USING THE LENS OF INNOVATION TO EXPLORE CHALLENGES AND OPPORTUNITIES FOR INTEGRATING COMPUTER SCIENCE IN THE K-8 CURRICULUM AT A TEACHER PREPARATION PROGRAM

A Capstone Project

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by

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Abstract

Nationwide, computer science (CS) education is expected to be integrated into K-8 classrooms (Code.org et al., 2022), but most teachers do not feel prepared because they have little or no prior experience with CS content or pedagogy (DeLyser et al., 2018; Rich et al., 2021; Sadik et al., 2020). Compounding this issue is an overall lack of CS education in teacher preparation programs (TPP), with TPP faculty also feeling ill-prepared to integrate CS into their practice. My Capstone study views the integration of CS in the K-8 TPP curriculum through the lens of innovation by employing the Concerns-based Adoption Model (CBAM) and Diffusion of Innovation (DOI) theory to explore K-8 faculty beliefs and concerns about CS education at the TPP. Findings show that TPP faculty have developing ideas about CS education. Their CBAM Stages of Concern (SoC) profile is typical of those who are not familiar with the innovation, but open to learning from others. Challenges to integrating CS in the K-8 TPP curriculum identified by faculty include time constraints and the need for more knowledge about CS. Opportunities to integrate CS in the K-8 TPP curriculum identified by faculty include integrating CS into existing courses and potentially creating new courses to focus on CS. Findings provide insight into how this TPP can work to support its pre-service teachers to integrate CS as called for by state standards.

Keywords: teacher preparation program, computer science education, K-8, curriculum integration, innovation

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Approval of the Capstone

This Capstone (Using the Lens of Innovation to Explore Challenges and Opportunities for Integrating Computer Science in the K-8 Curriculum at a Teacher Preparation Program) has been approved by the Graduate Faculty of the School of Education and Human Development in partial fulfillment for the degree of Doctor of Education.

________________________________ Chair Signature

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Date: ______________________

Dedication

To Tom and Betty Wilkens: You are life-long learners that inspire me every day.

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Chapter 1: Introduction

Statement of the Problem

Technology is profoundly changing our personal and professional lives including the way we work, govern, educate, and communicate. Demand for a tech-savvy workforce is growing at a rate faster than all other occupations (U.S. Bureau of Labor Statistics, 2022). Computer science (CS) is the foundation of all technological innovations and CS education is focused on helping students understand why technology works and how to create it (ACM et al., 2016). CS education provides a pathway for students to become creators, not just consumers, of the next wave of discoveries, solutions, and innovations (Wing, 2008; Wilson et al., 2010). Beyond the pragmatic need to meet the demands for a CS-knowledgeable workforce, there is an underlying social justice theme related to K-12 CS education endeavors because of the persistent, pervasive, and problematic gender and racial gaps that plague CS education and technology fields (Cerf & Johnson, 2016; DuBow, W. & Gonzalez, 2020; Grover & Pea, 2013; Margolis et al., 2012). The keys to sparking interest amongst diverse populations of students include access to K-12 CS education and nurturing their tech identity (Cohoon et al., 2011).

To meet the demand and address equity issues, the Computer Science for All (CSforAll) initiative launched in 2016 by the Obama White House, the National Science Foundation (NSF), and the Department of Education aimed to make CS education available at every grade level for all K-12 students (Smith, 2016). In 2018, the Code.org Advocacy Coalition outlined nine policy recommendations for states to follow to expand their CS education initiatives which included defining and establishing K-12 CS standards and implementing clear certification pathways for teachers. Virginia was the first of 39 states to adopt K-12 CS education standards (Code.org et al., 2021; Sawczuk, 2017).

While states were rapidly putting K-12 CS standards in place (Code.org, 2021; Code.org & CSTA, 2018; Code.org et al., 2022) and identifying CS endorsement pathways for K-12 teachers (Guo & Ottenbreit-Leftwich et al., 2021), very few teacher preparation programs (TPP) were focused on preparing pre-service teachers to teach CS (DyLyser et al., 2018; Ottenbreit-Leftwich et al., 2021; Yadav et al., 2014). In the 1980s, promoting the teaching of CS in K-12 schools and supporting K-12 teachers with professional learning opportunities was primarily accomplished through individual researchers interested in K-12 CS education and professional associations like the International Society for Technology Education (ISTE) and the Computer Science Teachers Association (CSTA; Gal-Ezer & Stephenson, 2014). Most K-8 teachers do not have previous experience with CS content or pedagogy (DeLyser et al., 2018; Rich et al., 2021; Sadik et al., 2020). For instance, a nationwide report found that only 26% of elementary schools and 38% of middle schools offered instruction in computing with only a very small percentage of elementary school teachers (6%) and middle school teachers (4%) feeling prepared to teach CS (Banilower et al., 2018).

In Virginia, the CS Standards of Learning (SOLs) are expected to be integrated into the K-8 curriculum (Board of Education Commonwealth of Virginia, 2017) in core content areas (e.g., Language Arts, Mathematics, Science, and Social Studies). Integration is planned to be the primary method to teach CS SOLs in K-8 according to 77% of the public school districts in Virginia (Atkins, 2022). The top barriers to integrating CS in K-8 identified by Virginia public school districts in a 2022 report were 1) lack of instructional time, 2) lack of educator knowledge about CS, 3) lack of curriculum resources in K-5, and 4) lack of endorsed CS teachers in 6-8 (Atkins, 2022). That same report from the Virginia Department of Education (VDOE) highlighted the need for Institutions of Higher Education (IHEs) to help provide training focused on the integration of CS for elementary educators (Atkins, 2022). Meanwhile, CS integration in K-8 is not required of TPPs by the Virginia State Board of Education regulations (Virginia Administrative Code, 2018). Virginia does have a CS endorsement for grades 6-12 which teachers can earn by taking or transferring 18 hours of CS credit or taking the CS praxis (Code.org, 2018).

My Capstone study is focused on a TPP which does not formally incorporate CS education into the elementary or special education coursework for pre-service teachers. There is a 1-hour credit technology course for secondary and ESL pre-service teachers that includes 3 weeks focused on CS-related content and pedagogy. With the CS SOLs expected to be integrated into the K-8 curriculum (Board of Education Commonwealth of Virginia, 2017), a majority of public school districts planning to teach CS SOLs through integration (Atkins, 2022), and the VDOE highlighting the need for increased support from IHEs to help school districts address CS education (Atkins, 2022), the leadership in this TPP needs to determine how it will prepare its teacher candidates to integrate CS in their K-8 teaching practice.

Conceptual Framework

The rapid advancement of technology has been viewed with both a sense of wonder and trepidation. This change has been so rapid and so profound that the educational systems in the U.S. often struggle to keep abreast of current technologies (Hew & Brush, 2006). McLuhan et al. (1967, pp. 8-9) described this technological transition where "everything is changing - you, your family, your neighborhood, your education, your job, your government, your relation to 'the others'.” The fear of change and not being able to keep up in the midst of rapid and rampant technological advancement is very real (Admiraal et al., 2017; Broady et al., 2008). Educators are dealing with paradigm shifts brought on by technology use inside and outside the classroom (Hew & Brush, 2006; Mishra & Koehler, 2006).

In my experience working with K-8 teachers as an instructional coach and professional development (PD) provider, I often found that when I suggested to a teacher that they incorporate a new technology, it could be anxiety inducing for them. However, if I suggested that they integrate CS into their curriculum, they seemed even more fearful and often had misconceptions about CS education. Some common misconceptions about CS include that it is all about coding on a computer (Yadav et al., 2014), that it is about learning how to use technology (Gallup, 2020), that older people are less tech savvy (Broady et al., 2008) and that you must be very smart to do it (Gallup, 2016). While incorporating new technology into the classroom may be daunting, it is an expectation in K-12 environments (Hew & Brush, 2007). The idea of integrating CS concepts into the curriculum as a strategy to bring CS education into K-8 classrooms (Israel et al., 2015a; National Academies of Sciences Engineering and Medicine, Sciences, 2021; National Research Council, 2013) is a much more recent phenomenon. Integration of CS standards in K-8 is expected by state departments of education (Board of Education Commonwealth of Virginia, 2017; Code.org et al., 2022) and desired by school districts (Atkins, 2022). However, that is a big ask of K-8 teachers who already have a full plate teaching their regular content areas, are dealing with ongoing challenges from the COVID-19 pandemic and have little to no prior experience with CS content or pedagogy.

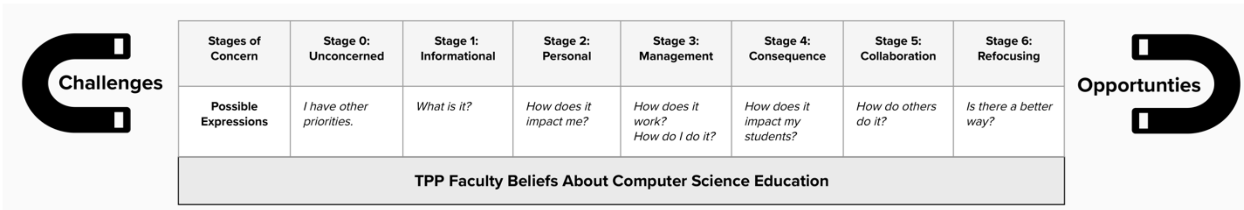
The idea of integrating CS in K-8 is fundamentally a new way of doing things in schools (Banilower et al., 2018) and TPPs (DeLyser et al., 2018; Mouza et al., 2021). It has the potential to change attitudes around education, such as when teachers incorporate CS as a tool for civic engagement through real-world problem-based learning (Cummings et al., 2021; Yadav &

Heath, 2022) or for providing personally meaningful learning experiences to students that enhances their engagement in school (Gannon et al., 2022; Ozturk et al., 2018; Rich et al., 2021).

I approached the idea of integrating CS in the K-8 TPP curriculum as an educational innovation. A product, idea, or practice is considered an innovation when it is perceived as something new by the individual or institution who is looking to adopt it (Rogers, 2003). For my Capstone study, I adopted elements from two innovation-related theoretical frameworks into my conceptual framework (Figure 1). One is the Stages of Concern (SoC) from the Concerns-based Adoption Model (CBAM) which was developed as a theoretical framework for facilitating the complex process of change in education (Fuller, 1969; Hall & Hord, 2015). The other element is from the Diffusion of Innovation (DOI) theory which seeks to describe how innovations are taken up by a potential population of users so that appropriate interventions can be crafted (Dearing, 2009; Rogers, 2003; Robinson, 2009). In my conceptual framework (Figure 1), the SoC rests on the foundation of faculty beliefs about CS education. The interrelationship between teacher concerns and beliefs was investigated in a study that found the more intense the personal concerns about an innovation were, the less self-efficacy teachers had toward the innovation, while the higher a teacher's efficacy belief is about their current instructional practice, the more intense their task and impact concerns about the innovation will be (Charalambous & Philippou, 2010). My conceptual framework (Figure 1) views perceived challenges identified by TPP faculty as having the potential to hamper movement across the SoC and perceived opportunities as having the potential to stimulate adoption of the innovation.

Figure 1

Conceptual Framework



Concerns-based Adoption Model

The CBAM framework "describes, explains, and predicts probable behaviors throughout the change process" (George et al., 2006, p. 5). The concerns model was developed out of research to support action and the implementation of change (George et al., 2006). CBAM is focused on increasing individual teachers' adoption and use of an innovation through targeted interventions (Hall & Hord, 2015). CBAM often uses an *implementation bridge* as a metaphor to represent change as a process and the movement of an individual across different stages of concerns (Hall & Hord, 2015). Studies that have employed CBAM confirm that there is generally a sequential nature to teacher concerns. For instance, Van den Berg & Ros (1999) found that in the beginning, teachers mainly express intense concerns related to the *Informational* and *Personal* stages, but that these concerns diminish over time while concerns related to *Management* increase. The change process is facilitated through interventions (Anderson, 1997) based on understanding educator concerns across the seven stages. According to George et al. (2006) lower stage concerns need to be supported and resolved before higher stage concerns.

Table 1

Stages of Concern and Potential Interventions

	Stage (George et al., 2006)	**Potential Interventions**
Stage 0: Unconcerned	Reflects a potential awareness of the innovation but other priorities are more concerning	Engage educators on a personal level to raise awareness about the innovation (McCarthy, 1982).
Stage 1: Informational	Reflects concern with the need to learn more about the innovation and potential impact of implementation.	Provide research-based information (McCarthy, 1982).
Stage 2: Personal	Reflects concern that individuals have relative to their self-efficacy, their belief in appropriateness of the innovation, and the personal cost to implement it.	Build rapport with individuals and provide encouragement (Anderson, 1997).
Stage 3: Management	Reflects concern about the logistical challenges of implementing the innovation.	Provide mentoring (Julius, 2007) and examples of how it would look (Anderson, 1997).
Stage 4: Consequence	Reflects concern about how implementation of the innovation is affecting students.	Demonstrate how it works and can be effective (Anderson, 1997).
Stage 5: Collaboration	Reflects concern about how individuals collaborate with others in using the innovation.	Encourage sharing ideas and strategies.
Stage 6: Refocusing	Reflects concern about improving or replacing the innovation.	Encourage sharing of struggles and successes with others.

Diffusion of Innovation

The DOI theory seeks to describe how innovations are taken up by a potential population of users across five stages of adoption including (Rogers, 2003; Robinson, 2009):

- Knowledge - an individual is aware of innovation but has no goal of adoption.

- Persuasion - an individual actively seeks out information about consequences, advantages and disadvantages associated with the innovation. At this stage, it is critical that the innovation be perceived as useful.
- Decision - an individual or group assesses the innovation through analysis and testing and decides whether to adopt or not.
- Implementation - the innovation is introduced. Ease of use and training are critical at this stage.
- Confirmation - an individual or group collects information that supports the decision of adoption or rejection.

Within these stages and across the potential adopters, Rogers (2003) identified five attributes (Table 2) that can be used as interventions or opportunities to help the innovation spread more easily (Dearing, 2009). The DOI theory proposes that the process of adoption is strongly shaped by social groups and role models, making educator groups like professional learning communities influential (Rogers, 2003). Conyers & Wilson (2016) suggest that educators can approach Rogers' model through five main lines of inquiry (Table 2).

Table 2

Five Attributes of Innovation That Stimulate Adoption

	Innovation Attributes (Rogers, 2003)	**Education Innovation Inquiry** (Conyers & Wilson, 2016)
Relative Advantage	Measured in terms of economic advantage, social prestige, convenience, and/or satisfaction.	How do faculty perceive the advantages of integrating CS in the K-8 TPP curriculum compared to the status quo?
Compatibility	The degree to which the innovation is perceived as being consistent with existing values and practices.	Is integrating CS in the K-8 TPP curriculum compatible with the current values and practices in the classroom and school?

Simple and Easy To Use	Ideas are adopted more rapidly when they do not require adopters to develop new understandings and skills.	What is the relationship between the complexity of integrating CS in the K-8 TPP curriculum and the relevance of CS integration to instruction?
Trialability	The extent to which a new idea can be experimented with helps adopters determine risk.	Is there an opportunity to experiment with integrating CS in the K-8 TPP curriculum before wider adoption?
Observable Results	Seeing the innovation in action lowers uncertainty and fosters interest within a community of practice.	Are results from early adoption of integrating CS in the K-8 TPP curriculum observable, so that it encourages wider adoption?

Purpose of the Study

A gap exists between the CS standards expected to be integrated into K-8 classrooms by the VDOE (Board of Education Commonwealth of Virginia, 2017) and public school districts across the state where the TPP exists (Atkins, 2022) and the preparation of K-8 pre-service teachers by the TPP to integrate CS into their teaching practice. Specifically, my Capstone project sought to address the following research questions in order to identify potential interventions to share with the TPP leadership for addressing this gap:

- RQ1: What beliefs do TPP faculty have about CS education?
- RQ2: What concerns do faculty have with respect to integrating CS in the K-8 TPP curriculum and where do those concerns fall along the SoC from CBAM?
- RQ3: What specific challenges do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the challenges reflected in the SoC mapping?
- RQ4: What specific opportunities do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the opportunities reflected in the DOI attributes that stimulate adoption?

Significance of the Study

The CSforAll movement along with nationwide advocacy organizations such as Code.org and CSTA have been successful in raising the profile of CS education, highlighting the importance of providing access to CS education to all K-12 students and helping states put K-12 CS education policies in place (Code.org, 2021, Code.org et al., 2022, Code.org & CSTA, 2018). However, TPPs are not keeping up with the need to prepare pre-service teachers to teach CS (DyLyser et al., 2018; Ottenbreit-Leftwich et al., 2021; Yadav et al., 2014). One reason is a mismatch between what is required of TPPs by state regulations and the CS standards expected to be taught by all teachers, especially in K-8 (Board of Education Commonwealth of Virginia, 2017; Code.org et al., 2022). A 2022 report on the state of K-12 CS education in Virginia, documented the need for training focused on the integration of CS for elementary educators and suggested that IHEs could help fill this gap (Atkins, 2022). Thus, TPPs need to determine how they can best prepare K-8 pre-service students to integrate CS education into their teaching practice. Viewing the integration of CS in the K-8 TPP curriculum through the lens of an educational innovation provides a way to capture concerns and opportunities the TPP faculty have around this idea and potential next steps to stimulate adoption at the TPP.

Definition of Terms

Following is a list of key terms defined in relation to the capstone study:

- *Computer science education* goes beyond just learning how to use computing technologies towards an understanding why computing technologies work and how to create technology (ACM et al., 2016). *Coding* is the act of writing instructions in a programming language for a computing device to run (ACM et al., 2016). *Computational thinking* is a way to solve problems through abstraction, algorithmic thinking, decomposition, pattern recognition, and debugging (Wing, 2006). In K-12 environments, *computer science*, *computational thinking* and *coding* are often used interchangeably (ACM et al., 2016; Voogt et al., 2015; Yadav et al., 2014). For the purposes of this paper, I view *computational thinking* and *coding* as elements within *computer science*.

- *Concerns* are "the composite representation of the feelings, preoccupation, thought, and consideration given to a particular issue or task" related to the innovation (Hall and Hord, 2015, p. 85). *Concerns* are neither good nor bad (George et al., 2006). For instance, two individuals who have different levels of *concern* within a stage does not mean that one is better than the other, but that in relation to the innovation, they each require different kinds of support (George et al., 2006).
- *Curriculum integration* is a strategy used in the classroom to bring together in meaningful association the teaching and learning of two or more subject areas into the same lesson, unit, or project (Drake & Reid, 2020; Lake, 2003). *Curriculum integration* has been shown to increase student engagement, address 21-century learning competencies, and lead to positive personal development and learning outcomes (Drake & Reid, 2020).
- *Educational innovation* includes the adoption of new ideas, tools, methods and/or technologies with the goal of improving pedagogical outcomes, the quality of education, and/or expanding knowledge accessibility (Marina & Christos, 2021). *Educational innovation* can also lead to the development of new attitudes towards education (Fullan, 2001).

- *Faculty* refers to any instructor involved with teaching pre-service students at the TPP. This may include general and tenured faculty, faculty advisors and coordinators, part-time adjuncts, and doctoral students.
- *Interventions* in CBAM are geared toward change and moving educators through the SoC. The Stages of Concern Questionnaire (SoCQ) is used to help identify and determine what *interventions* should be used based on the peak stages of concern for a group, sub-group or individual (Julius, 2007). In DOI, innovation attributes including relative advantage, compatibility, simple, trialability, and observable results (Rogers, 2003) can be positioned as potential *interventions* (Dearing, 2009). My Capstone will explore how *challenges* and *opportunities* identified by faculty for integrating CS in the K-8 TPP curriculum may or may not be related to CBAM *interventions* and innovation attributes from the DOI.

Chapter 2: Literature Review

The literature review explores how prior studies have defined CS and CS education, provides an overview of research about CS education and concerns around adoption in K-8 settings, and explores the pathways for CS endorsement and concerns around adoption in TPPs. Finally, the review highlights research looking at CS education through the lens of educational innovation.

What is CS?

There is a lot of terminology and jargon around CS. The Association for Computing Machinery (ACM) Model Curriculum for K-12 CS defines CS as "the study of computers and algorithmic processes including their principles, their hardware and software design, their applications, and their impact on society" (Tucker et al., 2003, p. 1). While this definition is technically accurate, it implies knowledge of CS to understand it and it does not tell the whole story. There have been multiple attempts to expand on this definition to explore what CS can mean to all students and teachers. The Code.org glossary defines CS as "using the power of computers to solve problems" and Benyo et al. (2009) positioned CS as being about passion, creativity, connecting people, and changing the world. CS is distinguished from other technology-related curricula that focus on how to use computer technology because CS is focused on understanding why it works and how to create it (ACM et al, 2016). As a new field, the definition of CS and what its educational value is continues to evolve (ACM et al., 2016; Barr & Stephenson, 2011; Yadav et al., 2014).

Sometimes coding is conflated with CS (ACM et al., 2016; Voogt et al., 2015; Yadav et al., 2014). The Virginia CS SOLs define six strands which includes coding, also known as *algorithms & programming,* as just one of several core concepts that are part of CS (Board of

Education Commonwealth of Virginia, 2017). The strands also include *computing systems* which relates to the interaction of humans with computing devices, *cybersecurity* which relates to the protection of computing devices, *data & analysis* which relates to how data is collected, stored, and used, *impacts of computing* which relates to both the positive and negative impacts that computing has on our everyday life, and *networks and the Internet* which relates to how computer networks connect people with each other worldwide (Board of Education Commonwealth of Virginia, 2017).

An important evolution in CS education was the introduction of computational thinking (CT), a term that Papert coined in his 1980 book, *Mindstorms: Children, Computers, and Powerful Ideas*. With the assumption that computers would become as ubiquitous as pencils in the classrooms, Papert viewed CT as the process of coding a computer and believed that process would also help students learn other subjects such as mathematics and language arts (Bull et al., 2020). Wing (2006) further expanded on the definition of CT as a set of mental tools for solving problems including abstraction, algorithmic thinking, decomposition, pattern recognition, and debugging. Wing (2006) envisioned the role of CT expanding across all disciplines which ignited engagement and discussion about the nature and purpose of CS education in K-12.

Why is CS Education Important?

For the past two decades, several national organizations have highlighted the importance of CS education and advocated for national and state policy recommendations to improve access in K-12. In 2009, the ACM launched CSEdWeek to raise awareness about the importance of CS education in K-12 (Fisher, 2016). In 2013, Code.org launched the Hour of Code (HoC) during CSEdWeek to get students and teachers hands-on with CS by providing fun, and easy to access activities and tutorials (Fisher, 2016). In 2015, CS education was formally recognized as part of

STEM education in K-12 public schools as part of the STEM Education Act, however, the T for technology in STEM education still mostly represents technology use. The CSforAll initiative launched in 2016 by the Obama White House, the National Science Foundation (NSF), and the Department of Education (ED) intended to ensure all K-12 students would have access to CS education at every grade level (Smith, 2016).

