom?</li> <li>• Is there anything you want to share on the discussion board?</li> </ul>	<ul style="list-style-type: none"> <li>• As you go through the day, watch and see if your clinical faculty integrates CS or the VA CS SOLs.</li> <li>• Do you see other teachers using it?</li> <li>• Have you asked your CF about the VA CS SOLs?</li> <li>• Try to incorporate the VA CS SOLs in a lesson you teach this semester.</li> </ul>

- What about computer science in general with elementary students?
  - Thoughts about incorporating computer science content, skills, applications, terminology?
  - Ideas or lesson plans to share? Anything you tried or your CF has tried?
  - Anything you think may have been computer science in a lesson?
- Tell us about:
  - Challenges
  - Benefits
  - Comfort
- Challenges for the rest of the semester:
  - Continue to watch lessons and see if you can pick out computer science.
  - Talk to your peers and CF about using CS and the VA CS SOLs in content lessons.
  - Try to incorporate CS and specific VA CS SOLs into your lesson plans.
  - Do not forget about the discussion board. I know you have been using it – keep it up!
- Parting thoughts?
  - Look for an email from me about a phone interview and questionnaire.
  - Anything else?

## Appendix E

### Individual Phone Interview Questions, Phase 1

Thank you for being part of this research and for agreeing to answer the following questions. There are no right or wrong answers, so please answer the following questions to the best of your ability.

1. Now that you are more familiar with the Virginia Computer Science Standards of Learning (VA CS SOLs), what benefits, if any, do you see in incorporating them in your content area lessons?
2. What challenges, if any, do you see to integrating computer science and the VA CS SOLs into your curricula?
  - a. Why do you see these as challenges?
3. Can you tell me your overall perceptions of the Virginia Computer Science standards in regard to elementary education?
4. What does the integration of computer science and the VA CS SOLs like in your placement school and classroom?
5. Do you feel as though you will be able to integrate the VA CS SOLs into your future classroom and content area lessons?
6. Do you see yourself integrating the VA CS SOLs into your future classroom and content area instruction?
  - a. Can you provide some examples of how or when you may use them?
7. Do you feel as though your perceptions or beliefs about computer science and the Virginia Computer Science Standards of Learning have changed since being provided the opportunity to discuss them with peers?
  - a. Why or why not?
8. Have you had the opportunity to engage in the online discussion board? If yes, did you find it helpful?



## Appendix F

### Individual Phone Interview Questions, Phase 2

Thank you for being part of this research and for agreeing to answer the following questions. There are no right or wrong answers, so please answer the following questions to the best of your ability.

1. Now that you have had time to reflect on the Virginia Computer Science Standards of Learning, have your perceptions or understanding of them changed?
  - a. Why/ why not?
  - b. How so?
2. Based on your experiences with student teaching, to what extent were the VA CS SOLs incorporated into elementary lessons, either explicitly or generally?
3. Are there any benefits that come to mind when thinking about incorporating the VA CS SOLs into your classroom lessons?
4. Are there any instructional challenges that you can see when thinking about teaching to the VA CS SOLs?
5. Since we last spoke, have you had the opportunity to incorporate CS in your lessons (either online or face-to-face) or to identify areas where they could be incorporated?
  - a. Where?
  - b. Why or why not?
6. Can you tell me about your experience with the VA CS SOLs in your teacher training and your student teaching placement?
  - a. To what extent was computer science a focus?
  - b. Were the standards clearly explained from an instructional standpoint?

**Appendix F (Continued)**

7. How or where, if at all, do you see computer science being most readily integrated into elementary classrooms?
8. How, if at all, has your view of the VA CS SOLs changed or evolved since you started student teaching?
9. In light of the current COVID-19 pandemic around the world, Virginia schools have had to restructure the way they instruct students. Has this restructuring had any effect on your view of the VA CS SOLs in elementary education?
  - a. How or why?
10. Anything else?

**VITA**

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**ACADEMIC PREPARATION:**

*Old Dominion University* -Norfolk, Virginia

Ph.D. Curriculum & Instruction, (anticipated) May 2021

Dissertation: *Investigating Pre-Service Teachers' Perceptions of the Virginia Computer Science Standards of Learning: A Qualitative Multiple Case Study*

Advisor: Dr. Jamie Colwell

*The George Washington University* – Washington, DC

M.A. in Education and Human Development, August 2006

Concentration: Educational Leadership and Administration

*Hollins University* – Roanoke, Virginia

B.A. in Communication Studies, May 2001

Minor: Studio Art

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**ACADEMIC APPOINTMENTS:**

2020 – current	Interim Director, Office of Clinical Experiences, Old Dominion University
2017 – 2019	Graduate Teaching / Research Assistant, Old Dominion University
2019 – 2020	Graduate Research Assistant, Old Dominion University

**PUBLICATIONS (ABRV):**

**Taylor, V.**, Tilhou, R., & Crompton, H. (2020) Computational thinking and coding across content areas to develop digital skills. In S. Yu, M. Ally, & A. Tsinakos (Eds.), *Emerging Technologies and Pedagogies in the Curriculum*. New York, NY: Springer.

Colwell, J., Gregory, K., & **Taylor, V.** (2021). Examining Preservice Teachers' Perceptions of Planning for Culturally Relevant Disciplinary Literacy. *Journal of Teacher Education*, 72(2), 195–208.

Dunkerly-Bean, J., Morris, J., & **Taylor, V.** (2020). Writing the Rainbow Facilitating Undergraduate Teacher Candidates' LGBTQIA+ Allyship Through Multimodal Writing. *Taboo: The Journal of Culture and Education*, 19, 93

**AWARDS (ABRV):**

Woofter Hall Scholar, Old Dominion University (2020)

Outstanding Doctoral Student of the Year, Old Dominion University (2019)

Officer, Literacy Research Association – Historian (2018 – 2020)