CS education is important because CS instills creativity, critical thinking skills, logical reasoning, is transferable to other disciplines, is needed for the workforce and is an alternate pathway to other science and math skills (Nager & Atkinson, 2016). CS can also empower students to become informed citizens who can critically engage with and express themselves through technology (ACM et al., 2016). Vogel et al. (2017) asked a variety of stakeholders in CS education including educators, researchers, program designers and policy makers what their arguments were for CS education. They identified seven areas of impact including: 1) economic and workforce development, 2) equity and social justice, 3) competencies and literacies, 4) citizenship and civic life, 5) scientific, technological, and social innovation, 6) school improvement and reform, and 7) fun, fulfillment, and personal agency (Vogel et al., 2017). However, CS education not only promotes the development of technical skills but can also shift educational experiences toward a community-oriented approach connected to students' lived experiences through solving authentic and community-based problems (Yadav & Heath, 2022). Tissenbaum et al. (2021) make the case that multiple, alternative endpoints are needed in CS education to support the wide variety of desired impacts. These diverse goals for CS education are often not reflected in current efforts to expand CS in K-12 as the educational landscape is geared primarily toward a pipeline model, funneling learners toward CS degrees and technology sector jobs (Tissenbaum et al., 2021).

CS Education in K-12

In 2003, CSTA released a model curriculum for CS in K-12 as a roadmap they hoped state departments of education and school districts would use to incorporate CS into their curriculum (Tucker, 2003). However, the roadmap still needed several steps to turn the model into a *deliverable* curriculum including the formulation of standards, the definition of PD needs, and the development of curriculum materials (Tucker, 2003). A review of models for introducing CS into K-12 education found that CS was generally not present in primary environments and an elective in secondary environments (Heintz et al., 2016). In 2018, a national coalition outlined nine policy recommendations for states to follow to expand their CS education initiatives including the need to define CS standards, implement clear CS endorsement pathways for teachers, and create pre-service programs in CS at IHEs (Code.org & CSTA, 2018).

CS Education in High School

CS education first found its way into high schools through Advanced Placement (AP) prep classes for the AP CS exam introduced in 1984 by the College Board (2021). One issue that became apparent with CS education in high school was the digital divide. Often thought of in terms of access to hardware and Internet connectivity, Margolis et al. (2003), found in their study of the CS pipeline in high schools, that access to CS education was also impacted by high stakes testing in other subject areas, lack of qualified CS teachers, and school administrators assuming computer literacy was equivalent with CS. Meanwhile, a 2010 report titled, *Running on Empty: The Failure to Teach K-12 Computer Science in the Digital Age* found that the state of K-12 CS education was in decline (Wilson et al., 2010). That report helped launch a variety of initiatives like CSEdWeek and CSforAll aimed at recognizing the importance of and increasing capacity for CS education in K-12 (Grover et al., 2016; Code.org, 2021) and the CS10K project aimed at increasing the number of high school CS teachers (Astrachan et al., 2011).

A 2021 report on the state of CS education in the United States, found that while 51% of high schools offered a foundational CS course, only 4.7% of high school students (across 37 states) were enrolled in foundational CS courses (Code.org et al., 2022). In Virginia, 87.3% of high school students attended a school that offered a CS course in the 2020/21 school year, but only 6.3% of high school students were enrolled in a CS course (Code.org et al., 2022).

CS Education in K-8

CS education in K-8 is a much more recent phenomenon. One important doorway for CS education in K-8 arrived in the form of CT (Barr & Stephenson, 2011; Grover & Pea, 2013; Ottenbreit-Leftwich & Yadav, 2022). Wing (2008) predicted CT would become an essential part of childhood education, while she also acknowledged that there were many "cultural, economic, political and social barriers in realizing this vision" (p. 3722). Wing extended CT beyond human-computer interactions to human-centric and CS activities that do not require a computer. Also known as CS Unplugged, these CT activities became a way forward for CS education in many K-8 environments because it was cheap and easy to implement (Bull et al., 2020). CT also became an integral part of the science and engineering practices of the Next Generation Science Standards (NGSS, National Research Council, 2013).

CS Integration in K-8. Beyond introducing CS through CT, integrating CS into the curriculum has been identified as another successful strategy for bringing CS education into K-8 classrooms, especially if teachers find it does not require additional instructional time (Israel et al., 2015; National Academies of Sciences Engineering and Medicine, Sciences, 2021). Research into STEM education has found that with support such as PD, teachers find that integration is "a natural way to think about teaching since most real-world problems cross disciplinary boundaries" (Wang et al., 2011, p. 10). Research also shows that the integration of CS into other subjects areas in K-8 has a positive impact on the study of science (Wiese & Linn, 2021), math (Rich et al., 2019; Sung et al., 2017) and literacy (Century et al., 2020). Project-based learning is an effective way to integrate CS into other subject areas which can also result in enhanced learning opportunities, greater collaboration, and more autonomy for students (Ozturk et al., 2018). Even the youngest learners can make associations with CS to other subject areas (Tran, 2013). However, these positive outcomes might count on expertise from the IHE where the research originates. For instance, the in-school study from Tran (2013) relied on an intervention program run by undergraduate students from the IHE who were trained across the 10-week program. As the study noted, "this type of learning might not have been possible with the lack of teacher knowledge and resources from the two districts" (Tran, 2013, p. 21).

States like Alabama, Mississippi, and Virginia expect the CS standards to be integrated into the K-8 curriculum. The latest report on the state of CS education finds that while thirty-nine states have adopted K-12 CS standards, only nineteen states provided CS data for K-8 and of those, only nine provided data for K-5 (Code.org et al., 2021). Most states are working on improving their K-8 data reporting. One issue is that if CS is integrated into the curriculum, it is harder to track (Code.org et al., 2021).

Types of Integration. Integration can take many forms. Jacobs (1989) identified strategies for integration including multidisciplinary, where a single topic is studied through the lens of different subject areas, interdisciplinary, where a common theme provides the context for learning across subject areas and transdisciplinary, where a real-world problem drives the learning across subject areas. Guzey et al. (2016) defined six key elements of meaningful integration in STEM teaching and learning that include 1) providing a motivating and engaging context, 2) active student participation in design challenges, 3) acknowledging failure as an essential element of student learning, 4) lessons that incorporate grade level appropriate learning activities in other subject areas, 5) learning activities that are student-centered, and 6) learning activities that encourage teamwork and collaboration.

Meanwhile, Waterman et al. (2018) identified three levels of CS integration in teacher-written materials including exist, enhance, and extend:

1) CS concepts, skills, and practices already *exist* in a lesson and just need to be called out.
2) The addition of CS-related learning activities *enhances* the disciplinary concept and provides explicit connections to computing concepts.
3) New lessons exploring CS *extend* the disciplinary concept.

CodeVA (2022) provided a depth of integration framework to help Virginia teachers identify the level of CS integration in their lessons. These include *CS emerging* (very little or no CS content), *CS embedded* (CS supports core content), *Engrained* (CS and core content are coequal), *Core Embedded* (Core content supports CS learning), and *Core Emerging* (CS content only).

Challenges with CS in K-8

There are three major issues facing CS education in K-8 including the need for: 1) K-8 teachers who feel prepared to teach CS (Banilower et al., 2018; DeLyser et al., 2018; Rich et al., 2021; Sadik et al., 2020), 2) K-8 curriculum resources (Atkins, 2022; Friend, 2022; Gal-Ezer & Stephenson, 2014), and 3) equitable access to CS education (Banilower et al., 2018; Code.org & CSTA, 2018; Grover & Pea, 2013; Margolis et al., 2008).

Prepared K-8 Teachers. Most K-8 teachers have not explored CS pedagogical or content knowledge during their pre-service education (DeLyser et al., 2018; Banilower et al., 2018). Even without this experience, a 2020 Gallup poll found that 75% of elementary school teachers in public schools say that offering CS is just as important to their students' future success as required subjects, but only 25% believe teacher efforts to teach CS are highly valued, 47% believe CS should be integrated into other subjects, and 19% are satisfied with the availability of CS education for their students.

Teacher self-efficacy towards teaching CS plays a crucial role in the successful implementation of CS education, which can be greatly affected by the amount of CS experience an educator has (Rich et al., 2017; Rich et al., 2021; Zhou, et al., 2020). A National Research Council (2011) report on the pedagogical aspects of CS suggested that by its nature CS places student interests at the center of problem solving which in turn can make teachers uncomfortable as this implies giving up control over parts of the learning process and not having all the answers. Rich et al. (2019) found that elementary teachers were concerned with limited class time, the need to balance exposing students to CS with the need to prepare students for standardized tests, and wondering whether the ideas of CS could be made developmentally appropriate for students. Rich et al. (2021) also found that in a study of over 100 elementary school teachers, that hands-on CS learning opportunities were the "primary driver of success" for increasing their confidence in coding (p. 13). A recent study reporting on differences in CS self-esteem in K-12 educators found that females reported significantly lower CS self-esteem than males, primary teachers lower than secondary, teachers with 0-3 years' experience had negative CS self-esteem, and teachers who lived in rural settings reported lower CS self-esteem than those in metropolitan areas (Vivian et al., 2020).

The voices of K-8 educators and their experiences of CS education are often missing from prominent, large-scale studies and reports about K-12 CS education. For instance, the

Running on Empty report only analyzed data at the high school level (Wilson et al., 2010). While the *Report of the 2018 NSSME+* had a school-level questionnaire that incorporated CS education across K-12, the teacher-level questionnaire related to CS education was only targeted at high school teachers (Banilower et al., 2018). Most CS education research and PD work has been generalized across K-12 (e.g., Pollock et al., 2017; Reding & Dorn, 2017) even though the CS content knowledge and pedagogical practices needed varies widely from early childhood to high school (Rosato et al., 2022; Shea et al., 2020). In a literature review summarizing empirical research studies on K–12 CS education, Vahrenhold et al. (2019) noted that addressing primary school teachers' attitudes toward CS will be crucial in its implementation, however, none of the dozens of studies they cited focused on K-8 teachers.

Curriculum Resources. Another gap in CS education is between the push for states to adopt CS education policies (Code.org et al., 2021) and the curriculum needed to support those policies (Atkins, 2022; Friend, 2022). With no national CS curriculum and standards varying state by state (Guo & Ottenbreit-Leftwich, 2020), the resulting landscape for K-8 CS curriculum is a hodgepodge of providers scrambling to create curricula to meet a variety of needs. CS standards do not often incorporate effective practices for integrating CS into discipline-specific curricula (McGinnis et al., 2020). High-quality curricular materials are content rich, culturally diverse, and include assessment (Polikoff & Dean, 2019; Steiner, 2017), but most K-8 CS curricular resources have a focus on CS content and/or the tool they are supporting and often do not address integration, assessment, or cultural diversity (Foster, 2022).

Equitable Access. An underlying theme behind raising the profile of K-12 CS education is addressing the gender and racial gaps that currently exist in CS education and technology fields (DuBow & Gonzalez, 2020). Interest in and knowledge of CS is still relatively low for students who identify as female, Black, and/or Latinx (Cerf & Johnson, 2016). When CS is treated as an enrichment activity instead of an integration activity in K-8, it runs the risk of only being offered to students who are high achieving in other subject areas (Weintrop et al., 2018). Integration also helps address practical issues like lack of time (Israel et al., 2015), pedagogical issues because integration provides richer problem-solving contexts (Fofang et al., 2020), and equity issues by ensuring all students have access.

In addition to access, teachers of CS “need to be prepared to develop teaching strategies to deal with significant diversity issues” (DeLyser et al., 2018, p. 13; Margolis et al., 2008). This includes helping students develop confidence, connecting instruction to career opportunities, and incorporating students’ cultural backgrounds into teaching (Banilower et al., 2018). On a positive note, research indicates that engaging teachers in CS learning opportunities combined with CS pedagogical strategies to mitigate bias may improve K-8 teacher self-efficacy towards teaching CS (Ryoo et al., 2015; Wilkens et al., 2021; Wilkens et al., 2022).

CS Education in TPPs

In a report titled, *Priming the Computer Science Teacher Pump* from DeLyser et al. (2018), the primary argument for moving CS education into schools of education is that if CS is really to be considered a core subject in K-12, then it must be treated the same as other subjects in pre-service education. The report highlighted that most of the K-12 CS education PD opportunities offered by IHEs were delivered by CS departments and geared toward in-service teachers (DeLyser et al., 2018). A review of this type of PD found that there was limited collaboration between IHEs and local school organizations in developing the PD which impacted the sustainability and long-term effects on changing teachers' practices and student learning (Meneske, 2015). Because of these issues, DeLyser et al. (2018) called on schools of education to use their knowledge and experience to create the needed methods courses across grade bands, to establish student teaching experiences in collaboration with local schools, and to conduct research into the best practices in the field of CS education.

In a recent chapter highlighting strategies for TPPs to build and expand their capacity to prepare and support pre-service teachers to teach CS, Yadav et al. (2021) suggested that TPPs need to ensure their K-8 teacher candidates receive basic CS literacy instruction and foundational pedagogy in CS, support faculty in familiarizing themselves with relevant K-12 CS standards for integration into their core pedagogical coursework, and facilitate connections between faculty and practitioners to ensure their coursework aligns with relevant offerings in regional schools (Yadav et al., 2021).

Some potential avenues for CS in TPPs include integrating it into existing educational technology courses or existing methods courses (Yadav et al., 2017). In one redesigned educational technology class that incorporated CS, researchers found there was increased understanding of CS concepts and practices from pre- and post-surveys, but the participants still faced challenges in designing and enacting lessons that seamlessly integrated CS content (Mouza et al., 2017). A study investigating how schools of education were incorporating CS nationwide found that of 1,200 elementary education programs surveyed, only 104 responded (Ottenbreit-Leftwich et al., 2021). Of those, 68% required CS education with 72% delivering content through an education technology course, 54% through a method course, and 16% through PD (Ottenbreit-Leftwich et al., 2021). Enderson et al. (2020) found that TPPs tend to focus on specific disciplines at the expense of curriculum integration.

CS Endorsement Pathways in TPPs

There is not a one-size-fits-all approach toward CS endorsement pathways in TPPs as each state offers its own set of guidelines and regulations (Adler & Beck, 2020; Shea et al., 2020; Standl et al., 2020; Toolin et al., 2021). Importantly, schools of education look to state-approved regulations to determine what CS pathways they are required to offer to their pre-service teacher candidates and currently 42 states employ an add-on license, 24 employ an authorization policy, and 19 states employ an initial certification program (Ottenbreit-Leftwich et al., 2022):

- **Initial license** - a standalone pathway validates that pre-service teachers can teach CS or that in-service teachers have completed the requirements. In Virginia, six TPPs have been approved by the VDOE to certify pre-service 6-12 teachers in CS through coursework and/or by passing the Praxis CS exam (Code.org, 2018).
- **Add-on license** - also known as endorsement, this is an add-on to an existing teacher license. In Virginia, teachers with existing licensure can obtain an add-on endorsement for CS through academic coursework or by passing the Praxis CS from state-approved programs (Code.org et al., 2022).
- **Authorization** - authorized teachers do not need to demonstrate that they know CS in order to teach it. Typically, this is done in the form of states allowing other subject area teachers to teach CS. In Virginia, middle and high school standalone courses in CS may be taught by educators with teaching endorsements in Math or Business and Information Technology (Balow, 2022). There is no additional endorsement or authorization needed to teach CS integrated into K-8 in Virginia (Balow, 2022).

Despite efforts to raise the profile of CS education and the need for CS educators in K-12, CS remains the least popular subject area for pre-service teachers with just 55 graduates earning an endorsement to teach CS across the U.S in the 2018-19 school year (U.S. Department of Education, 2022). That compares with 13,304 in math, 7,158 in social studies and 5,321 in general science (U.S. Department of Education, 2022).

K-8 CS Pathways in TPPs. CS endorsement pathways available for all K-12 pre-service teachers often focus on undergraduate-level knowledge of computing concepts (Code.org, 2018; Ottenbreit-Leftwich et al., 2021; Rosato et al., 2022) versus the ability to meaningfully integrate CS into activities appropriate for young children (Rosato et al., 2022). For instance, in Virginia there is only a CS endorsement pathway for 6-12 teachers, with no additional endorsement or authorization needed to teach CS in K-8 (Balow, 2022). One example of coursework for the 6-12 CS endorsement in Virginia includes Foundation of CS for Educators, Discrete Mathematics, Programming in Python, Programming in Java, Data Structures, and Algorithm Analysis. The Praxis exam requires advanced CS content knowledge including the ability to read complex pseudocode and to understand concepts like recursion, randomization, application programming interfaces (APIs) and logic gates (ETS, 2018).

A Mississippi-based research-practice partnership (RPP) between the TPP, the CS and engineering department at a university, and the state department of education determined that to be qualified to teach CS, elementary teachers did not need the same level of coursework as high school teachers (Shea et al., 2020). They created a 12-hour endorsement for K-8 including topics such as digital tools, graphics and web design, intro to CS and a separate 20-hour endorsement for grades 7-12 including topics such as cybersecurity, computer programming, and data structures and algorithms (Shea et al., 2020).

St. Scholastica took a more holistic approach in the creation of a pilot program to prepare all their K-12 teacher candidates with foundational CS knowledge, regardless of licensure area

(Lucarelli et al., 2021). There were no CS standards or certification pathways for CS in Minnesota, so they forged their own pathway over three phases (Lucarelli et al., 2021). First, they prepared their education faculty with 20 hours of PD that focused on CS literacy, getting hands-on with CS activities, integration strategies, and inclusive methods for teaching CS (Lucarelli et al., 2021). During the next phase, the education faculty infused CS into their course curricula for pre-service teachers. Finally, the TPP helped provide pre-service teachers connections with school placements where they could apply their CS learning in the classroom (Lucarelli et al., 2021).

Challenges with CS in TPPs

Several challenges have been identified within TPPs and other university departments with respect to incorporating CS education into pre-service education. The Mississippi RPP found that university departments were concerned with funding, rigor, enrollment, and capacity (Shea et al., 2020). Another study of 22 faculty responsible for a wide range of teacher education courses identified concerns related to integrating CS in pre-service courses including: lack of content knowledge, time, and content constraints (Mouza et al., 2021). Preliminary results from a nationwide study of CS education in TPPs confirmed these concerns and identified additional barriers at the elementary education level including a lack of credit hours in teacher education programs and lack of pre-service teacher awareness of CS while barriers at the secondary education level also included low pre-service enrollment and lack of pre-service interest (Ottenbreit-Leftwich et al., 2021).

CS Integration as an Educational Innovation

Viewing the integration of CS in the K-8 TPP curriculum as an educational innovation, provides tools like CBAM to better understand TPP faculty concerns with adoption and the DOI theory to craft potential interventions to address those concerns. The CBAM framework has been used to investigate a variety of factors relative to innovation diffusion in school. "The concerns model was largely developed out of research to support action" (George et al., 2006, p. 65). One of the most recent trends for CBAM use is related to the study of technology integration in schools (George et al., 2008). For example, Atkins and Vasu (2000) found that in schools with more technology personnel supporting technology use, teacher concerns around technology integration peaked around *Stage 3*: *Management* and *Stage 4: Consequence* while teacher concerns in schools that did not have technology specialists were concentrated in *Stage 1: Informational* and *Stage 2: Personal*. Other examples show results from CBAM informing interventions such as PD (Burns & Reid, 1998; Howland & Mayer, 1999) and identifying barriers to readiness (Dass, 2001).

However, Lau and Jong (2022), who employed CBAM in their study noted that "little is known about teachers' concerns" with respect to teaching integrated STEM (p. 3). In a paper summarizing existing scholarship on the diffusion of CS-specific educational innovations, Taylor et al. (2018) found that there was less research on educational innovation adoption in CS compared to other STEM disciplines. In their literature review of innovations in CS education, they identified common faculty concerns and suggested interventions. Looking at their results, it is possible to interpret the concerns through CBAM's SoC model and the suggested interventions through the DOI attributes of innovation that stimulate adoption (Table 3). Taylor et al. (2018) concluded that it is not enough to publish attitudinal results or hold a workshop to disseminate new ideas, but that a system-level approach to change is required.

Table 3

Concerns and Interventions for the Diffusion of an Innovation in IHEs

Concern (Taylor et al., 2018)	Potential Intervention (Taylor et al., 2018)
Innovation seen as replacing traditional methods (*Stage 1: Informational*)	Word of mouth and faculty or student champions are more effective than relying on academic publications to tout effectiveness (*Compatibility, Observable Results*).
Lack of knowledge and skills about the innovation (*Stage 1: Informational*)	Provide appropriate training and support through mentoring (*Simple and Easy to Use*, *Trialability*).
Professional identities working against the adoption of a new innovation (*Stage 2: Personal*)	Positive social experiences that leverage what identities are important to faculty can help alleviate this barrier (*Relative Advantage*).
The innovation does not seem to fit within existing practices (*Stage 3: Management*)	Help faculty see how the innovation fits within current attitudes, processes, and practices of faculty members (*Compatibility*).
Time and effort constraints will impact innovation implementation (*Stage 3: Management*)	Administrators help increase adoption by considering policies that reduce faculty workload to deal with time and effort constraints like reworking curriculum (*Relative Advantage*)
Concerns about student resistance and buy-in to the innovation (*Stage 4: Consequence*)	Communicate and collaborate with students about the change (*Compatibility*, *Trialability*)

Note. I mapped the concerns and interventions identified by Taylor et al., (2018) to my conceptual framework.

Conclusion

CS education is important because it empowers students to express themselves through and critically engage as informed citizens with technology (ACM et al., 2016; Nager & Atkinson, 2016; Vogel et al., 2017). Efforts to expand CS education have primarily been focused at the high school level by increasing the number of qualified CS teachers (Astrachan et al.,

2011) and at the K-8 level by increasing awareness, tools, and curriculum through efforts like the Hour of Code (Grover et al., 2016; Code.org, 2021).

Integrating CS is seen as a path forward to expanding CS education in K-8 (Israel et al., 2015; National Academies of Sciences Engineering and Medicine, Sciences, 2021), however K-8 teachers have often not been prepared to teach CS (Banilower et al., 2018; DeLyser et al., 2018; Rich et al., 2021; Sadik et al., 2020), there is a lack of curriculum resources (Atkins, 2022; Friend, 2022; Gal-Ezer & Stephenson, 2014), and equitable access to CS education has not been achieved (Banilower et al., 2018; Code.org & CSTA, 2018; Grover & Pea, 2013; Margolis et al., 2008). The voices and experiences of K-8 educators are also missing from important K-12 CS education surveys and research (Vahrenhold et al., 2019; Wilson et al., 2010).

CS education is slowly finding its way into TPPs through three endorsement pathways: initial license, add-on license, and authorization (Ottenbreit-Leftwich et al., 2022). Overall concerns about CS education in TPPs include a lack of awareness, content knowledge, time, and low enrollment (Mouza et al., 2021; Ottenbreit-Leftwich et al., 2021).

CBAM highlights how the concerns of educators towards an educational innovation like integrating CS in K-8 can impact its diffusion within an organization (George et al., 2006). In higher education, these concerns can be related to professional identity, whether it is viewed as a good fit, how one feels about the time and effort constraints, and how students will respond to the innovation (Taylor et al., 2018). The potential interventions identified included DOI attributions of adoption such as *Relative Advantage* by providing positive social experiences that leverage faculty identities, *Compatibility* by helping faculty see how the innovation fits in the program, and *Simple and Easy to Use* by providing training and support. Taylor et al. (2018) also determined that a system-level approach to change was more effective than focusing on one intervention.

Chapter 3: Methods

Research Questions

Positioning the integration of CS in the K-8 TPP curriculum as an educational innovation, my goal is to address the following research questions:

- RQ1: What beliefs do TPP faculty have about CS education?
- RQ2: What concerns do faculty have with respect to integrating CS in the K-8 TPP curriculum and where do those concerns fall along the SoC from CBAM?
- RQ3: What specific challenges do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the challenges reflected in the SoC mapping?
- RQ4: What specific opportunities do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the opportunities reflected in the DOI attributes that stimulate adoption?

Study Design

My Capstone research employed an intrinsic case study design which included data collection to provide a detailed snapshot of the specific bounded case of the TPP under study (Hancock & Algozzine, 2016). The case study explored the nature of the problem of practice from two perspectives: *Stages of Concern* and *Diffusion of Innovation*. CBAM provides the SoCQ which is a well-vetted quantitative instrument for mapping educator concerns about a proposed innovation across seven stages (George et al., 2006). This instrument was used to address RQ2.

Nemutanzhela and Iyamu (2015) make the case that qualitative data is a good fit for exploring DOI because innovation adoption is shaped by the "social process of communication" (p. 604) within particular environments. To dig deeper into faculty beliefs, concerns, perceived challenges, and opportunities to integrate CS in K-8 TPP curriculum, qualitative data was collected through open-ended questions in the survey and semi-structured individual interviews to address RQ1, RQ3, and RQ4.

Context

The focus of my Capstone case study is a TPP in Virginia. The TPP offers both in-person and online instruction to pre-service teacher candidates. For the purposes of this study, I primarily focused on the in-person instruction which offers Bachelor of Science (BS) degrees in Early Childhood Education, Elementary Education, and Special Education and Master of Teaching (MT) degrees in English as a Second Language, Elementary, English, Mathematics, Science, Social Studies, and Special Education. There are 36 instructors, which include general and tenured faculty, part-time adjuncts, and doctoral students, for the in-person TPP courses. In the 2022/23 school year, there were around 150 in-person, pre-service students in the BS and MT programs (Table 4).

Table 4

Number of In-person Pre-service Students Per Area of Study

Number	Area of study
9	Early Childhood BSEd
57	Elementary BSEd
15	Special Education BSEd
20	Elementary MT
8	English MT
7	ESL MT
1	Mathematics MT
2	Science - Biology MT
4	Science - Chemistry MT

1	Science - Earth Science MT
22	Social Studies MT
3	Special Education MT

Participants and Recruitment Process

The criterion for the survey participants was instructors who teach or have taught an in-person course to K-8 teacher candidates in the past year. The director of the TPP provided a list of 36 instructors. Once I had IRB and Teacher Education Data Committee approval, I sent out an initial recruitment email (Appendix A) with a survey link on January 13, 2023. I sent follow-up emails on January 19 and 25 reminding potential participants that the survey would close at midnight on January 27, 2023.

For the interviews, I identified a criterion-based sampling and then worked with the director of the TPP to identify instructors that met the criterion (Patton, 2008). The first criterion was to focus on instructors who teach in the elementary BS program. The reason to focus on elementary education is that K-5 does not generally have standalone CS classes, so integration is the only path for CS education. The reason to focus on the BS is because it is a four-year program versus the MT which is one year, so there might be more flexibility to add CS integration into coursework in the BS. Within this group, I wanted to interview at least one program coordinator who facilitates curriculum discussions, at least three instructors who teach in core subject areas such as math, science, and reading, and at least one instructor who receives curriculum guidance from faculty. My goal was to interview at least six instructors within the criterion, and I worked with the director of the TPP to identify a primary pool of interview participants as well as a few backup candidates.

To prepare for scheduling the interviews, I created an online calendar to share with participants to book their interview time. I sent out the first interview request e-mails (Appendix B) on January 11, 2023, to nine instructors who fit the criteria with a link to my calendar to book an interview slot. Based on responses I received to that e-mail, an additional two candidates were identified and contacted January 17, 2023. From these eleven instructors, eight expressed an interest in being interviewed, seven scheduled their interview time slots and six interviews were completed.

Survey Participant Demographics (n=19)

The survey results were anonymous, but the participants were asked to provide their demographic information at the end of the survey (Appendix C). To protect individual identities, I decoupled the subject areas taught (Figure 2) from the other demographic responses (Figure 3). In the data analysis, individual survey responses (SR) are coded with letters “A” through “S”, e.g. SR-B.

Figure 2

Number of Instructors per Subject Area

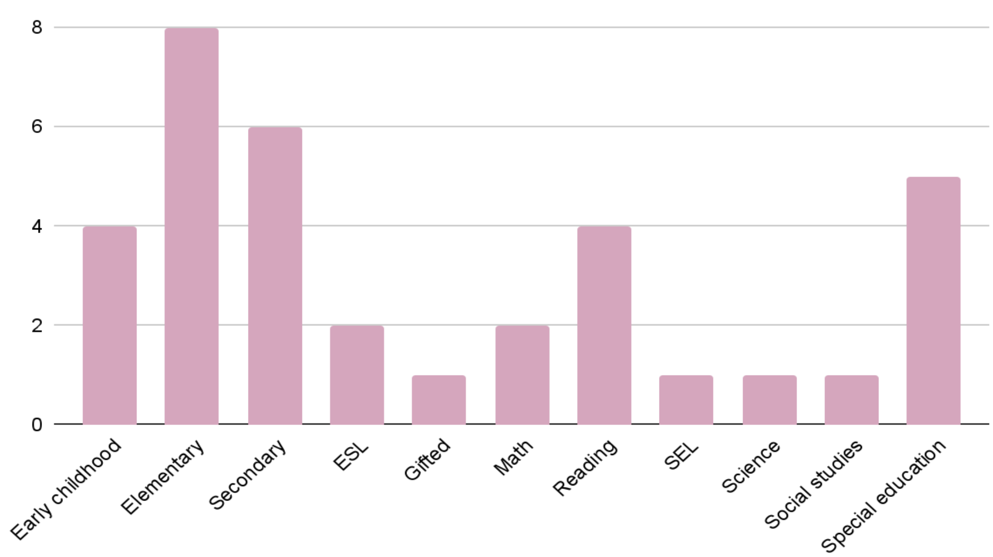
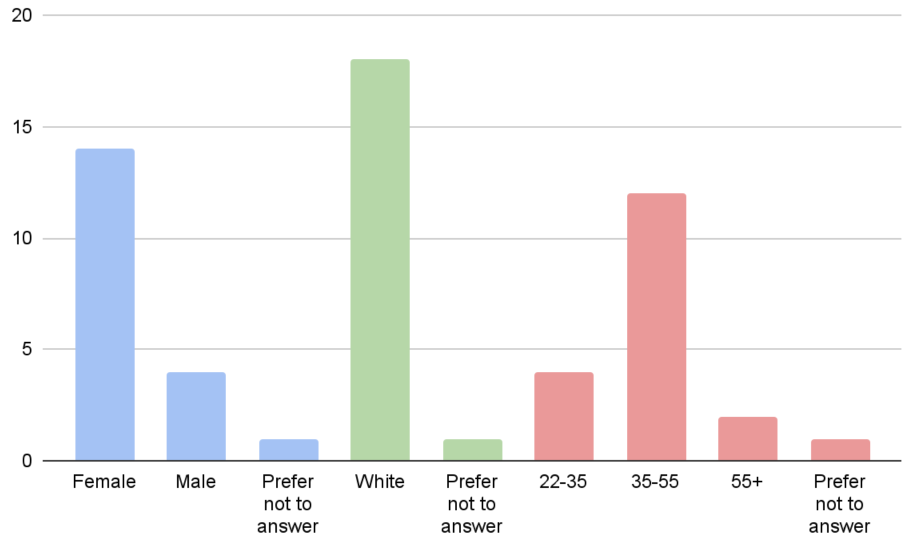


Figure 3

Participant Demographics



Interview Participant Demographics (n=6)

The interview participants have been at the TPP from 4-20 years. They teach subjects including early childhood education, special education, elementary methods, science, math, and language arts. Their roles at the TPP include being PhD students, program coordinators, associate professors, and research scientists. I created pseudonyms for the interview participants (Kendall, Terry, Dara, Quinn, Morgan, and Lane), but to protect their identities, I am not associating these pseudonyms with their demographic information.

Data Sources

I gathered quantitative data in the form of an online survey that incorporated the SoCQ and qualitative data in the form of open-ended questions in the survey and semi-structured interviews.

Innovation Survey: Integrating Computer Science in K-8

The SoCQ is made up of 35 items or concern statements, which respondents rate using a seven-point Likert scale. The responses range from *Irrelevant (0)*, *Not sure of me now (1-2)*, *Somewhat true of me now (3-5)* and *Very true of me now (6-7)*. The SoCQ has been proven valid and reliable with group and individual data (George et al., 2006). The SoCQ has been used in hundreds of studies to measure the relative intensities of the seven SoC expressed by teachers (Chen & Jang, 2014; George et al., 2006). The SoCQ was developed in the early 1970s through an iterative process of expert contributions, expert review, and factor analysis (George et al., 2006). To ensure high internal reliability, the creators of the SoCQ only included an item on the questionnaire if it correlated other items measuring the same stage (George et al., 2006). Across seven large studies that used the SoCQ between 1979 and 1991, internal reliability coefficients were lowest for stage 0 (between .50 and .77) with the rest of the stages generally above .70 (George et al., 2006).

While this instrument has been found reliable, some studies have either proactively altered the questions or recommended changes based on their findings (George et al., 2006). George et al. (2006) caution researchers about making such changes, but one study that employed SoC with respect to technology integration found that some questions were too broad and misunderstood by the survey respondents (Chen & Jang, 2014). Based on this finding I initially modified 28 questions to be more specific about the innovation being the integration of CS in the K-8 TPP curriculum (Appendix D). In addition to the SoCQ, I added three open-ended questions including one related to what CS education meant to the respondents and two around the opportunities and challenges of integrating CS in the K-8 TPP curriculum as well as demographic-related questions (Appendix C).

After I moved the survey into Qualtrics, I solicited pretest survey feedback from three expert reviewers who have experience with education research and the context of the TPP (McMillan, 2020). Their feedback resulted in final updates to twelve questions including removing Stage 6 questions based on the belief that no instructors in the TPP are at this stage so the questions would be confusing to almost everyone, replacing the word “students” with “teacher candidates”, and adding more clarification that the innovation is the integration of CS in the K-8 TPP curriculum (Appendix D).

Semi-structured Interviews

A semi-structured interview guide (Appendix B) included questions that asked participants to consider the idea of integrating CS in the K-8 TPP curriculum as an innovation through both the lens of DOI attributes of *relative advantage*, *compatibility*, *simple*, *trialability*, and *observable results* (Rogers, 2003) and SoC from CBAM. The rest of the questions in the interview guide were focused on beliefs around CS education and grouped from *Stage 0: Unconcerned* to *Stage 6: Collaboration*.

Data Collection

Innovation Survey: Integrating Computer Science in K-8

Thirty-six instructors received an invitation to complete the online survey. Survey data was collected online through Qualtrics. Results exported from Qualtrics showed that the survey was started 24 times with 19 completed results.

Semi-structured Interviews

Eleven instructors were invited to participate in an interview and six interviews were conducted in January and February 2023. I had also interviewed one of the participants in April 2022 as part of my Field Study. Since that interview was under the same IRB and some of the questions were duplicates, I used data collected from both the Capstone and Field Study interviews for that participant. All the interviews were held online over Zoom to take advantage of technology to record the sessions and take a first pass at transcriptions. Video and audio recordings as well as transcripts were initially downloaded onto my laptop. For each interview, I first watched the video recording to compare it against the transcript provided by Zoom. At this stage, I made corrections in the transcript as needed and highlighted key ideas. After this process, I uploaded each video and transcript onto the secure cloud-based storage system approved by the IRB. To protect privacy and confidentiality, participants were assigned a code letter and pseudonyms prior to coding. The list connecting the participant name to their code was kept in a password-protected Word doc on my computer. When the video and audio files have been analyzed and study completed, this list will be destroyed along with video and audio recordings on my computer and the secure cloud-based storage system.

Data Analysis

This study incorporated quantitative data in the form of the 30 items from the SoCQ in the online survey and qualitative data in the form of open-ended questions in the online survey and semi-structured interviews. Table 5 outlines the relationship between the research questions, data sources, data collection strategies, and the analysis method.

Table 5

Data Collection and Analysis Grid

RQ1: What beliefs do TPP faculty have about CS education?			
Data Sources	**Data Collection Strategies**	**Quality Considerations**	**Analysis Methods**
Open-ended responses from instructors about what CS means to them and other beliefs about	Included an open-ended question related to what CS means in the online survey and interview	Credibility: Incorporated the following strategies to enhance credibility (Guba	Open-ended responses and interview transcripts coded using a priori and emerging codes

CS education related to K-8 students, K-8 pre-service teachers and TPP faculty.	guide (Appendix C) Included additional questions related to beliefs about CS education to the interview guide (Appendix E).	& Lincoln, 1989; Lincoln: 2009): ● Peer debriefing ● Reflective journal ● Member checks ● Multiple data sources	documented in the codebook (Appendix F).
RQ2: What concerns do faculty have with respect to integrating CS in the K-8 TPP curriculum and where do those concerns fall along the SoC from CBAM?			
Data Sources	**Data Collection Strategies**	**Quality Considerations**	**Analysis Methods**
Likert-scale responses to items from the Stages of Concern Questionnaire (SoCQ) Open-ended responses from instructors about what stage they see themselves in.	Recreated the SoCQ in Qualtrics (Appendix C). Included an open-ended question in the interview guide about where most of their concerns about integrating CS in the K-8 TPP curriculum would fall and why (Appendix E).	Validity & reliability: The SoCQ has been used in hundreds of studies to measure the relative intensities of the seven SoC expressed by teachers (Chen & Jang, 2014; Rogers, 2006). Credibility: same as RQ1	The SoCQ data was analyzed following measurement procedures documented by George et al. (2006). Open-ended responses: same as RQ1.
RQ3: What specific challenges do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the challenges reflected in the SoC mapping?			
Data Sources	**Data Collection Strategies**	**Quality Considerations**	**Analysis Methods**
Open-ended responses from instructors about what they see as challenges with respect to integrating CS in the K-8 TPP curriculum.	Included an open-ended question related to challenges in the online survey (Appendix C) and interview guide (Appendix E).	Credibility: same as RQ1	Open-ended responses: same as RQ1.
RQ4: What specific opportunities do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the opportunities reflected in the DOI attributes that stimulate adoption?			
Data Sources	**Data Collection Strategies**	**Quality Considerations**	**Analysis Methods**
Open-ended responses from instructors about what they see as opportunities with respect to integrating CS in the K-8 TPP curriculum and what DOI attributes are important to them when considering adopting an innovation.	Included an open-ended question related to opportunities in the online survey (Appendix C) and interview guide (Appendix E). Included an open-ended question in the interview guide about ranking the	Credibility: same as RQ1	Open-ended responses: same as RQ1.

	DOI attributes in terms of helping them adopt an innovation (Appendix E).		

The analysis was an iterative process where I first looked at the data through a literal lens focusing on content and form, then a reflexive lens, focusing on making connections between the data and the codebook and finally an interpretive lens, focusing on organizing themes and drawing conclusions (Check & Schutt, 2012). Throughout the data analysis process, I incorporated reflective journaling, analytic memos, peer debriefing, and member checking (Guba & Lincoln, 1989; Lincoln: 2009). Keeping a reflective journal throughout the research process was a way to acknowledge and make visible how my opinions, feelings, thoughts, and experiences impact the research process (Ortlipp, 2009). Peer debriefings occurred during my meetings with my capstone committee chair, with feedback from my capstone committee, and through sharing work in progress with my advisor's research group. I engaged in member checking with interview participants to get feedback on the perceived accuracy of my preliminary interpretations while ensuring confidentiality is maintained.

RQ1 Analysis

I brought the responses to the question "What does CS mean to you?" from the survey and semi-structured interviews into a spreadsheet and analyzed using a priori codes related to the CS strands (Appendix F). In a separate spreadsheet, I brought in the responses from the semi-structured interviews focused on beliefs about CS education, like *do you believe all K-8 teacher candidates should learn some level of CS* and *would it be helpful to collaborate*. I also captured the total of their *Yes*, *No*, and *Maybe* responses along with highlighting key discussion points faculty shared related to their responses.

RQ2 Analysis

The SoCQ from the survey was analyzed following measurement procedures documented by George et al. (2006). Raw scores for each stage were calculated by taking the average of responses for each question in that stage and then adding those average scores together. Raw scores were converted to percentile scores using a conversion table provided by CBAM (Appendix G). The percentile scores are based on a group of 830 elementary and secondary teachers and university faculty members from 1974 and have undergone a variety of validity studies (George et al., 2006).

RQ3 and RQ4 Analysis

Opportunity and challenge responses from the survey were brought into a spreadsheet. I first identified and highlighted opportunity statements and then challenge statements. I found that some opportunities were identified in the challenge responses and some challenges in the opportunity responses. I then looked for categories that emerged from the highlighted statements and added those codes into the codebook (Appendix F). I went through the same process for the interview responses related to challenges and opportunities. No additional codes emerged while analyzing the interview data.

In the semi-structured interviews (Appendix C), participants were asked to rank the DOI attributes in order of importance to them when considering incorporating an innovation into their teaching practice. I compiled the rankings into a table and calculated the rankings across the group. I also brought the discussion data around each ranking into a spreadsheet and highlighted common and unique responses for each DOI attribute. Participants were also asked to place themselves along the SoC relative to integrating CS into the TPP curriculum during the semi-structured interview. For the SoC responses, I used a graphic image to show where each instructor placed themselves along the stages. I then brought in the discussion from this question into another spreadsheet and highlighted the rationale each instructor gave for the stage(s) they placed themselves in.

Ethical Concerns

I updated the IRB from my Field Study to add the survey instrument (Appendix C), the semi-structured interview instrument (Appendix E), recruitment material (Appendices A and B), and informed consent for each instrument (Appendix H). Data collection started January 2023 after I received IRB and Teacher Education Data Committee approval. The informed consent was collected from both survey and interview participants. The informed consent agreement (Appendix H) outlined the purpose of the research study, what participants would do, any potential risks and benefits of participating in the study, how confidentiality will be addressed, the voluntary nature of participation in the study, and the right to withdraw.

Limitations and Delimitations

The more complex the innovation and context is, the more challenging it is to isolate the variables related to the innovation itself (George et al., 2006). CS education in K-12 environments is already a complex topic. Adding to the complexity is the idea that integrating CS education is both an innovation in K-8 environments (Israel et al., 2015; National Academies of Sciences Engineering and Medicine, Sciences, 2021) and a new way of doing CS education (Code.org, 2018; Ottenbreit-Leftwich et al., 2021; Rosato et al., 2022).

The use of CBAM is typically based on the assumption that the innovation will be adopted and is meant to be used longitudinally to measure change in concerns over time. My study asks participants to consider their concerns about integrating CS in K-8 as an innovation, even though it is not currently a charge from the leadership in the TPP. This means that there could be a wide variety of interpretations about what integrating CS education means to the research participants. To mitigate this issue, I updated the SoCQ statements to clarify that the innovation was integrating CS in the K-8 TPP curriculum. George et al. (2006) caution researchers about changing the statements, so I looked at an example of research from Chen and Jang (2014) where they found they needed to update the statements to make the innovation of technology integration clearer. I also gathered pretest feedback from three expert reviewers (McMillan, 2020). This pretest feedback also resulted in removing Stage 6: Refocusing because those statements were the most confusing in this context.

In C-BAM implementation, the SoC survey statements are used to get at what the SoC profile is for each participant. I used this approach in my study for the survey, but for the semi-structured interviews I tried a novel approach of sharing the SoC with participants to encourage discussion around what the stages meant to them. In addition, while DOI has mainly been applied as a lens to analyze data (Nemutanzhela & Iyamu, 2015), for this study, I employed the DOI attributes as part of the semi-structured interview guide to gain insight into what attributes resonated most with faculty participants and why.

Other limitations include the small size and homogeneity of the TPP and the short window of time to collect and analyze data, determine findings and craft recommendations. The findings from this TPP may or may not generalize to other TPPs, especially considering how CS licensure varies by state (Ottenbreit-Leftwich et al., 2022).

Researcher Positionality

Through my work at the local, state, national, and global level, I clearly have a bias towards seeing the integration of CS in K-8 become a reality. For instance, as the founder of a non-profit working to address the gender gap in technology through K-12 outreach and in my previous role as the CS coordinator at a K-8 school, I have become a passionate advocate for integrating CS into a variety of subject areas to engage students, support project-based learning, and address gender and racial diversity gaps in CS education and technology fields. I am now part of several efforts aimed at helping K-8 teachers integrate CS into their teaching practice, including organizing and facilitating online and in-person professional learning opportunities. I am also designing a K-8 CS integration guide for the VDOE. While I am clearly invested in the outcome of the research, I understand the importance of not tainting the results with my bias. Towards that end, I incorporated feedback from my capstone committee and expert reviewers on the interview guide (Appendix B) to ensure that it is focused on the research questions around this problem of practice. I also engaged in member checking, soliciting feedback on my preliminary findings with the people I interviewed (Merriam & Tisdale, 2015).

Chapter 4: Findings and Interpretations

The problem of practice that I explored with my Capstone project is the gap between expectations from the VDOE that the K-8 CS SOLs should be integrated into K-8 classrooms and the preparation of K-8 teacher candidates in the TPP to integrate CS into their teaching practice. The idea of integrating CS in K-8 is fundamentally a new way of doing things in K-12 schools, so I am looking at potential pathways for adoption by TPP faculty through the lens of innovation. I used the following research questions to guide my research:

- RQ1: What beliefs do TPP faculty have about CS education?
- RQ2: What concerns do faculty have with respect to integrating CS in the K-8 TPP curriculum and where do those concerns fall along the SoC from CBAM?
- RQ3: What specific challenges do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the challenges reflected in the SoC mapping?
- RQ4: What specific opportunities do faculty identify for integrating CS in the K-8 TPP curriculum and to what extent, if any, are the opportunities reflected in the DOI attributes that stimulate adoption?

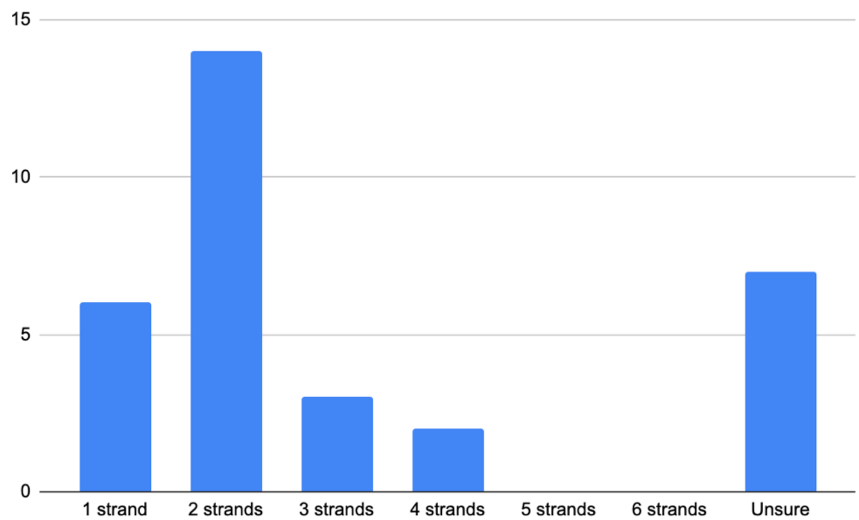
RQ1: TPP Faculty Beliefs About CS Education

What Does CS Education Mean to TPP Faculty?

One of the first things I wanted to establish, using both the survey and semi-structured interviews, is what CS education meant to the TPP faculty. I first looked at how many of the CS strands they touched on in their explanation (Figure 4). Fourteen responses incorporated two strands, six responses incorporated just one strand, three responses incorporated three strands, two responses incorporated four strands. Seven of the respondents either prefaced their response with a caveat that they didn't know much about CS or incorporated question marks in their answer.

Figure 4

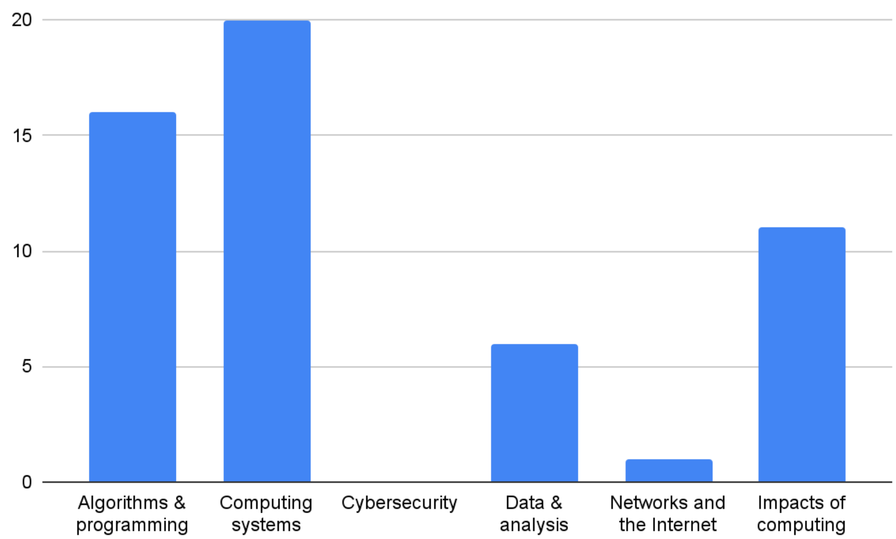
Number of CS Strands per Response



Next, I looked at how many times each strand was represented in the survey and interview responses (Figure 5). The *Computing systems* strand was touched on the most, noted 20 times, for example, "the study and use of computers for personal and professional purposes" (SR-B). *Algorithms and programming* strand was reflected in 16 answers that incorporated something about coding, designing and/or problem solving, for example, "it's a systematic process for solving problems, whether that includes technology or not" (SR-O). The *Impact of computing* strand was included in 11 responses, for instance, "the ways in which technology supports/impacts/informs our lives" (SR-J). The *Data & analysis* strand was included in 6 responses, for instance, "using computers to make lots of data more manageable/interpretable" (SR-H). The *Networks and Internet* strand was only touched on by one faculty member and nobody incorporated the *Cybersecurity* strand.

Figure 5

CS Strands Represented in Responses



What Beliefs Do TPP Faculty Have About CS Education?

During the semi-structured interviews, I was able to take a deeper dive into faculty awareness of and beliefs about CS education (Table 6). Only one interview participant indicated they were previously aware of the K-8 CS SOLs or the expectation that these standards are to be integrated into K-8 subjects. When asked if all K-8 students should learn some level of CS, five responded yes and one said maybe. A common thread was the societal impact of technology. Lane stated that "computers are everywhere in our society", while Morgan suggested that "if our jobs as educators are to prepare them to be citizens of the world, they need to have these skills" and Terry shared that "we are more and more going to be a combination of technological and literate society." Quinn admitted that:

> I suppose if it's a state standard, then yes. I guess I don't know enough about it to say I think that this is one of the core things that everybody should know, because I'm not really sure exactly what it entails.

Table 6

Teacher Beliefs About CS Education

	Yes	No	Maybe
Are you aware of the K-12 computer science Standards of Learning?	1	5	
Are you aware that the K-8 CS SOLs are intended to be integrated into other subject areas?	1	5	
Do you believe all K-8 students should learn some level of computer science?	5		1
Do you believe that all K-8 teacher candidates at the TPP should learn some level of computer science?	4		1
Do you believe that you should incorporate some CS education into your teaching practice?	4	1	1
Would you be willing to share curricular resources for your course(s) for an analysis of where CS might fit? *(With follow-up request, 4 shared their syllabi with me.)*	6		
Would it be helpful to you to collaborate with other instructors in the teacher education program and /or outside the program who are integrating CS?	6		

When asked if all K-8 teacher candidates at the TPP should learn some level of CS, four said yes and one said maybe. As Terry expressed, "yes, and they have, like 18,000 things." Morgan stated that "I think that [learning CS] is something that should be a really big part of their experience." Lane ventured that "if it's important for students, we want our teachers to be able to do the things they're going to be expected to do to support children." When asked if they believed that they should incorporate some CS education into their teaching practice, four responded yes, one no and one maybe. Kendall admitted that "I think if I knew more what it might look like, that I might be more inclined to think that I should be incorporating it. But I think right now I think it's somebody else's job." Terry shared that "I do, but it's hard, and I try. And I think there are some cool things out there… like I just cannot do powerpoint for the rest of my life." Morgan shared that "I certainly feel I should be doing it, especially given what I learned about the standards in Virginia, and that we're preparing Virginia teachers... But again, we have minimal time."

When asked what type of information would help them determine whether and how they should integrate CS into their own curriculum, four responses included the need to understand where it fits in the program. For instance, Morgan stated that "I think it would be useful to have a framework for implementation where there's specific and planned coherence about how it's getting implemented across the program." Four responses included the need to gain pedagogical content knowledge, like Lane stating that "I would need to know what we mean by CS. Are we thinking about it in terms of content knowledge? Are we thinking about it in terms of practices?" Dara referenced the need "to look at the curriculum map from the DOE to see how they are envisioning it lining up... what are they [school districts] envisioning."

Finally, collaboration was seen as a positive step in general, "I think collaboration is always helpful" (Kendall) and specifically to address CS education because "I think when you collaborate particularly on an innovation that is new and maybe scary, it's helpful to see how other people are doing it and have a cohort to debrief and reflect and refine what you're doing" (Morgan) and "it would be great. I mean, I don't think I could not possibly figure out how to do this by myself" (Lane).

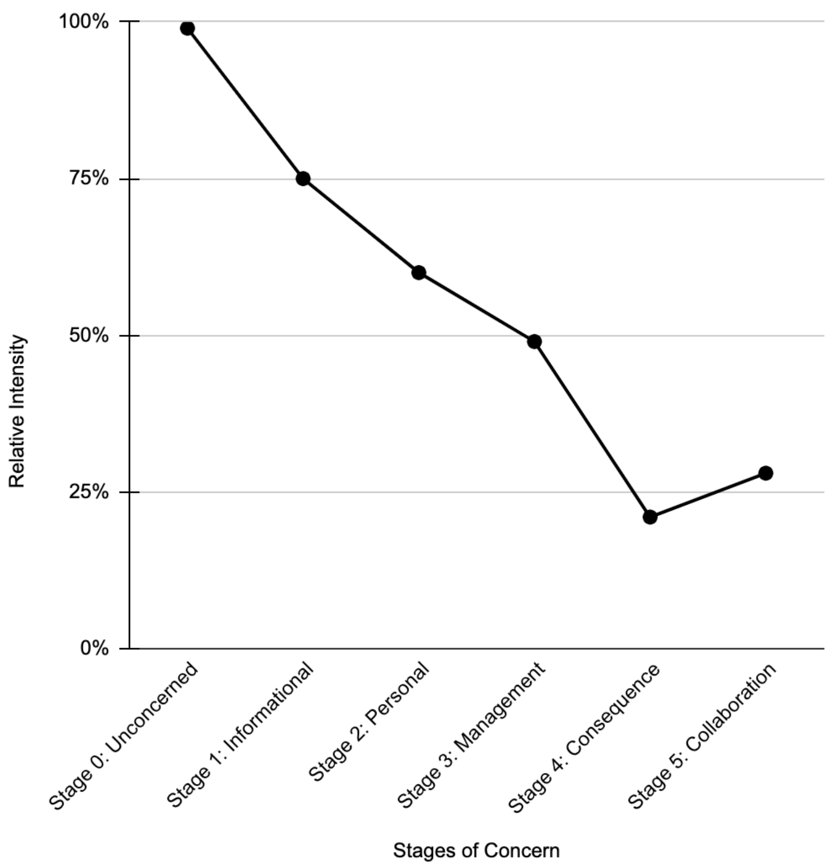
RQ2: Stages of Concern

SoC Analysis from the Survey

Based on the survey results, the TPP Faculty Profile for the SoC (Figure 6) shows the highest concern is in *Stage 0: Unconcerned* with a slope downward to *Stage 4: Consequences* and then a slight bump up at *Stage 5: Collaboration*. According to George et al. (2006) this profile is typical of individuals who are not fully aware of the innovation. In addition, high *Stage 1: Information* concerns along with elevated *Stage 5: Collaboration* concerns "suggests a desire to learn from what others know and are doing" as opposed to concerns about working with others (George et al., 2006, p. 54). This openness to collaborate was also reflected in the interviews.

Figure 6

Stages of Concern TPP Faculty Profile

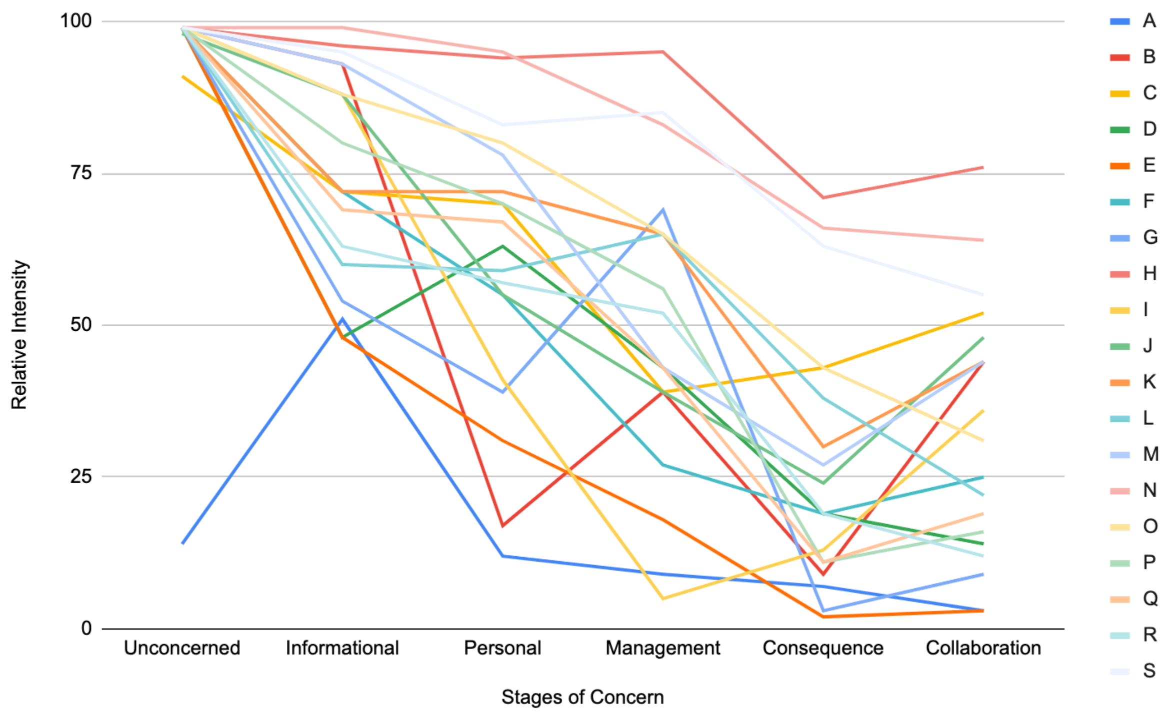


There is a similar pattern in many of the individual responses with a few outliers which demonstrates that addressing concerns is not a one-size-fits-all endeavor. The outliers include one response where *Stage 1: Informational* is higher than *Stage 0*, one response where *Stage 2:*

Personal is higher than *Stage 1*, five responses where *Stage 3: Management* is higher than *Stage 2* and one response where *Stage 4: Consequence* is higher than *Stage 3* (Figure 7).

Figure 7

Individual TPP Faculty Stages of Concern Profiles



I also separated the data across grade bands (Figure 8) and gender and age (Figure 9) to see if any patterns emerged. Faculty teaching secondary courses had slightly higher concerns across all stages except *Stage 2: Personal*, while faculty teaching special education (SPED) courses had less concern in most areas except *Stage 3: Management*. Faculty who identified as male had a higher intensity of concern across all stages than those who identified as female and *Stage 3: Management* saw the largest difference between the two groups with it being a higher degree of concern among men than women (Figure 9). Faculty who identified as 22-35 had lower intensity of concern across stages than 35-55 and 35-55 had lower intensity of concern across stages than 55+ (Figure 9).

Figure 8

Stages of Concern by Grade Band

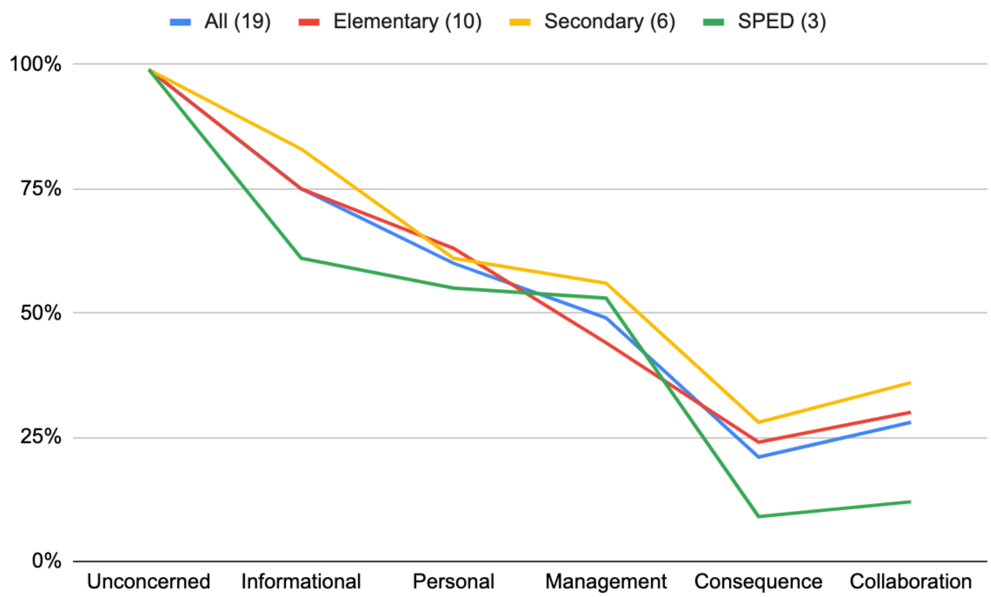
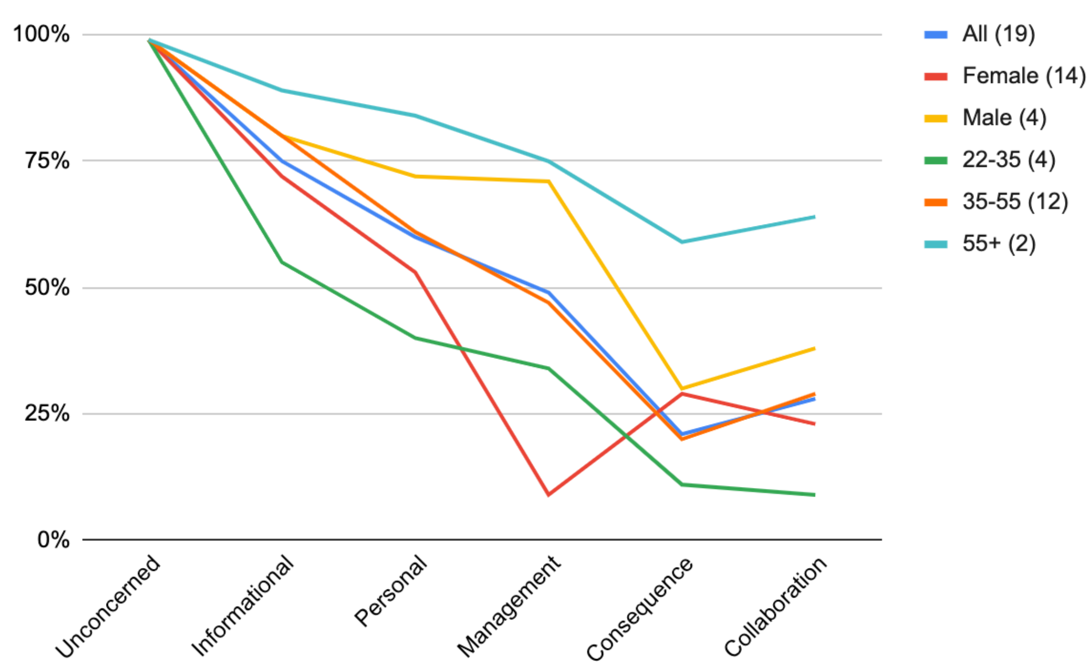


Figure 9

Stages of Concern by Gender and Age



Highest and Lowest Concern Statements Per Stage. I also went through the five questions for each stage and identified the statements that garnered the most and least concern per stage (Table 7).

Table 7

Highest and Lowest Concern Statements

Stage	Highest Concern Statement	Lowest Concern Statement
Unconcerned	30. Currently, other priorities prevent me from focusing my attention on CS education. (5.95)	12. I am not concerned about CS education at this time. (4)
Informational	6. I have a very limited knowledge of CS education. (5.05)	26. I would like to know what integrating CS will require in the immediate future. (3.53)
Personal	17. I would like to know how my teaching or administration is supposed to change as a result of integrating CS. (3.95)	7. I would like to know the effect of integrating CS on my professional status. (2.26)
Management	16. I am concerned about my inability to manage all that integrating CS requires. (3.21)	8. I am concerned about conflict between my interests and my responsibilities for CS. (1.84)
Consequence	32. I would like to use feedback from teacher candidates to inform how I approach integrating CS. (4.74)	1. I am concerned about teacher candidates' attitudes towards CS education. (2.63)
Collaboration	29. I would like to know what other faculty are doing with regard to integrating CS (4.26)	5. I would like to help other faculty integrate CS education. (1.47)

SoC Analysis from the Interviews. During the interview, I shared the SoC from CBAM (Figure 10) and asked each participant where they thought most of their concerns about integrating CS in the K-8 TPP curriculum would fall. None of the interview participants landed on just one stage (Figure 11). Some saw themselves between two adjacent stages. Kendall placed herself between *Stage 0* and *1* because:

> I have no idea what it is or what it would look like." Lane stated that "I think I'm between 4 and 5. And I think to me, they're connected... I want to make sure that if I'm doing something new, I feel like I have a clear rationale for it for my students... And then the collaboration piece feels really important to me, because computer science is not like one of the traditional content areas that we've been talking about.

Morgan found that her feelings were "different in the different spaces." As an instructor, she stated that "I think I'm at Stage 0, I have other priorities. We are covering so much content, and then we are also incorporating a research study and there's so much to cover." She went on to say that:

> More broadly across the program, I think, given my focus in [STEM subject], and the idea of incorporating STEM and computer science can be done in really impactful and empowering ways. And I think I would be really interested in, how does it work and how do we do it.

Dara picked *Stage 4: Consequence* first because she's "always thinking about the students first" and then *Stage 1: Informational* because she does not feel "very computer savvy." Quinn saw herself across three stages: *Stage 2* – "How does it impact me?", *Stage 3* – "Where's my responsibility within the classes I teach, because they're very focused on a specific thing. I would want to know what my part of that is and what's my responsibility to be part of the team", and *Stage 4*:

> What's the impact on my students? Because you're going to have to give something up anytime you adjust the… Not necessarily give something up but figure out a way to integrate it in a way that is not how I've been doing it.

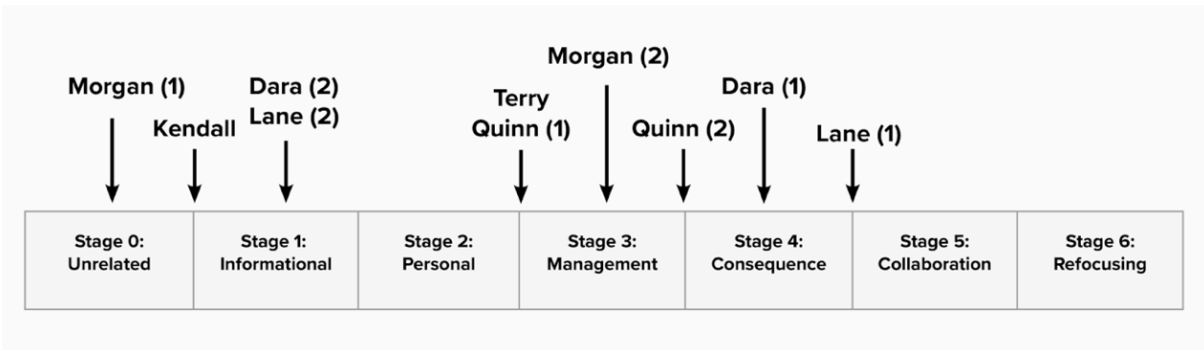
Figure 10

SoC Graphic for Interview

Stages of Concern	Stage 0: Unrelated	Stage 1: Informational	Stage 2: Personal	Stage 3: Management	Stage 4: Consequence	Stage 5: Collaboration	Stage 6: Refocusing
Possible Expressions	*I have other priorities.*	*What is it?*	*How does it impact me?*	*How does it work? How do I do it?*	*How does it impact my students?*	*How do others do it?*	*Is there a better way?*

Figure 11

Faculty SoC from Interview



RQ3: Challenges and RQ4: Opportunities

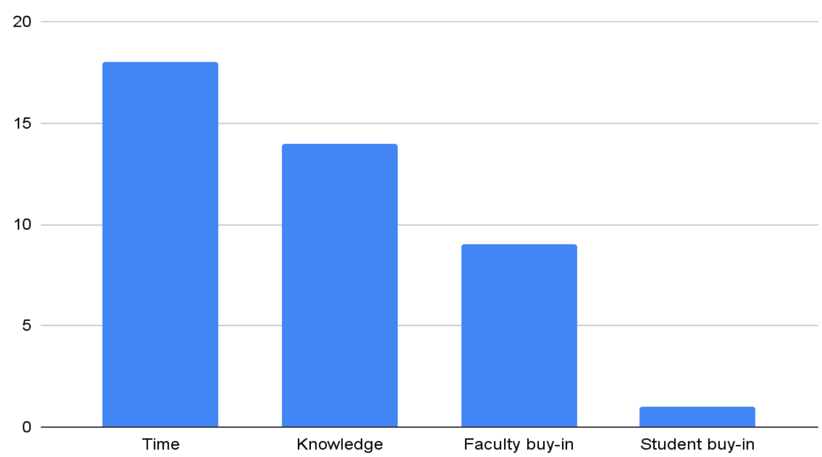
The survey and semi-structured interview included two additional questions in common, related to challenges and opportunities for integrating CS education into the K-8 TPP curriculum. Between the survey (n=19) and interview (n=6) responses, there were more challenges identified (42) than opportunities (26). As I read through the responses, a few themes emerged. The challenges (Figure 12) fell into four categories:

- Time constraints (18). For instance, “some courses do not have additional time to integrate additional things because they have been condensed already” (SR-A), faculty are “reluctant to add more if it means losing other pieces” (Kendall), and “finding time to learn new content” (SR-G).

- A need for knowledge (14). For instance, "faculty have thin content knowledge around CS, which makes it hard to integrate" (SR-I) and "teacher preparation faculty and schools' lack of depth of knowledge in CS" (SR-C).
- Faculty buy-in (9). For instance, "as a faculty, we tend to be very attached to what we've been doing. So with only a few exceptions, people are not very like experimental" (Kendall), "I think there's not a lot of incentive for innovation and there's a lot of disincentive for innovation (Lane), and "I would assume many of us already feel stretched to ensure we are meeting the needs of our students relative to our own discipline" (SR-S).
- Student buy-in (1). For instance, "teaching candidates need to understand the importance of learning about CS" (SR-Q).

Figure 12

Challenges to Integrating CS in the K-8 TPP Curriculum



Meanwhile, opportunities fell into five categories including (Figure 13):

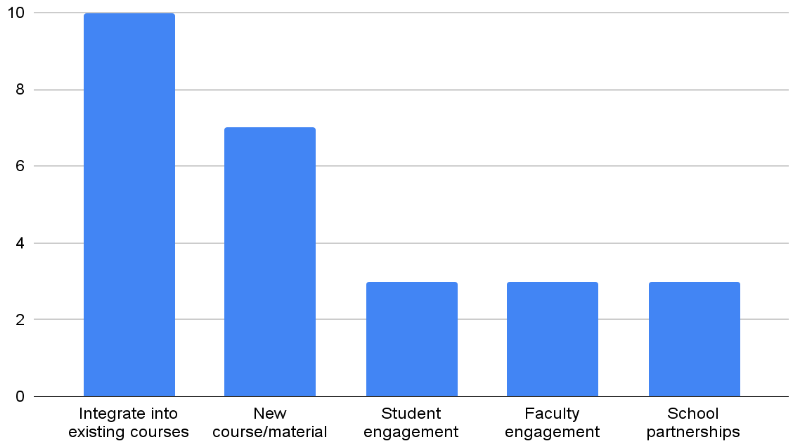
- Integrating CS into existing courses (10). For instance, Kendall and two survey respondents agree "it would be great to see CS become integrated into the science methods" (SR-B).

Methods courses like math and literacy were also brought up as possible CS integration points by Dara, Morgan, and three survey respondents.

- Creating new courses and/or materials for CS education (7). For instance, Terry suggested a workshop or online modules and SR-R suggested podcasts and webinars. Morgan and SR-P would like to see the addition of a STEM course that focuses on integration across multiple subjects including CS and SR-F suggests a mandatory CS-related course.
- CS education as a way to increase student engagement (3). For instance, “talking about the various programs/standards/applications that are available to make things more interesting and engaging and useful” (SR-J).
- CS education as a way to increase faculty engagement (3). For instance, "teachers' status in society needs to be elevated, and integrating practical skills that are relevant to society will help with that" (SR-C), "I would love to learn more about this!" (SR-K), and "this could be an impetus for pushing us to talk to each other and think about where we all make can make space for it. I think could be really powerful" (Lane).
- School partnerships (3). For instance, “building partnerships with school- and division-based partners to better understand how the CS curriculum and standards play out in schools and classrooms” (SR-M).

Figure 13

Opportunities for Integrating CS in the K-8 TPP Curriculum



Innovation Attributes. During the semi-structured interviews, I shared Figure 14 and asked participants to rank the five attributes that stimulate adoption from the DOI theory from most important (1) to least (5) when they consider adopting an innovation into their teaching practice (Table 8).

Figure 14

Five Attributes Graphic from Interview

Relative Advantage	compared to the status quo
Compatibility	consistent with current values and practices
Simple and easy to use	the relationship between the complexity of the innovation and the relevance to instruction
Trialability	the ability to experiment before adoption
Observable results	seeing the innovation in action

The highest ranked attribute among those interviewed was *Compatibility*. Three participants talked about *Compatibility* in terms of aligning personally to “what I believe is pedagogically sound and useful instructionally” (Morgan) and “if something felt like conceptually or like in some way ideologically incompatible with like those like principles that I that are like are so important to me like, I probably wouldn't do it either” (Lane). Quinn spoke about both the need for the innovation to be “in line with my current values” and she also brought up that the potential expense needs to be considered because of “limited funds”. Kendall viewed *Compatibility* through the lens of the TPP stating that “we're moving toward coherence across our course work with our mission, and so making sure that whatever it was consistent with those values would be important.”

Table 8

Ranking of Five Attributes that Stimulate Adoption

	Relative Advantage	Compatibility	Simple and Easy to Use	Trialability	Observable Results
Kendall	4	1	3	5	2
Terry	2	3	1	5	4
Dara	4	4	2	3	1
Quinn	1	2	3	4	5
Morgan	1	2	4	5	3
Lane	4	2	3	5	1
	2.7	2.3	2.7	4.5	2.7

Observable Results, Relative Advantage, and *Simple and Easy to Use* were tied as the second ranked. For *Observable Results*, Dara wants to understand “how it [the innovation] could apply to helping elementary teachers teach [specific subject area]” and Kendall explained that “we're not real big on experimentation at the moment, just because there's so much that we're required to do because of the regulations from the DOE." *For Relative Advantage,* Morgan expects that innovation "will improve my instruction, because it adds a new layer to what I'm already doing and makes what I'm doing even better", Terry explained that "because I tend to keep doing what I'm doing as humans do sometimes. There would have to be some advantage to using it in order for me to want to - you know, it's not broken, don't fix it." and Quinn "won't even be looking for something if it's not going to be beneficial to me and my students". Lane stated that "time is like our scarcest commodity, so I think, having something that is not incredibly cumbersome to adopt feels important". Kendall suspects that *Simple and Easy to Use* is important because "we've got a lot of faculty who don't fancy themselves particularly computer science or tech savvy" and Terry echoed this sentiment about herself, "technology is not as intuitive to me as it is to some of the younger folks in the world".

The last ranked item was *Trialability*. On one end of the spectrum of responses, Kendall stated that "I don't know who you would experiment on.... I would not want to experiment on our own students." On the other end Dara shared that "I would want them to be able to try it." In between these two responses, Morgan shared that, "I feel less strongly about the requirement to experiment with how I adopt and more interested in systematically advanced in a way we know, it's going to better improve our instruction."

Discussion of Findings

RQ1: What Beliefs Do TPP Faculty Have About CS Education?

Many of the responses from the survey and semi-structured interviews to the open-ended question of what CS means demonstrate that the TPP faculty have a developing understanding of CS. The TPP faculty recognized some key components of CS especially related to the CS SOL strands of *Computing systems*, *Algorithms & programming*. and *Impacts of computing*. However, they also held some common misconceptions, like the focus of CS being on learning how to use technology (Gallup, 2020), conflating CS with coding (Yadav et al., 2014), and having the stereotype that age impacts CS ability (Broady et al., 2008). Data from the interviews show a lack of awareness of CS SOLs and their intention to be integrated in K-8. However, faculty understood the importance of CS through the lens of the societal impact of technology and generally believed it was important for all K-8 students, all K-8 teacher candidates, and themselves to learn some level of CS. They also expressed a willingness and desire to collaborate around innovation adoption. This is reinforced by the SoC TPP Faculty Profile (Figure 6) which is typical of individuals who are not familiar with the innovation and are open to learning from others through collaboration (George et al., 2006).

RQ2: Stages of Concern

This research question focused on what concerns faculty have with respect to integrating CS in the K-8 TPP curriculum and looking at where those concerns fall along the SoC from CBAM. The SoC TPP Faculty Profile (Figure 6) is typical of those who are not familiar or have no previous experience with the innovation. Other priorities and limited knowledge of CS were rated as the highest concern statements. The interview participants highlighted concerns across Stages 0 through 5, for instance:

- Stage 0: Unconcerned - “I have other priorities,” (Morgan) including content and research study priorities.
- Stage 1: Informational - "Because I'm not very computer savvy, then I would go down to informational… what is this thing?" (Dara)
- Stage 2: Personal - “How does it impact me?” (Quinn)

- Stage 3: Management - "How does it work? And how do we do it? So I'd really want to know more about what does the vision of that look like successfully." (Morgan)
- Stage 4: Consequence - “I want to make sure that if I’m doing something new, I feel like I have a clear rationale for it for my students.” (Lane)
- Stage 5: Collaboration - “The collaboration piece feels really important to me because CS is not like one of the other traditional content areas that we’ve been talking about.” (Lane)

The interview discussion around the SoC also revealed that faculty can feel differently about the stages depending on what “hat” they are wearing. For instance, as an instructor, Morgan identified with Stage 0, but thinking about the TPP overall, she sees the value in integrating CS and so she’s thinking about Stage 3 concerns.

RQ3: Challenges

This research question focused on challenges identified by the faculty for integrating CS in the K-8 TPP curriculum and determining to what extent, if any, the challenges are reflected in the SoC mapping. The challenges identified by the TPP faculty in the survey and interviews fell into four categories (Figure 12): time constraints (18), the need for CS knowledge (14), faculty buy-in (9), and student buy-in (1). These challenges are reflected in the SoC TPP Faculty Profile (Figure 6) with lack of time reflected in *Stage 0: Unconcerned* and *Stage 3: Management*, a lack of knowledge in *Stage 1: Informational*, faculty buy-in in *Stage 2: Personal*, and student buy-in in *Stage 4: Consequence*.

RQ4: Opportunities

This research question focused on opportunities identified by the faculty for integrating CS in the K-8 TPP curriculum and determining to what extent, if any, the opportunities are reflected in the DOI attributes that stimulate adoption. The opportunities identified by the TPP faculty (Figure 13) in the survey and interviews fell into five categories including: integrating CS into existing courses (10), creating new courses and/or materials for CS education (7), CS education as a way to increase student engagement (3), CS education as a way to increase faculty engagement (3), and school partnerships (3).

From the interviews, *Compatibility* was ranked as the most important DOI attribute when considering the adoption of an innovation. Decisions around integrating CS into existing courses or creating new coursework will need to take current values and practices at the TPP into account. *Compatibility* could also be important for the TPP to be in synch with their school partners. *Observable Results, Relative Advantage,* and *Simple and Easy to Use* were tied for second. *Observable Results* could impact student and faculty engagement as results from early adoption can encourage wider adoption. Because the SoC TPP Faculty Profile (Figure 6) is typical of inexperienced or nonusers of the innovation, consideration needs to be given to where *Observable Results* can be found. *Simple and Easy to Use* and *Relative Advantage* both also play an important role in faculty and student engagement.

Overall, the findings indicate that the TPP faculty face many of the same challenges and opportunities for integrating CS in the K-8 curriculum as their counterparts. They have incomplete ideas about CS that are similar to many current educators as highlighted by DeLyser et al. (2018), Banilower et al. (2018), and Ottenbreit-Leftwich et al. (2021). TPP faculty find that CS education is important to K-8 students, their own K-8 teacher candidate students, and themselves because of the impact of technology on society which is reflected in Vogel et al. (2017) findings about the importance of CS to education stakeholders. The challenges identified by TPP faculty to integrating CS in the K-8 curriculum are found in research, for instance, time constraints from Israel et al. (2015), Rich al. (2019), and Mouza et al. (2021), needing more knowledge from Mouza et al. (2021), faculty buy-in from Taylor et al. (2018) and student buy-in from Ottenbreit-Leftwich et al. (2021) and U.S. Department of Education (2022). The opportunities identified by TPP faculty can also be found in research like integrating into existing courses from Yadav et al. (2017), adding a course from Lucarelli et al. (2021), increasing faculty engagement from Taylor et al. (2018) and school partnerships from Lucarelli et al. (2021). By looking at these challenges and opportunities through the lens of innovation, this study highlights some potential interventions to move TPP faculty along the SoC towards adoption.

Chapter 5: Translation to Practice

In Virginia, the growing importance of CS education was affirmed in 2017 when the VDOE adopted K-12 CS SOLs (Sawczuk, 2017), with the K-8 standards “designed to be integrated into instruction in multiple subject areas" (Board of Education Commonwealth of Virginia, 2017, p. 4). However, most K-8 teachers do not have previous experience with CS content or pedagogy (DeLyser et al., 2018). There is no other discipline like CS education that is expected to be “taught across all US schools which is not also taught in pre-service teacher education programs” (DeLyser et al., 2018, p. 15).

One issue is that TPPs are often not preparing K-8 pre-service teachers to integrate CS into their teaching practice (DeLyser et al., 2018; Mouza et al., 2021). Because the idea of integrating CS in K-8 is fundamentally a new way of doing things in TPPs, I used the lens of innovation to explore challenges and opportunities for integrating CS in the K-8 TPP curriculum from the perspective of the TPP faculty.

The findings from this intrinsic case study suggest that there are a variety of potential interventions that could help foster the adoption of integrating CS in the K-8 TPP curriculum to support their teacher candidates. I have developed a set of recommendations based on the findings that I document in this chapter. I also created a slide deck with notes (Appendix I) to share with potential change agents including TPP administrators and program coordinators.

Recommendations

Address TPP Faculty Beliefs

Low self-efficacy towards an innovation can result in intense personal concerns while high self-efficacy towards the current way of doing things can result in more intense task and impact concerns about an innovation (Charalambous & Philippou, 2010). Because of this interrelationship between teacher concerns and beliefs, it is important to address faculty beliefs and self-efficacy towards integrating CS in K-8 TPP curriculum. Teacher beliefs and self-efficacy towards CS education play a critical role in their ability to learn CS and integrate it into their teaching practice (Rich et al., 2017; Rich et al., 2021; Zhou, et al., 2020).

Recommendations to help bolster self-efficacy include providing a variety of opportunities for the TPP faculty to learn about what CS is and why it needs to be integrated into K-8 environments. It is important that these opportunities build on faculty beliefs around the importance of CS education because of the societal impact of technology and that all K-8 students should learn some level of CS. A first step could be to provide informal experiential learning experiences to introduce CS concepts in a low stakes and safe environment (Rich et al., 2021). Incorporating equitable CS pedagogical strategies with CS learning can also improve self-efficacy towards teaching CS (Ryoo et al., 2015; Wilkens et al., 2021; Wilkens et al., 2022). A research lab at the TPP already offers informal experiential learning for pre- and in-service teachers and could craft specific learning opportunities for the TPP faculty based on findings from this study.

Once expectations are set around the integration of CS in K-8 TPP curriculum, then the TPP will need to offer more formal, in-depth PD for faculty. The same lab has designed more in-depth PD to help K-8 teachers create equitable CS experiences and this PD could be customized for TPP faculty and delivered in person or online. Another option is to encourage a cohort of TPP faculty to join a new online course being launched by the VDOE in June that is all about helping K-8 teachers learn about integrating CS into a variety of subject areas. The efforts to create K-8 CS education opportunities for TPP faculty and support their learning should be done in collaboration with the CS department at the university.

The TPP should consider a phased approach to adopting the integration of CS in the K-8 curriculum similar to the pilot program at St. Scholastica (Lucarelli et al., 2021). Year one could be focused on TTP faculty learning and getting familiar with CS, year two on working with a CS coach and/or a cohort model to integrate CS into at least one unit, and year three on implementing CS-infused lessons.

Address Faculty Concerns

My conceptual framework (Figure 1) incorporates the SoC from the CBAM. Addressing faculty concerns towards integrating CS in the K-8 TPP curriculum is important to help them move across the different stages of concerns towards implementation (Charalambous & Philippou, 2010; Hall & Hord, 2015). With the introduction of an innovation, teachers typically express intense concerns related to the *Informational* and *Personal* stages (Van den Berg & Ros, 1999) and these lower stages of concern need to be addressed before resolving higher stage concerns (George et al., 2006). The bulk of TPP faculty concerns were revealed to be at *Stage 0: Unconcerned* and *Stage 1: Informational*, so addressing these concerns should be the top priority, but the TPP should also plan for the interventions needed at later stages:

- Stage 0 Interventions - Other priorities are preventing faculty from engaging with CS education, so the TPP needs to raise awareness about the importance of CS education and provide incentives to encourage adoption into the K-8 TPP curriculum.
- Stage 1 Interventions - Faculty feel they have very limited knowledge of CS education, so the TPP needs to provide opportunities and safe spaces for learning more about it. Interventions at this stage should also focus on the DOI attribute of *Simple and Easy to Use*. One way to do this is to provide support for faculty in the form of a CS knowledgeable facilitator and coach (Atkins & Vasu, 2000).

- Stage 2 Interventions - Faculty need to understand exactly what the expectations are with regard to integrating CS in the K-8 TPP curriculum. The TPP needs to work with faculty to foster a sense of ownership around the innovation. Interventions at this stage should also focus on DOI attributes of *Compatibility* and *Relative Advantage* related to the innovation.
- Stage 3 Interventions - The TPP needs to take a system level approach to addressing the innovation and provide a framework for implementation across the K-8 TPP curriculum (Taylor et al., 2018). Interventions at this stage should also focus on the DOI attribute of *Observable Results*. One way to do this is to connect TPP faculty with in-service K-8 teachers who have experience integrating CS into their curriculum.
- Stage 4 Interventions - The TPP should encourage teacher candidates to provide input into and feedback about the innovation adoption. Interventions at this stage can focus on the DOI attribute of *Trialability*.
- Stage 5 Interventions - The TPP needs to provide opportunities for faculty to collaborate on implementing the innovation.

Finally, the TPP should consider using the SoCQ annually to get an updated perspective on faculty concerns and to understand if current interventions are working and what interventions are still needed to continue to support faculty as they work toward adopting the innovation.

Address Challenges Identified by Faculty

My conceptual framework (Figure 1) views perceived challenges identified by the TPP faculty as having the potential to hamper movement across the SoC. It is important for the TPP to address these challenges which include:

- A perceived lack of time:

    - Review syllabi and other curricular materials to find areas where integrating CS does not take away from but enhances subject knowledge.
    - Acknowledge and make space for the time it takes to learn about and incorporate the innovation.
    - Help faculty identify and incorporate integration strategies such as exist, enhance, and extend (Waterman et al., 2018) that best fit their curricular materials and learning objectives.
- A perceived lack of knowledge:
    - Provide PD opportunities built around a community of practice model that is a safe space for learning.
    - Support faculty with a CS knowledgeable facilitator and coach (Atkins & Vasu, 2000).
- Faculty buy-in:
    - Clarify expectations around integrating CS in the K-8 TPP curriculum that fosters shared ownership.
    - Identify early adopters who can be champions and share their experience and enthusiasm (Taylor et al., 2018).
    - Highlight the opportunity for the TPP to be a K-8 CS education leader at the state, national, and global level.
- Student buy-in:
    - Provide opportunities for teacher candidates to explore CS education, including informal experiential learning, formal integration in the TPP curriculum, and practical experience teaching CS in the classroom.

Foster Opportunities Identified by Faculty

My conceptual framework (Figure 1) views the perceived opportunities identified by the TPP faculty as having the potential to stimulate adoption of the innovation, so it is important for the TPP to foster these opportunities. Some faculty members identified opportunities to integrate CS into existing methods courses. Other faculty members identified the opportunity to create a new STEM course that focuses on integration across multiple subjects, where multiple faculty collaborate across disciplines to bring the course to life. Another recommendation was to create a CS-specific course. Before considering these potential opportunities, the TPP should go through a discernment process to identify the most effective method to prepare all its K-8 teacher candidates to integrate CS into their teaching practice. One place to start is the CS Visions Toolkit developed by CSforAll that includes an interactive activity for fostering reflection, debate, and discussion about the purposes of CS education with the mission of helping educators make informed decisions about what kind of CS learning experiences they want to facilitate and support (Santo et al., 2019). Going through the process of answering the question of why integrating CS in the K-8 curriculum is important to the TPP also addresses the DOI attribute of *Compatibility* and ensuring the way the innovation is envisioned aligns with current values and practices at the TPP (Rogers, 2003).

Increasing K-8 teacher candidate and TPP faculty engagement through CS education was also highlighted as an opportunity. The idea that CS education can be used as a tool for civic engagement through real-world problem-based learning (Cummings et al., 2021; Yadav & Heath, 2022) and for facilitating personally meaningful learning experiences with students that enhances their engagement in school (Gannon et al., 2022; Ozturk et al., 2018; Rich et al., 2021) should be highlighted. In addition, the TPP can call attention to the expectations around CS integration in K-8 from the state department of education and regional public school districts.

Finally, school partnerships were seen as an opportunity for integrating CS in the K-8 TPP curriculum (Yadav et al., 2021). The TPP can highlight current RPP work with regional school districts as a resource for integration ideas and helping TPP faculty making connections with local K-8 educators integrating CS in their teaching practice. There are also upcoming opportunities for TPP faculty to get involved with a new state-funded grant project to bring CS integration problem-based projects to a local middle school and a newly established global center for equitable CS education partnership.

Summary of Recommendations

I created a slidedeck (Appendix I) to share recommendations with change agents at the TPP including administration and program coordinators. For this audience, I organized the recommendations as a phased action plan:

1. *Establish importance of integrating CS in the K-8 curriculum*. The TPP should help faculty establish why it is important for them to integrate CS in the K-8 TPP curriculum by facilitating a discernment process. One place to start this process by employing the CS Visions Toolkit developed by CSforAll which includes an interactive activity for fostering reflection, debate, and discussion about the purposes of CS education with the mission of helping educators make informed decisions about what kind of CS learning experiences they want to facilitate and support. Going through the process of answering the question of why integrating CS in the K-8 curriculum is important to the TPP also addresses the DOI attribute of Compatibility and ensuring the way the innovation is envisioned aligns with current values and practices at the TPP.

2. *Address faculty concerns*. While addressing Stage 0 and Stage 1 concerns should be the current priority, the TPP also needs to be cognizant of the interventions needed at later stages.
3. *Make a short-term plan*. While the discernment process is happening, there are steps that can be taken now to begin addressing faculty beliefs and self-efficacy towards CS like providing informal experiential learning experiences, highlighting the expectations around CS integration in K-8 from the VDOE, highlighting current RPP and other grant work with local school districts to emphasize the importance of CS education to school partners, identifying early adopters who can be champions, and review syllabi and other curricular materials to find areas where integrating CS does not take away from but enhances subject knowledge.
4. *Make a long-term plan*. Once expectations are set around the integration of CS in the K-8 TPP curriculum, then the TPP will need to offer more formal, in-depth PD for faculty. This could include reaching out to St. Scholastica to learn from their experience and establish a pilot program. One option comes from a lab at the TPP that has already designed more in-depth PD to help K-8 teachers create equitable CS experiences and this PD could be customized for TPP faculty and delivered in person or online. Another option is to encourage a cohort of TPP faculty to join a new online course being launched by the VDOE in June that is all about helping K-8 teachers learn about integrating CS into a variety of subject areas.
5. *Lead by example*. There is a mismatch of expectations around CS education at the state level. On the one hand current state-approved regulations for primary, elementary, and middle education do not mention CS education and on the other hand, the state

department of education expects that CS standards will be integrated in K-8. In addition, the only CS endorsement pathway for K-12 teachers is for 6-12 which requires advanced content knowledge of CS but does not address the content knowledge and pedagogical practices needed by K-8 teachers integrating CS into their classrooms (Rosato et al., 2022; Shea et al., 2020). Working in collaboration with the CS department at the University, current RPPs working on PD for in-service K-8 teachers, and the recently launched global center for equitable CS education, the TPP can take the lead in developing a CS pathway for K-8 pre-service teachers that builds on the tenets from Yadav et al. (2021), to provide education faculty with meaningful PD and school connections. Research from this work can be published so others can learn from the successes and challenges of integrating CS in the K-8 curriculum at this TPP.

References

ACM/IEEE-CS Joint Curriculum Task Force. (1991). Computing curricula 1991. *Communication of the ACM, Vol. 34*, No. 6.

ACM, Code.org, CSTA, Cyber Innovation Center, & National Math and Science Initiative. (2016). *K–12 computer science framework*. http://www.k12cs.org

Adler, R. F., & Beck, K. (2020). Developing an introductory computer science course for pre-service teachers. *Journal of Technology and Teacher Education*, *28*(3), 519-541.

Admiraal, W., Louws, M., Lockhorst, D., Paas, T., Buynsters, M., Cviko, A., Janssen, C., de Jonge, M., Nouwens, S., Post, L., van der Ven, F., & Kester, L. (2017). Teachers in school-based technology innovations: A typology of their beliefs on teaching and technology. *Computers & Education, 114*, 57–68. https://doi.org/10.1016/j.compedu.2017.06.013

Anderson, S. E. (1997). Understanding teacher change: Revisiting the concerns-based adoption model. *Curriculum Inquiry*, *27*(3), 331–367. https://doi.org/10.1080/03626784.1997.11075495

Astrachan, O., Stephenson, C., Cuny, J. & Wilson, C. (2011). The CS10K project: Mobilizing the community to transform high school computing. *SIGCSE, March 9-12*, Dallas, Texas, USA.

Atkins, R. (2022, January 14). *A review of computer science in the Commonwealth report*. Office of the Superintendent of Public Instruction. https://rga.lis.virginia.gov/Published/2022/RD83/PDF

Atkins, N. E., & Vasu, E. S. (2000). Measuring knowledge of technology usage and stages of concern about computing: A study of middle school teachers. *Journal of Technology and Teacher Education, 8*(4), 279–302.

Balow, J. (2022, June 14). *Implementation of computer science instruction*. Superintendent's memo #140-22. Commonwealth of Virginia Department of Education. https://doe.virginia.gov/administrators/superintendents_memos/2022/140-22.pdf

Banilower, E.R., Smith, P.S., Malzahn, K.A., Plumley, C.L., Gordon, E.M., and Hayes, M.L. (2018). *Report of the 2018 NSSME+*. Chapel Hill, NC: Horizon Research, Inc.

Barr, V. & Stephenson, C. (2011). Bringing computational thinking to K12: What is involved and what is the role of the computer science education community? *ACM Inroads 2*, 1, 4854.

Benyo, J., White, J., Ross, J. Wiehe, B., Sigur, M. (2009). *New image for computing: Report on market research*. Boston, MA: WGBH Educational Foundation and New York City, NY: Association for Computing Machinery.

Board of Education Commonwealth of Virginia. (2017). *Computer science standards of learning for Virginia public schools*. https://www.doe.virginia.gov/testing/sol/standards_docs/computer-science/index.shtml

Broady, T., Chan, A., & Caputi, P. (2008). Comparison of older and younger adults' attitudes towards and abilities with computers: Implications for training and learning. *British Journal of Educational Technology, 41*(3), 473–485.

Bull, G., Garofalo, J., & Hguyen, N. R. (2020). Thinking about computational thinking. *Journal of Digital Learning in Teacher Education, 3*6(1), 6–18. https://doi.org/10.1080/21532974.2019.1694381

Century, J., Ferris, K. A., & Zuo, H. (2020). Finding time for computer science in the elementary school day: A quasi-experimental study of a transdisciplinary problem-based learning approach. *International Journal of STEM Education, 7*(1), 20. https://doi.org/10.1186/s40594-020-00218-3

Cerf, V. G., & Johnson, M. (2016). Enrollments explode! but diversity students are leaving….*Communications of the ACM, 59*(4), 7. https://doi.org/10.1145/2898431

Charalambous, C. & Philippou, G. (2010). Teachers' concern and efficacy beliefs about implementing a mathematics curriculum reform: Integrating two lines of inquiry. *Educational Studies in Mathematics 75*:1-21.

Check, J., & Schutt, R. (2012). *Research methods in education*. SAGE Publications, Inc.

Chen, Y.-H., & Jang, S.-J. (2014). Interrelationship between stages of concern and technological, pedagogical, and content knowledge: A study on Taiwanese senior high school in-service teachers. *Computers in Human Behavior*, *32*, 79–91. https://doi.org/10.1016/j.chb.2013.11.011

Code.org. (2021). *K–12 computer science policy and implementation in states.* https://code.org/advocacy/landscape.pdf

Code.org & CSTA. (2018). *2018 state of computer science education: Policy and implementation*.https://advocacy.code.org/2018_state_of_cs.pdf

Code.org, CSTA, & ECEP Alliance (2022). *2022 state of computer science education: Understanding our national imperative*. https://advocacy.code.org/2022_state_of_cs.pdf

CodeVA. (2022). *Integration Planning Guide*.

Cohoon, J. M., Nable, M. & Boucher, P. (2011). Conflicted identities and sexism in computing graduate programs. *Frontiers in Education Conference*. Rapid City, SD.

College Board. (2021). *The gender gap in Advanced Placement Computer Science: Participation and performance, 1984-1996*. The Elective. https://elective.collegeboard.org/gender-gap-advanced-placement-computer-science-participation-and-performance-1984-1996

Conyers, M., & Wilson, D. (2016). *Smarter teacher leadership: Neuroscience and the power of purposeful collaboration*. New York, NY: Teachers College Press

Cummings, D., Anthony, M., Watson, C., Watson, A., & Boone, S. (2021). Combating social injustice and misinformation to engage minority youth in computing sciences. *Proceedings of the 52nd ACM Technical Symposium on Computer Science Education*, 1006–1012. https://doi.org/10.1145/3408877.3432452

Dearing, J. W. (2009). Applying diffusion of innovation theory to intervention development. *Research on Social Work Practice, 19*(5), 503–518. https://doi.org/10.1177/1049731509335569

DeLyser, L., Goode, J., Guzdial, M., Kafai, Y. and Yadav, A. (2018). *Priming the computer science teacher pump*. http://www.computingteacher.org

DuBow, W. & Gonzalez, J.J. (2020). *NCWIT scorecard: The status of women in technology*. Boulder, CO: NCWIT. https://www.ncwit.org/resources/ncwit-scorecard-status-women-computing-2020-updat

Drake, S. M., & Reid, J. L. (2020). 21st century competencies in light of the history of integrated curriculum. *Frontiers in Education*, *5*. https://www.frontiersin.org/articles/10.3389/feduc.2020.00122

Enderson, M. C., P. A. Reed, & M. R. Grant. (2020). Secondary STEM teacher education. *In Handbook of research on STEM education*. New York and London: Routledge, 349–360.

ETS. (2018). *Computer science: The Praxis' study companion*. https://www.ets.org/pdfs/praxis/5652.pdf

Fisher, L. M. (2016). A decade of ACM efforts contribute to computer science for all. *Communications of the ACM, 59*(4), 25–27. https://doi.org/10.1145/2892740

Fofang, J. S., Weintrop, D., Walton, M., Elby, A., & Walkoe, J. (2020). Mutually supportive mathematics and computational thinking in a fourth-grade classroom. In Gresalfi, M. and Horn, I. S. (Eds.), *The Interdisciplinarity of the Learning Sciences*, 14th International Conference of the Learning Sciences (ICLS) 2020, Volume 3 (pp. 1389-1396). Nashville, Tennessee: International Society of the Learning Sciences.

Foster, J., Zeitz, M., Manzi, L. & Petty, D. (2022). *2022 Massachusetts digital literacy and computer science curriculum guide*. https://www.doe.mass.edu/stem/dlcs/curriculum-guide.pdf

Friend, M. (2022, July 16). *Solving the challenges that face K-12 CS teachers* [Conference presentation]. *CSTA 2022 Annual Conference,* Chicago, IL, United States.

Fullan, M. (2001). *The new meaning of educational change*. Routledge.

Fuller, F. (1969). Concerns of teachers: A developmental conceptualization. American *American Educational Research Journal, 6*(2), 207-226.

Gal-Ezer, J., & Stephenson, C. (2014). A tale of two countries: Successes and challenges in K-12 computer science education in Israel and the United States. *ACM Transactions on Computing Education (TOCE), 14*(2), 1-18.

Gallup. (2016). *Trends in the state of computer science in U.S. K-12 schools*. https://services.google.com/fh/files/misc/trends-in-the-state-of-computer-science-report.pdf

Gallup. (2020). *Current perspectives and continuing challenges in computer science education in U.S. K-12 education*. Gallup and Google. https://csedu.gallup.com

Gannon, A., Gavahi, M., Yuan, X., Whalley, D., Southerland, S., Andrews-Larson, C., & Granger, E. (2022). Experience with integrating computer science in middle school mathematics. *Proceedings of the 27th ACM Conference on Innovation and Technology in Computer Science Education Vol. 1*, 40–46. https://doi.org/10.1145/3502718.3524787

George, A. A., Hall, G. E., & Stiegelbauer, S. M. (2006). *Measuring implementation in schools: The Stages of Concern Questionnaire.* Austin, TX: SEDL. http://www.sedl.org/pubs/catalog/items/cbam17.html

Grover, S., & Pea, R. (2013). Computational thinking in K–12: A review of the state of the Field. *Educational Researcher, 42*(1), 38-43.

Grover, S., Pea, R., & Cooper, S. (2016). Factors influencing computer science learning in middle school. *In Proceedings of the 47th ACM Technical Symposium on Computing Science Education (pp. 552-557)*. ACM.

Guba, E. G., & Lincoln, Y. S. (1989). *Fourth generation evaluation*. Sage.

Guo, M., & Ottenbreit-Leftwich, A. (2020, October). Exploring the K-12 computer science curriculum standards in the US. *In Proceedings of the 15th Workshop on Primary and Secondary Computing Education* (pp. 1-6).

Guzey, S. S., Moore, T. J., & Harwell, M. (2016). Building up STEM: An analysis of teacher-developed engineering design-based STEM integration curricular materials. *Journal of Pre-College Engineering Education Research (J-PEER)*, *6*(1), 2.

Hall, G.E. & Hord, S.M. (2015). *Implementing change: Patterns, principles, and potholes*. Upper Saddle River, NJ: Pearson.

Hancock, D. R., & Algozzine, B. (2016). *Doing case study research: A practical guide for beginning researchers* (3rd ed.). Teachers College Press.

Heintz, F., Mannila, L., & Färnqvist, T. (2016). A review of models for introducing computational thinking, computer science and computing in K-12 education. *2016 IEEE Frontiers in Education Conference (FIE)*, 1–9. https://doi.org/10.1109/FIE.2016.7757410

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, 55(3), 223-252. doi: 10.1007/s11423-006-9022-5

Israel, M., Pearson, J.N., Tapia, T., Wherfel, Q.M., and Reese, G. (2015). Supporting all learners in school-wide computational thinking: A cross-case qualitative analysis. *Computers & Education, 82*, 263–279.

Jacobs, H. H. (1989). Design options for an integrated curriculum. In, H. H. Jacobs (Ed, .), *Interdisciplinary curriculum: Design and implementation* (pp.13–25). Alexandria, VA: ASCD Publications.

Julius, J. (2007). *A concerns-based adoption model study of university instructors engaged in faculty development for enhancing learning with technology* [Doctoral dissertation, University of San Diego]. https://doi.org/10.22371/05.2007.021

Lake, K. (2003). *School improvement research series-integrated curriculum*. U.S. Department of Education. https://educationnorthwest.org/sites/default/files/integrated-curriculum.pdf

Lincoln, Y. S. (2009). Ethical practices in qualitative research. In D. M. Mertens & P. E. Ginsberg (Eds.), *Handbook of social research ethics* (pp. 150– 169). Thousand Oaks, CA: SAGE.

Lucarelli, C., Long, J., Rosato, J., Treichel, C., & Benedict, H. (2021). A teacher preparation model that prepares all teachers to facilitate computer science concepts. In *Preparing pre-service teachers to teach computer science: Models, practices, and policies*. Charlotte, NC. Information Age Publishing, Inc., 91-112.

Marina, A., & Christos, M. (2021). Exploring the barriers of educational innovation. In A. I. Cristea & C. Troussas (Eds.), *Intelligent Tutoring Systems* (pp. 22–27). Springer International Publishing. https://doi.org/10.1007/978-3-030-80421-3_3

Margolis, J., Holme, J. J., Estrella, R., Goode, J., Nao, K., & Stumme, S. (2003). The computer science pipeline in urban high schools: access to what? for whom? *IEEE Technology and Society Magazine, 22*(3), 12–48. https://doi.org/10.1109/mtas.2003.1237467

Margolis, J., Estrella, R., Goode, J. & Holme, J. & Nao, K. (2008). *Stuck in the shallow end*. Cambridge, MA: The MIT Press.

Mathison, S., & Freeman, M. (1997). *The logic of interdisciplinary studies. Paper presented at the American Educational Re- search Association*, Chicago, IL. http:// www.albany.edu/cela/reports/mathisonlogic12004.pdf

McCarthy, B. (1982). Improving staff development through CBAM and 4MAT. *Educational Leadership, 40*(1), 20-25.

McGinnis, J.R., Hestness, E., Mills, K., Ketelhut, D.J., Cabrera, L., & Jeong, H. (2020). Preservice science teachers' beliefs about computational thinking following a curricular module within an elementary science methods course. *Contemporary Issues in Technology and Teacher Education, 20*(1).

McLuhan, M., Fiore, Q., & Agel, J. (1967, September 16). *The Medium is the Massage: An Inventory of Effects* (1st ed.). Bantam Books.

McMillan, J. H. (2000). Foundations of educational measurement. *Educational Research. Fundamentals for the Consumer*. 3rd Ed. Virginia Commonwealth University.

Menekse, M. (2015) Computer science teacher professional development in the United States: a review of studies published between 2004 and 2014. *Computer Science Education, 25*:4, 325-350, DOI: 10.1080/08993408.2015.1111645

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation* (4th ed.). John Wiley & Sons.

Mouza, C., Yang, H., Pan, Y.-C., Yilmaz Ozden, S., & Pollock, L. (2017). Resetting educational technology coursework for pre-service teachers: A computational thinking approach to the development of technological pedagogical content knowledge (TPACK). *Australasian Journal of Educational Technology, 33*(3). https://doi.org/10.14742/ajet.3521

Mouza, C., Garvin, M., O'Grady-Cunniff, D., & Pollock, L. (2021). Developing computationally literate teacher educators. *SITE 2021 Online,* United States.

Mouza, C., Yadav, A., Ottenbreit-Leftwich, Anne. (2021). *Preparing pre-service teachers to teach computer science: Models, practices, and policies*. Charlotte, NC. Information Age Publishing, Inc.

Nager, A., & Atkinson, R. D. (2016). The case for improving U.S. computer science education. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3066335

National Academies of Sciences Engineering and Medicine, Sciences. (2021). *Cultivating interest and competencies in computing: Authentic experiences and design factors*. The National Academies Press. http://nap.edu/25912

National Research Council. (2011). *Report of a workshop of pedagogical aspects of computational thinking*. The National Academies Press, Washington, D.C., 2011.

National Research Council. (2013). *Next generation science standards: For states, by states*. Washington, DC: The National Academies Press.

Nemutanzhela, P., & Iyamu, T. (2015). Theory of diffusion of innovation for analysis in information systems studies. *2015 Science and Information Conference* (SAI), 603–608. https://doi.org/10.1109/SAI.2015.7237205

Ottenbreit-Leftwich, A., Brush, T., DeLyser, L., Yadav, A., Simon, B., & Childs, J. (2021, November 3). How are we preparing our preservice teachers to teach CS? A national perspective. *AECT International Convention*, Chicago, Illinois

Ottenbreit-Leftwich, A. T., Childs, J., Fletcher, C., Kim, J., Edwards, K. M., & Hendrickson, K. (2022). Defining computer science teacher qualification pathways. *Policy Futures in Education*, 14782103221123364. https://doi.org/10.1177/14782103221123364

Ottenbreit-Leftwich, A., & Yadav, A. (2022). Introduction: Computational thinking in preK-5: empirical evidence for integration and future directions. In *Computational Thinking in PreK-5: Empirical Evidence for Integration and Future Directions* (pp. iii-vi). https://dl.acm.org/doi/pdf/10.1145/3507951.3519281

Ortlipp, M. (2008). Keeping and using reflective journals in the qualitative research process. *The Qualitative Report, 13*(4), 695-705.

Ozturk, Z., Dooley, C.M., & Welch, M. (2018). Finding the hook: Computer science education in elementary contexts. *Journal of Research on Technology in Education, 50*(2), 149-163.

Patton, M. Q. (2018). *Principles-focused evaluation: The guide.* New York: Guilford Press.

Polikoff, M. & Dean, J. (2019). *The supplemental-curriculum bazaar: Is what's online any good?* Washington, DC: Thomas B. Fordham Institute. https://fordhaminstitute.org/national/research/supplemental-curriculum-bazaar

Pollock, L., Mouza, C., Czik, A., Little, A., Coffey, D., & Buttram, J. (2017). From professional development to the classroom: Findings from CS K-12 teachers. *In Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (pp. 477–482). New York: ACM.

Reding, T. E., & Dorn, B. (2017). Understanding the "teacher experience " in primary and secondary CS professional development. *In Proceedings of the 2017 ACM Conference on International Computing Education Research* (pp. 155–163). New York: ACM.

Rich, K., Strickland, C., & Franklin, D. (2017, March 8-11). A literature review through the lens of computer science learning goals theorized and explored in research. *In Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education*. Seattle, WA, USA. DOI: http://dx.doi.org/10.1145/3017680.3017772

Rich, K. M., Yadav, A., & Schwarz, C. V. (2019). Computational thinking, mathematics, and science: Elementary teachers' perspectives on integration. *Journal of Technology and Teacher Education, 27*(2), 165-205.

Rich, P. J., Mason, S. L., & O'Leary, J. (2021). Measuring the effect of continuous professional development on elementary teachers' self-efficacy to teach coding and computational thinking. *Computers & Education, 168*, 104196. https://doi.org/10.1016/j.compedu.2021.104196

Rogers, E. M. 2003. *Diffusion of innovations*. 5th ed. New York: Free Press.

Rosato, J., Friend, M., & Moallem, M. (2022). Computer science as a fundamental discipline in education. *SITE 2022*, San Diego.

Ryoo, J., Goode, J., & Margolis, J. (2015). It takes a village: supporting inquiry-and equity-oriented computer science pedagogy through a professional learning community. *Computer Science Education, 25*(4), 351-370.

Sadik, O, Ottenbreit-Leftwich, A. & Brush, T.A. (2020). Secondary computer science teachers' pedagogical needs. *International Journal of Computer Science Education in Schools, 4* (1) (2020), pp. 1-21.

Santo, R., Vogel, S., & Ching, D. (2019). *CS for what? Diverse visions of computer science education in practice*. New York, NY: CSforALL. https://www.csforall.org/visions

Sawczuk, S. (2017, November 21). Virginia becomes first state to require computer science instruction. *Education Week*. https://www.edweek.org/teaching-learning/virginia-becomes-first-state-to-require-computer-science-instruction/2017/11

Shea, D., Hollis, S., and Long, L. (2020). Add-on computer science endorsements: A community effort. *Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, pp. 1-2, doi: 10.1109/RESPECT49803.2020.9272509.

Smith, M. (2016, January 30). *Computer science for all*. The Whitehouse, President Barack Obama. https://obamawhitehouse.archives.gov/blog/2016/01/30/computer-science-all

Standl, B., Rosato, J., Leftwich, A., & Fragapane, V. (2020). (How) do they bring computer science to everyone? Pre-service computer science teacher programs in Germany and in the USA. *SITE 2020 - Online*.

Steiner, D. (2017). *Curriculum research: What we know and where we need to go*. StandardsWork. https://standardswork.org/curriculum-research-what-we-know-and-where-we-need-to-go

Sung, W., Ahn, J., & Black, J. B. (2017). Introducing computational thinking to young learners; Practicing computational perspectives through embodiment in mathematics education. *Technology, Knowledge and Learning, 22*(3), 443-463.

Taylor, C., Spacco, J., Bunde, D. P., Butler, Z., Bort, H., Hovey, C. L., Maiorana, F. & Zeume, T. (2018, July). Propagating the adoption of CS educational innovations. *In Proceedings Companion of the 23rd Annual ACM Conference on Innovation and Technology in Computer Science Education* (pp. 217-235).

Tissenbaum, M., Weintrop, D., Holbert, N., & Clegg, T. (2021). The case for alternative endpoints in computing education. *British Journal of Educational Technology*, *52*(3), 1164–1177. https://doi.org/10.1111/bjet.13072

Toolin, R., Dion, L., & Erickson, R. (2021). The computer science education collaborative: Promoting computer science teacher education programs for preservice and in-service teachers. *The Journal of Computational Science Education, 12*, pp. 2–7. https://doi.org/10.22369/issn.2153-4136/12/1/1

Tran, Y. (2018). Computational thinking equity in elementary classrooms: What third-grade students know and can do. *Journal of Educational Computing Research, 57*(1), 3–31. https://doi.org/10.1177/0735633117743918

Tucker, A. (2003). *A model curriculum for K-12 computer science: Final Report of the ACM K-12 task force curriculum committee*. Association for Computing Machinery, New York, NY, USA.

U.S. Bureau of Labor Statistics. (2022, April 18). *Occupational outlook handbook: Computer and information technology occupations*. https://www.bls.gov/ooh/computer-and-information-technology/home.htm

U.S. Department of Education. (2022). *Preparing and credentialing the nation's teachers: The secretary's report on the teacher workforce*. https://title2.ed.gov/Public/OPE%20Annual%20Report.pdf

Vahrenhold, J., Cutts, Q., & Falkner, K. (2019). *Schools (K–12*). In S. Fincher & A. Robins (Eds.), *The Cambridge handbook of computing education research* (Cambridge Handbooks in Psychology, pp. 547-583). Cambridge: Cambridge University Press. doi:10.1017/9781108654555.019

Van den Berg, R., & Ros, A. (1999). The permanent importance of the subjective reality of teachers during educational innovation: A concerns-based approach. *American educational research journal, 36*(4), 879-906.

Vivian, R., Falkner, K., Busuttil, L., Quille, K., Sentence, S., Cole, E., McGill, M., Barksdale, S., Liebe, C. (2020). An international pilot study of K-12 teachers' computer science self-esteem. *ITiCSE '20, June 15–19, 2020*, Trondheim, Norway.

Virginia Administrative Code. (2018, August 23). 8VAC20-543-90. Professional studies requirements for early/primary education, elementary education, and middle education. *Virginia Register Volume 34, Issue 24*. https://law.lis.virginia.gov/pdf/admincode/8/20/543/90/

Vogel, S., Santo, R., & Ching, D. (2017). Visions of computer science education: unpacking arguments for and projected impacts of CS4All initiatives. *In Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education* (pp. 609–614).

Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies*, *20*(4), 715-728.

Wang, H.-H., Moore, T., Roehrig, G., & Park, M. (2011). STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research (J-PEER)*, *1*(2). https://doi.org/10.5703/1288284314636

Waterman, K., Goldsmith, L., Pasquale, M., Goldenberg, E.P., Malyn-Smith, J., DeMallie, A., & Lee, I.A. (2018). *Integrating computational thinking into elementary mathematics and science curriculum materials and instruction*. In Pixel (Ed.), Conference Proceedings: the Future of Education 2018. Florence, Italy: LibreriaUniversitaria Edizioni.

Weintrop, D., Hansen, A. K., Harlow, D. B., & Franklin, D. (2018). Starting from scratch: Outcomes of early computer science learning experiences and implications for what comes next. *ICER '18, August 13-15, 2018*. Espoo, Finland. https://www.terpconnect.umd.edu/~weintrop/papers/WeintropEtAl_SIGCSE_2019.pdf

Wiese, E. S., & Linn, M. C. (2021). "It must include rules": Middle school students' computational thinking with computer models in science. *ACM Transactions on Computer-Human Interaction, 28*(2), 1–41. https://doi.org/10.1145/3415582

Wilkens, K., Tychonievich, L. & Chiu, J. (2021). Changes in K-8 teacher self-efficacy with CS and culturally responsive teaching through an RPP workshop. *SIGCSE '21, March 13–20, 2021, Virtual Event, USA*. https://doi.org/10.1145/3408877.3439644

Wilkens, K., Bredder, E. & Chiu, J. (2022). Planned use and perceived challenges of equitable computer science teaching strategies with K-8 teachers. 2*022 AERA Annual Meeting, April 21-26. San Diego, CA*. DOI: 10.3102/IP.22.1889602

Wilson, C., Sudol, L. A., Stephenson, C., & Stehlik, M. (2010). *Running on empty: The failure to teach K-12 computer science in the digital age*. The Association for Computing Machinery. The Computer Science Teachers Association.

Wing, J.M. (2006). Computational Thinking. *Communications of the ACM, 49*(3). 33-35.

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences, 366*(1881), 3717–3725. https://doi.org/10.1098/rsta.2008.0118

Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education (TOCE)*, *14*(1), 1-16.

Yadav, A., Stephenson, C., & Hong, H. (2017). Computational thinking for teacher education. *Communications of the ACM, 60*(4), 55–62. https://doi.org/10.1145/2994591

Yadav, A., DeLyser, L.A., Kafai, Y., Guzdial, M, & Good, J. (2021). Building and expanding the capacity of schools of education to prepare and support teachers to teach computer science. In *Preparing pre-service teachers to teach computer science: Models, practices, and policies*. Charlotte, NC. Information Age Publishing, Inc., 191-203.

Yadav, A., & Heath, M.K. (2022). Breaking the code: Confronting racism in computer science through community, criticality, and citizenship. *TechTrends 66*, 450–458. https://doi.org/10.1007/s11528-022-00734-9

Zhou, N., Nguyen, H., Fischer, C., Richardson, D., & Warschauer, M. (2020). High school teachers' self-efficacy in teaching computer science. *ACM Transactions on Computing Education, 20*(3), 1–18. https://doi.org/10.1145/3410631

Appendix A

Survey Recruitment

My name is Kim Wilkens and I'm an EdD candidate in Curriculum & Instruction working on my Capstone project. The problem of practice that I am exploring is the gap between expectations from the Virginia Department of Education that the K-8 Computer Science (CS) Standards of Learning (SOLs) are to be integrated into K-8 classrooms plus the 77% of public school districts that plan to adopt the CS SOLs through integration in K-8 and the preparation of K-8 pre-service students to integrate CS.

The purpose of this survey is to determine the concerns faculty and instructors might have when thinking about how the teacher education program prepares K-8 teacher candidates to integrate CS in their teaching practice. Previous experience with computer science education is not required to complete the survey. The Teacher Education Data Committee has reviewed and approved this study. Your participation in this survey is completely voluntary. You can withdraw at any time during the survey. Any information you provide will be handled confidentially. I expect the survey to take 15-20 minutes to complete. The survey will be available until January 27, 2023. Please don’t hesitate to contact me with questions or concerns.

Survey link:

Thank you for your consideration,
Kim Wilkens, EdD candidate

Appendix B

Interview Recruitment

My name is Kim Wilkens and I'm an EdD candidate in Curriculum & Instruction working on my Capstone. I would really appreciate the opportunity to interview you for this research project. You can find details about my Capstone project below and while it is focused on computer science education, previous experience with computer science is not required. If you are willing, I have set up an interview sign-up schedule here, where you can hopefully find a date and time that works for you. If you would like further information, please let me know.

Thank you for your consideration,
Kim

The problem of practice that I am exploring with my Capstone project is the gap between expectations from the Virginia Department of Education that the K-8 Computer Science (CS) Standards of Learning (SOLs) are to be integrated into K-8 classrooms and the 77% of public school districts that plan to adopt the CS SOLs through integration in K-8, and the preparation of K-8 teacher candidates to integrate CS into their teaching practice.

I would like the opportunity to interview you to gain your thoughts and insights around CS education. The plan is for the interview to take place over Zoom at a date/time that is convenient for you. The interview will be scheduled for one hour and will be recorded. The Teacher Education Data Committee has reviewed and approved this study. Participation in an interview is purely voluntary and your input will be kept confidential. Transcriptions of the interview conversation and the final Capstone project will not identify any participants by name.

Kim Wilkens, EdD candidate

Appendix C

Innovation Survey: Integrating Computer Science in K-8

Consent Agreement

Please read this consent agreement carefully before you decide to participate in the study.

Purpose of the research study: The purpose of this study is to understand what concerns and opportunities there are around integrating computer science education in K-8.

What you will do in the study: Complete an online survey.

Time required: 15-20 minutes.

Risks: We do not anticipate any risks associated with participating in this research.

Benefits: There are no direct benefits to you for participating, but the study may help us understand ways of supporting pre-service students in integrating CS education in their future practices.

Confidentiality: The information that you give in the study will be handled confidentially. Your name will not be collected. When the study is completed and the data have been analyzed, the survey results will be destroyed.

Voluntary participation: Your participation in the study is completely voluntary. You may skip any question that makes you feel uncomfortable or that you do not wish to answer.

How to withdraw from the study: If you do not submit the survey, you are withdrawn from the study.

Payment: You will receive no payment for participating in the study.

Using data beyond this study: We may be asked to make the information collected in this study available to other researchers after the study is completed, including but not limited to survey responses, which will have no identifying information (like your name) included. Transfer of files would be done using password-protection encrypted files, and will not be posted on any public websites. Researchers of future studies will not ask your permission for each new study. The other researcher will not have access to your name or any other information that could potentially identify your participation in this study.

You may print a copy of this form for your records.

Agreement: A button must be selected before continuing.

- I agree
- I do NOT agree

Definition of computer science

The purpose of this survey is to determine the concerns faculty and instructors might have when thinking about preparing K-8 teacher candidates to integrate computer science in their teaching practice.

What does computer science mean to you?

Stages of Concern Questionnaire

Virginia was the first state to adopt computer science (CS) Standards of Learning (SOLs) in 2017 and a 2022 survey of Virginia public school districts found that 77% plan to integrate CS in K-8. The idea of integrating CS in K-8 is fundamentally a new way of doing things in schools.

For this 30-item questionnaire, consider that CS education goes beyond just learning how to use computing technologies towards an understanding why computing technologies work and how to create technology. CS can be used to solve problems in every field and empowers students to express themselves and critically engage as informed citizens with technology.

It is possible that several items on this survey may appear to be of little or no relevance to you at this time. For the completely irrelevant items, please mark a "0" on the scale. Other items will represent those concerns you do have, in varying degrees of intensity, and should be marked higher on the scale. For example:

- "This statement is very true of me at this time" might be marked as a 7.
- "This statement is somewhat true of me now" might be marked as a 4.
- "This statement is not at all true of me at this time" might be marked as a 1.

Please respond to items in terms of your present concerns, or how you feel about your involvement or potential involvement with integrating CS in the K-8 TPP curriculum.

Select one number for each item from this scale:
0 = Irrelevant
1-2 = Not sure of me now
3-5 = Somewhat true of me now
6-7 = Very true of me now

	0	1	2	3	4	5	6	7
I am concerned about teacher candidates' attitudes towards CS education. (1)	○	○	○	○	○	○	○	○
I am more concerned about other disciplines at this time. (3)	○	○	○	○	○	○	○	○

I am concerned about not having enough time to organize myself to address the CS standards. (4)	○	○	○	○	○	○	○	○
I would like to help other faculty integrate CS education. (5)	○	○	○	○	○	○	○	○
I have a very limited knowledge of CS education. (6)	○	○	○	○	○	○	○	○
I would like to know the effect of integrating CS on my professional status. (7).	○	○	○	○	○	○	○	○

Section 2 of 5

Please respond to items in terms of your present concerns, or how you feel about your involvement or potential involvement with integrating CS in the K-8 TPP curriculum.

Select one number for each item from this scale:
0 = Irrelevant
1-2 = Not sure of me now
3-5 = Somewhat true of me now
6-7 = Very true of me now

	0	1	2	3	4	5	6	7
I am concerned about conflict between my interests and my responsibilities for CS education. (8)	○	○	○	○	○	○	○	○
I would like to develop working relationships with both our faculty and outside faculty who are integrating CS. (10)	○	○	○	○	○	○	○	○
I am concerned about how integrating CS affects teacher candidates. (11)	○	○	○	○	○	○	○	○
I am not concerned about CS education at this time. (12)	○	○	○	○	○	○	○	○
I would like to know who will make the decisions about integrating CS education into the program. (13)	○	○	○	○	○	○	○	○
I would like to discuss the possibility of integrating CS. (14)	○	○	○	○	○	○	○	○

Section 3 of 5

Please respond to items in terms of your present concerns, or how you feel about your involvement or potential involvement with integrating CS in the K-8 TPP curriculum.

Select one number for each item from this scale:
0 = Irrelevant
1-2 = Not sure of me now
3-5 = Somewhat true of me now
6-7 = Very true of me now

	0	1	2	3	4	5	6	7
I would like to know what resources are available if we decide to adopt CS education. (15)	○	○	○	○	○	○	○	○
I am concerned about my inability to manage all that integrating CS requires. (16)	○	○	○	○	○	○	○	○
I would like to know how my teaching or administration is supposed to change as a result of integrating CS. (17)	○	○	○	○	○	○	○	○
I would like to familiarize other departments or persons with our progress of integrating CS. (18)	○	○	○	○	○	○	○	○
I am concerned about evaluating my impact on teacher candidates' ability to integrate CS. (19)	○	○	○	○	○	○	○	○
I am preoccupied with other things besides integrating CS education. (21)	○	○	○	○	○	○	○	○

Section 4 of 5

Please respond to items in terms of your present concerns, or how you feel about your involvement or potential involvement with integrating CS in the K-8 TPP curriculum.

Select one number for each item from this scale:
0 = Irrelevant
1-2 = Not sure of me now
3-5 = Somewhat true of me now
6-7 = Very true of me now

	0	1	2	3	4	5	6	7
I spend little time thinking about CS education. (23)	○	○	○	○	○	○	○	○
I would like to excite teacher candidates about their part in integrating CS. (24)	○	○	○	○	○	○	○	○

	0	1	2	3	4	5	6	7
I am concerned about time spent working with nonacademic problems related to CS education. (25)	○	○	○	○	○	○	○	○
I would like to know what integrating CS will require in the immediate future. (26)	○	○	○	○	○	○	○	○
I would like to coordinate my effort with others to maximize the effect of integrating CS. (27)	○	○	○	○	○	○	○	○
I would like to have more information on the time and energy commitments required by integrating CS. (28)	○	○	○	○	○	○	○	○

Section 5 of 5

Please respond to items in terms of your present concerns, or how you feel about your involvement or potential involvement with integrating CS in the K-8 TPP curriculum.

Select one number for each item from this scale:
0 = Irrelevant
1-2 = Not sure of me now
3-5 = Somewhat true of me now
6-7 = Very true of me now

	0	1	2	3	4	5	6	7
I would like to know what other faculty are doing with regard to integrating CS. (29)	○	○	○	○	○	○	○	○
Currently, other priorities prevent me from focusing my attention on CS education. (30)	○	○	○	○	○	○	○	○
I would like to use feedback from candidates to inform how I approach integrating CS. (32)	○	○	○	○	○	○	○	○
I would like to know how my role will change when I am integrating CS. (33)	○	○	○	○	○	○	○	○
Coordination of tasks and people is taking time away from integrating CS. (34)	○	○	○	○	○	○	○	○
I would like to know how integrating CS is better than what we do now. (35)	○	○	○	○	○	○	○	○

Open-ended Questions

What do you see as opportunities for integrating CS education into the teacher education curriculum?

____

What do you see as challenges to integrating CS education into the teacher education curriculum?

____

Demographic Info

What areas do you teach? (select all that apply)

- □ Curriculum & Instruction
- □ Early childhood education
- □ Elementary education
- □ ESL education
- □ Gifted education
- □ Instructional technology
- □ Mathematics education
- □ Reading education
- □ Science education
- □ Secondary education
- □ Social and emotional learning
- □ Special education
- □ Teacher education
- □ Other (please specify)

What gender identity do you most identify with?

- □ Female
- □ Male
- □ Non-binary
- □ Prefer to self-describe (please specify)
- □ Prefer not to answer

What race do you identify with? (select all that apply)

- □ American Indian or Alaska Native
- □ Asian American
- □ Black or African American
- □ Native Hawaiian or Other Pacific Islander
- □ White
- □ Prefer not to answer

What ethnicity do you identify with? (select one)

- □ Hispanic or Latino
- □ Not Hispanic or Latino
- □ Prefer not to answer

What is your age? (select one)

- ◻ 22-35 years old
- ◻ 35-55 years old
- ◻ 55+ years old
- ◻ Prefer not to answer

Appendix D

Modified SoC Questions

Stage 0: Unconcerned			
	Original	**Proposal update**	**Final update**
3	I am more concerned about another innovation.	No change	I am more concerned about ***other disciplines at this time***.
12	I am not concerned about this innovation at this time.	I am not concerned about ***CS education*** at this time.	No change
21	I am preoccupied with things other than this innovation.	I am completely occupied with things other than CS education.	I am preoccupied with other things ***besides integrating CS education***.
23	I spend little time thinking about this innovation.	I spend little time thinking about ***CS education***.	No change
30	Currently, other priorities prevent me from focusing my attention on this innovation.	Currently, other priorities prevent me from focusing my attention on ***CS education***.	No change
Stage 1: Informational			
	Original	**Proposal update**	**Final update**
6	I have a very limited knowledge about the innovation.	I have a very limited knowledge of ***CS education***.	No change
14	I would like to discuss the possibility of using the innovation.	I would like to discuss the possibility of ***integrating CS***.	No change
15	I would like to know what resources are available if we decide to adopt this innovation.	I would like to know what resources are available if we decide to adopt ***CS education***.	No change
26	I would like to know what the use of the innovation will require in the immediate future.	I would like to know what ***integrating CS*** will require in the immediate future.	No change
35	I would like to know how this innovation is better than what we have now.	I would like to know how ***integrating CS*** is better than what we do now.	No change
Stage 2: Personal			
	Original	**Proposal update**	**Final update**

7	I would like to know the effect of the innovation on my professional status.	I would like to know the effect of ***integrating CS*** on my professional status	No change
13	I would like to know who will make the decisions in the new system.	I would like to know who will make the decisions ***about incorporating CS education***.	I would like to know who will make the decisions ***about integrating CS education into the program***.
17	I would like to know how my teaching or administration is supposed to change.	I would like to know how my teaching or administration is supposed to change ***as a result of integrating CS***.	No change
28	I would like to have more information on time and energy commitments required by this innovation.	I would like to have more information on the time and energy commitments required by ***integrating CS***.	No change
33	I would like to know how my role will change when I am using the innovation.	I would like to know how my role will change when I am ***integrating CS***.	No change
Stage 3: Management			
	Original	**Proposal update**	**Final update**
4	I am concerned about not having enough time to organize myself each day.	No change	I am concerned about not having enough time to organize myself ***to address the CS standards***.
8	I am concerned about conflict between my interests and my responsibilities.	No change	I am concerned about conflict between my interests and my responsibilities ***for CS education***.
16	I am concerned about my inability to manage all the innovation requires.	I am concerned about my inability to manage all ***that integrating CS*** requires.	No change
25	I am concerned about time spent working with nonacademic problems related to this innovation.	I am concerned about time spent working with nonacademic problems related to ***CS education***.	No change
34	Coordination of tasks and people is taking too much of my time.	No change	***Currently,*** coordination of tasks ***and/or*** people is taking time away from ***considering how to integrate CS***.
Stage 4: Consequence			
	Original	**Proposal update**	**Final update**

1	I am concerned about students' attitudes toward this innovation.	I am concerned about students' attitudes towards ***CS education***.	I am concerned about ***teacher candidates'*** attitudes towards ***CS education***.
11	I am concerned about how the innovation affects students.	I am concerned about how ***integrating CS*** affects students.	I am concerned about how ***integrating CS*** affects ***teacher candidates***.
19	I am concerned about evaluating my impact on students.	No change	I am concerned about evaluating my impact on ***teacher candidates' ability to integrate CS***.
24	I would like to excite my students about their part in this approach.	I would like to excite my students about their part in ***integrating CS***.	I would like to excite ***teacher candidates*** about their part in ***integrating CS***.
32	I would like to use feedback from students to change the program.	I would like to use feedback from students to change ***how I approach integrating CS***.	I would like to use feedback from ***teacher candidates*** to inform ***how I approach integrating CS***.
Stage 5: Collaboration			
	Original	**Proposal update**	**Final update**
5	I would like to help other faculty in their use of the innovation.	I would like to help other faculty ***integrate CS education***.	No change
10	I would like to develop working relationships with both our faculty and outside faculty using this innovation.	I would like to develop working relationships with both our faculty and outside faculty ***who are integrating CS***.	No change
18	I would like to familiarize other departments or people with the progress of this new approach.	I would like to familiarize other departments or persons with our progress of ***integrating CS***.	No change
27	I would like to coordinate my effort with others to maximize the innovation's effects.	I would like to coordinate my effort with others to maximize the ***effect of integrating CS***.	No change
29	I would like to know what other faculty are doing in this area.	No change	I would like to know what other faculty are doing ***with regard to integrating CS***.
Stage 6: Refocusing			
	Original	**Proposal update**	**Final update**
2	I now know of some other approaches that might work better.	No change	**Removed** (I now know of some other approaches *to CS education that might work better than integration.)*

9	I am concerned about revising my use of the innovation.	I am concerned about revising my use of ***CS education***.	**Removed** (I am concerned *that my current approach to CS integration will be revised.)*
20	I would like to revise the innovation's instructional approach.	I would like to revise the ***approach to CS education***.	**Removed** (I would like to revise *the approach we are taking to CS education.)*
22	I would like to modify our use of the innovation based on the experiences of our students.	I would like to modify how we ***integrate CS*** based on the experiences of our students.	**Removed** (*Based on the previous CS integration experiences of our teacher candidates,* I would like to modify our approach *to CS education.)*
31	I would like to determine how to supplement, enhance, or replace the innovation.	I would like to determine how to supplement, enhance, or replace ***CS education integration***.	**Removed**

Appendix E

TPP Faculty Interview Guide

Date & Time:
Interviewee:

Opening script:
Thank you so much for taking time to do this interview. This interview is part of my Capstone research project. The purpose of this research is to explore opportunities, challenges, and concerns with integrating CS in K-8 in the teacher preparation program curriculum.

You have already signed the IRB consent form and I will be recording this interview, but I wanted to remind you that your participation is voluntary and you have the right to withdraw from the study at any time as well as pass on any questions I ask today. Also, your personal information will be kept confidential.

Do you have any questions about the consent process before we start? If not, I will start recording.

- *More -> Record on this Computer*
- *More -> Captions -> View full transcript*

Intro Questions:
I'd like to start by learning a little about you:

- □ What drew you to education and how did you get started?
- □ What courses do you teach?
- □ How long have you been at the TPP?

Innovation Attributes:
The idea of integrating CS in K-8 is fundamentally a new way of doing things in schools, so I am looking at how it gets adopted by educators through the lens of innovation.

- *Share screen and show attributes*

Relative Advantage	compared to the status quo
Compatibility	consistent with current values and practices
Simple and easy to use	the relationship between the complexity of the innovation and the relevance to instruction
Trialability	the ability to experiment before adoption
Observable results	seeing the innovation in action

The Diffusion of Innovation theory highlights 5 attributes that stimulate adoption:

- Relative advantage - compared to the status quo
- Compatibility - consistent with current values and practices
- Simple and easy to use - the relationship between the complexity of the innovation and the relevance to instruction
- Trialability - the ability to experiment before adoption
- Observable results - seeing the innovation in action

When you consider incorporating an innovative practice or tool into your teaching, how would you rank the following attributes in terms of helping you adopt the innovation?

Why is your first ranked attribute the most important to you?

Stages of Concern:
Another innovation lens I'm using for this research is called the Concerns-based Adoption Model which suggests that educators go through a series of stages of concern about an innovation. Concerns are feelings, preoccupation, thought and consideration given to a particular issue or task related to the innovation.

- *Share screen and show SoC image*

Stages of Concern	Stage 0: Unrelated	Stage 1: Informational	Stage 2: Personal	Stage 3: Management	Stage 4: Consequence	Stage 5: Collaboration	Stage 6: Refocusing
Possible Expressions	*I have other priorities.*	*What is it?*	*How does it impact me?*	*How does it work? How do I do it?*	*How does it impact my students?*	*How do others do it?*	*Is there a better way?*

Based on this image, where do you think most of your concerns about integrating CS in the K-8 TPP curriculum would fall?

- ▫ Stage 0: Unconcerned
- ▫ Stage 1: Informational
- ▫ Stage 2: Personal
- ▫ Stage 3: Management
- ▫ Stage 4: Consequence
- ▫ Stage 5: Collaboration
- ▫ Stage 6: Refocusing

Stage 0: Unconcerned - reflects a potential awareness of the innovation but other priorities are more concerning.

- ▫ Are you aware of the K-12 computer science Standards of Learning? When did you become aware?
- ▫ Are you aware that the K-8 CS SOLs are intended to be integrated into other subject areas? When did you become aware?
- ▫ What are your perceptions of computer science education? In other words, what does CS education mean to you?

Stage 1: Informational - reflects concern with the need to learn more about the innovation and potential impact of implementation.

- ▫ Do you believe all K-8 students should learn some level of computer science? Why or why not?
- ▫ Do you believe that all K-8 teacher candidates at the TPP should learn some level of computer science? Why or why not?
- ▫ Do you believe that you should incorporate some CS education into your teaching practice? Why or why not?

Stage 2: Personal - reflects concern that individuals have relative to their self-efficacy, their belief in appropriateness of the innovation, and the personal cost to implement it.

- ▫ What type of information do you need to help you determine whether and how you should integrate CS into your curriculum?
- ▫ Would you be willing to share curricular resources for your course(s) for an analysis of where CS might fit?

Stage 3: Management - reflects concern about the logistical challenges of implementing the innovation.

- ▫ What do you see as opportunities for integrating CS in the K-8 teacher education curriculum?
- ▫ What do you see as challenges to integrating CS in the K-8 teacher education curriculum?

Stage 4: Consequence - reflects concern about how implementation of the innovation is affecting students.

- ▫ If an innovation like preparing K-8 teacher candidates to integrate CS in their teaching practice is adopted, how would you and/or the teacher education program know it was successful?

Stage 5: Collaboration - reflects concern about how individuals collaborate with others in using the innovation.

- Would it be helpful to you to collaborate with other instructors in the teacher education program and /or outside the program who are integrating CS?

Closing script:
That is all the questions I have today. I may be following up by e-mail with clarifying questions or to check my understanding. Again, thank you so much for your time and please don't hesitate to reach out to me if you have any questions related to this interview or study.

Appendix F

Codebook

Code Category	Code Name	Definition
CS Strand	Algorithms & programming	An algorithm is a series of steps designed to solve a specific problem or accomplish a specific task. Algorithms are translated into programs, or code, to provide instructions to a computing device.
CS Strand	Computing systems	The interaction of humans with computing devices which are made up of hardware and software.
CS Strand	Cybersecurity	The protection of computers, networks, programs, and data from unauthorized or unintentional access, manipulation, or destruction.
CS Strand	Data & analysis	Data is collected and stored so that it can be analyzed to better understand the world and make more accurate predictions.
CS Strand	Impacts of computing	The impact, both positive and negative, that computing has on daily life.
CS Strand	Networks and the Internet	Computer networks and the Internet enable people to connect with each other worldwide.
RQ3	Challenge	A barrier to integrating CS in the K-8 TPP curriculum.
Challenge	Time	Lack of time highlighted as a barrier to integrating CS in the K-8 TPP curriculum.
Challenge	Knowledge	Lack of knowledge highlighted as a barrier integrating CS in the K-8 TPP curriculum.
Challenge	Faculty buy-in	Getting faculty buy-in highlighted as a barrier to integrating CS in the K-8 TPP curriculum.
Challenge	Student buy-in	Getting student buy-in highlighted as a barrier to integrating CS in the K-8 TPP curriculum.
RQ3	Opportunity	An idea for integrating CS in the K-8 TPP curriculum.
Opportunity	Integrate	Integrating CS in existing courses highlighted as an opportunity to integrating CS in the K-8 TPP curriculum.
Opportunity	Create new course	Creating a new course and/or material highlighted as an opportunity to integrating CS in the K-8 TPP curriculum.
Opportunity	Student engagement	Student engagement highlighted as an opportunity to integrating CS in the K-8 TPP curriculum.
Opportunity	Faculty engagement	Faculty engagement highlighted as an opportunity to integrating CS in the K-8 TPP curriculum.
Opportunity	School partnerships	School partnerships highlighted as an opportunity to integrating CS in the K-8 TPP curriculum.
SoC	Unconcerned	Reflects a potential awareness of the innovation, but other priorities are more concerning.
SoC	Informational	Reflects concern with the need to learn more about the innovation and potential impact of implementation.
SoC	Personal	Reflects concern that individuals have relative to their self-efficacy, their belief in appropriateness of the innovation, and the personal cost to implement it.
SoC	Management	Reflects concerns about the logistical challenges of implementing the innovation.
SoC	Consequence	Reflects concerns about how implementation of the innovation is affecting students.
SoC	Collaboration	Reflects concerns about how individuals collaborate with others in using

		the innovation.
SoC	Refocusing	Reflects concerns about improving or replacing the innovation.
DOI Attributes	Advantage	Identifies an advantage of integrating CS in the K-8 TPP curriculum compared to the status quo.
DOI Attributes	Compatibility	Identifies that integrating CS in the K-8 TPP curriculum is compatible with the current values and practices in the classroom and school.
DOI Attributes	Simple	Identifies that there is a positive relationship between the complexity of integrating CS in the K-8 TPP curriculum and the relevance of CS integration to instruction.
DOI Attributes	Trialability	Identifies the importance of experimenting with integrating CS in the K-8 TPP curriculum before adoption.
DOI Attributes	Observable	Identifies that results from early adoption of integrating CS in the K-8 TPP curriculum will foster interest.

Appendix G

Raw Score to Percentile Conversion Table

Raw scale score	Percentile Scores						
	0	1	2	3	4	5	6
0	0	5	5	2	1	1	1
1	1	12	12	5	1	2	2
2	2	16	14	7	1	3	3
3	4	19	17	9	2	3	5
4	7	23	21	11	2	4	6
5	14	27	25	15	3	5	9
6	22	30	28	18	3	7	11
7	31	34	31	23	4	9	14
8	40	37	35	37	5	10	17
9	48	40	39	30	5	12	20
10	55	43	41	34	7	14	22
11	61	45	45	39	8	16	26
12	69	48	48	43	9	19	30
13	75	51	53	47	11	22	34
14	81	54	55	52	13	25	38
15	87	57	57	56	16	28	42
16	91	60	59	60	19	31	47
17	94	63	63	65	21	36	52
18	96	66	67	69	24	40	57
19	97	69	70	73	27	44	60
20	98	72	72	77	30	48	65
21	99	75	76	80	33	52	69
22	99	80	78	83	38	55	73
23	99	84	80	85	43	59	77
24	99	88	83	88	48	64	81
25	99	90	85	90	54	68	84
26	99	91	87	92	59	72	87
27	99	93	89	94	63	76	90
28	99	95	91	95	66	80	92
29	99	96	92	97	71	84	94
30	99	97	94	87	76	88	96
31	99	98	95	98	82	91	97
32	99	99	96	98	86	93	98
33	99	99	96	99	90	95	99
34	99	99	97	99	92	97	99
35	99	99	99	99	96	98	99

Appendix H

Informed Consent Agreement

Please read this consent agreement carefully before you decide to participate in the study.

Purpose of the research study: The purpose of this study is to understand what concerns and opportunities there are around integrating computer science education in K-8.

What you will do in the study: You will participate in an individual semi-structured interview.

Time required: 60 minutes.

Risks: We do not anticipate any risks associated with participating in this research.

Benefits: There are no direct benefits to you for participating, but the study may help us understand ways of supporting educators in implementing CS education in classrooms.

Confidentiality: The information that you give in the study will be handled confidentially. Your information will be assigned a code number. The list connecting your name to this code will be password-protected and your survey responses will have your name removed from them. When the study is completed and the data have been analyzed, this list will be destroyed. Your name and individual information will not be used in any report.

Voluntary participation: Your participation in the study is completely voluntary. You may skip any question that makes you feel uncomfortable or that you do not wish to answer.

Right to withdraw from the study: You have the right to withdraw from the study at any time without penalty, in which case any materials related to your participation will be destroyed.

How to withdraw from the study: At any point, before, during or after the focus group or interview, you can request to withdraw from one of the study contacts. There is no penalty for withdrawing.

Payment: You will receive no payment for participating in the study.

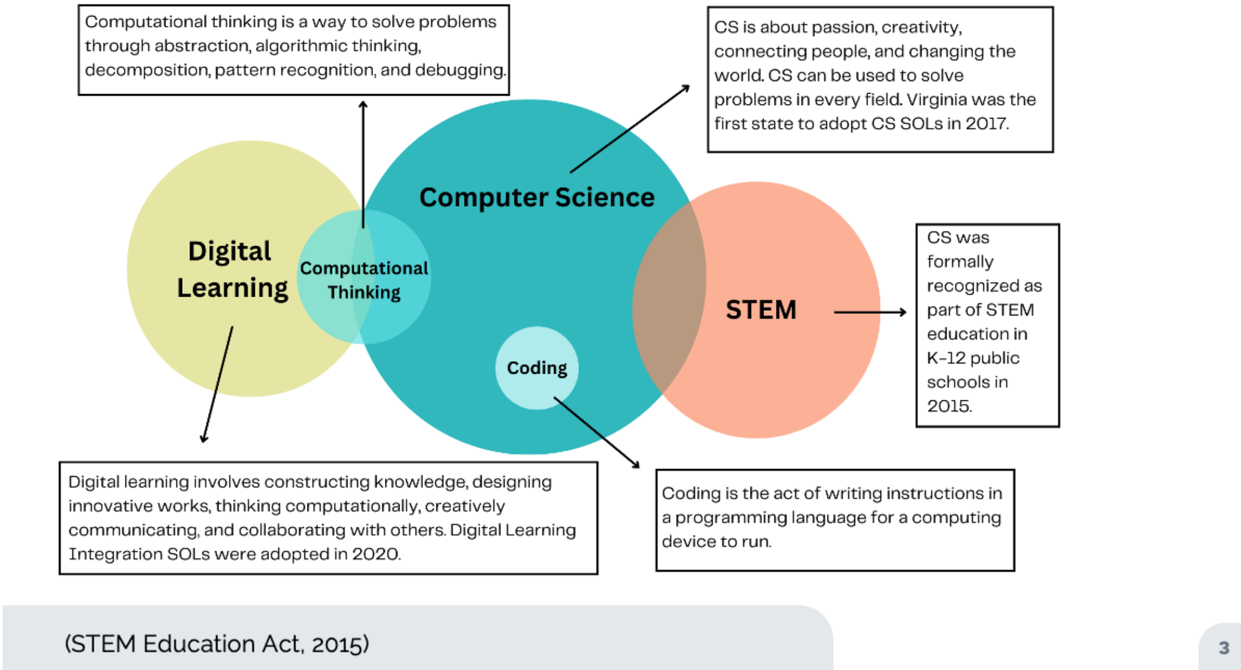
Using data beyond this study: We may be asked to make the information collected in this study available to other researchers after the study is completed, including but not limited to survey responses, which will have no identifying information (like your name) included. Transfer of files would be done using password-protection encrypted files, and will not be posted on any public websites. Researchers of future studies will not ask your permission for each new study. The other researcher will not have access to your name or any other information that could potentially identify your participation in this study.

Appendix I

Capstone Recommendations Slidedeck

Speaker notes: In Virginia, the growing importance of CS education was affirmed in 2017 when the VDoE adopted K-12 CS SoLs (Sawczuk, 2017) and with the K-8 standards “designed to be integrated into instruction in multiple subject areas" (Board of Education Commonwealth of Virginia, 2017, p. 4). However, most K-8 teachers do not have previous experience with CS content or pedagogy (DeLyser et al., 2018). There is no other discipline like CS education that is expected to be “taught across all US schools which is not also taught in pre-service teacher education programs” (DeLyser et al., 2018, p. 15).

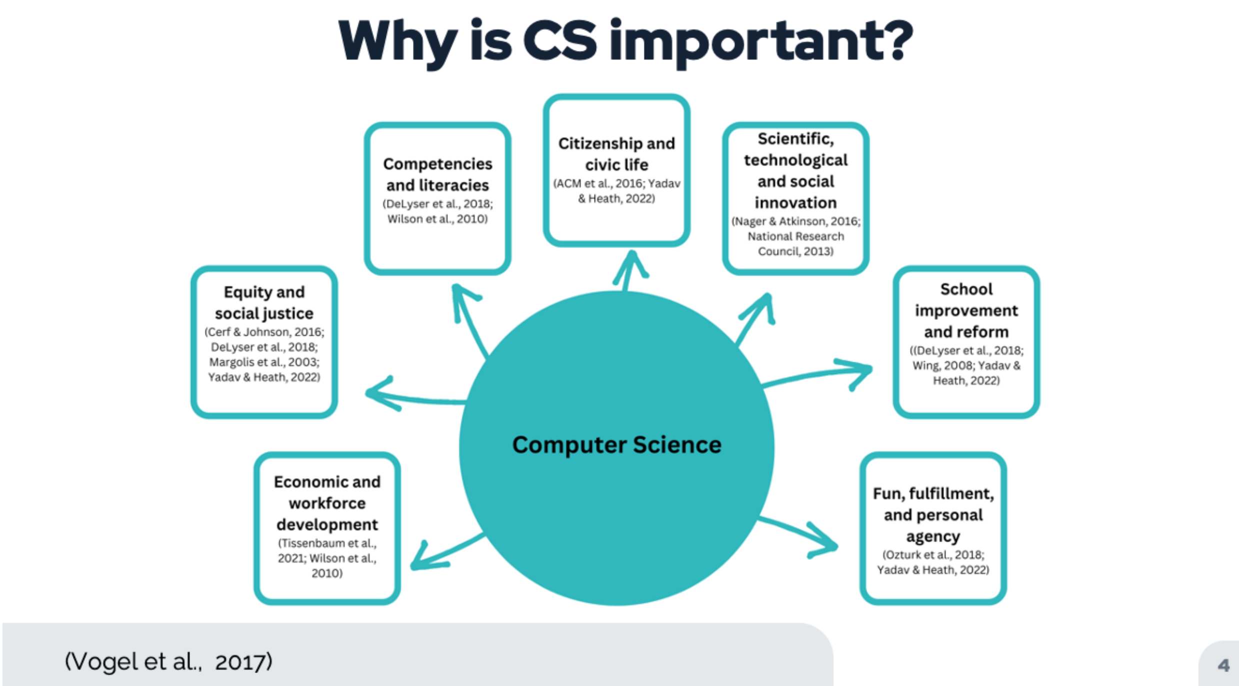
Speaker notes: There is a lot of terminology and jargon around computer science, so the first thing I want to do is unpack what computer science education is.



Speaker notes: CS is about passion, creativity, connecting people, and changing the world. CS can be used to solve problems in every field. Virginia was the first state to adopt CS SOLs in 2017. Coding is often conflated with computer science. Coding is the act of writing instructions in a programming language for a computing device to run. The Virginia CS SOLs define 6 strands which including coding, also known as algorithms & programming as just one of several core concepts that are part of computer science which also includes computing systems, networks and the internet, data and analysis, cybersecurity, and impacts of computing.

Computational thinking is a way to solve problems through abstraction, algorithmic thinking, decomposition, pattern recognition, and debugging. Computational thinking is also sometimes used interchangeably with computer science. In 2020, Virginia defined digital learning SOLs that also include computational thinking.

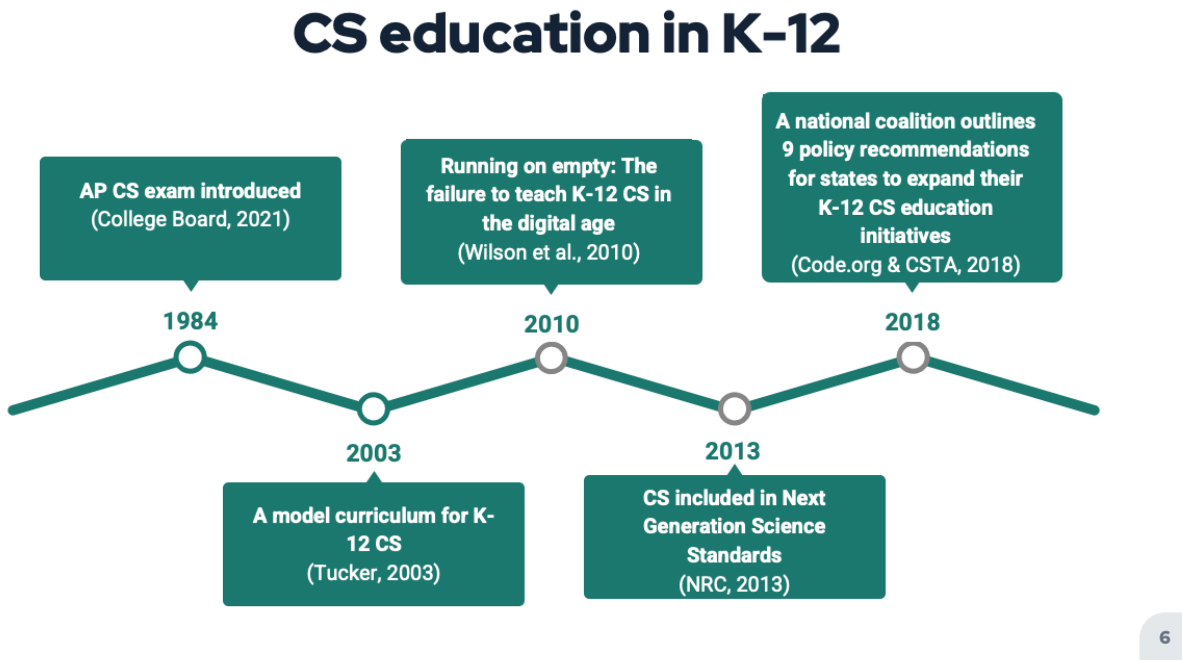
Computer science was formally recognized as part of STEM education in K-12 public schools as a part of the STEM education Act in 2015, but by and large the T for technology in STEM education still mostly represents technology use. For our purposes, we will computational thinking and coding as elements within computer science and CS as an element of STEM education.



Speaker notes: Vogel et al. found that stakeholders in CS education including educators, researchers, program designers and policy makers identified seven primary areas of impact and we can see these areas represented throughout K-12 CS education research:

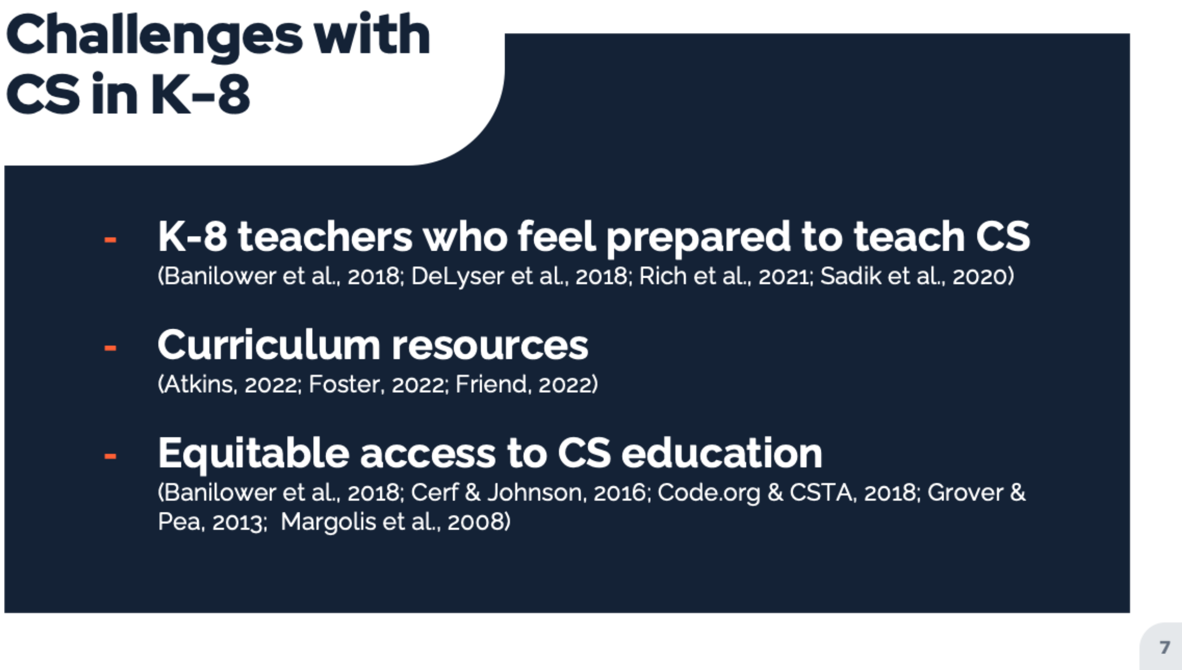
- economic and workforce development
- equity and social justice
- competencies and literacies
- citizenship and civic life
- scientific, technological, and social innovation
- school improvement and reform
- fun, fulfillment, and personal agency

Speaker notes: Here is a brief history of CS education in K-12



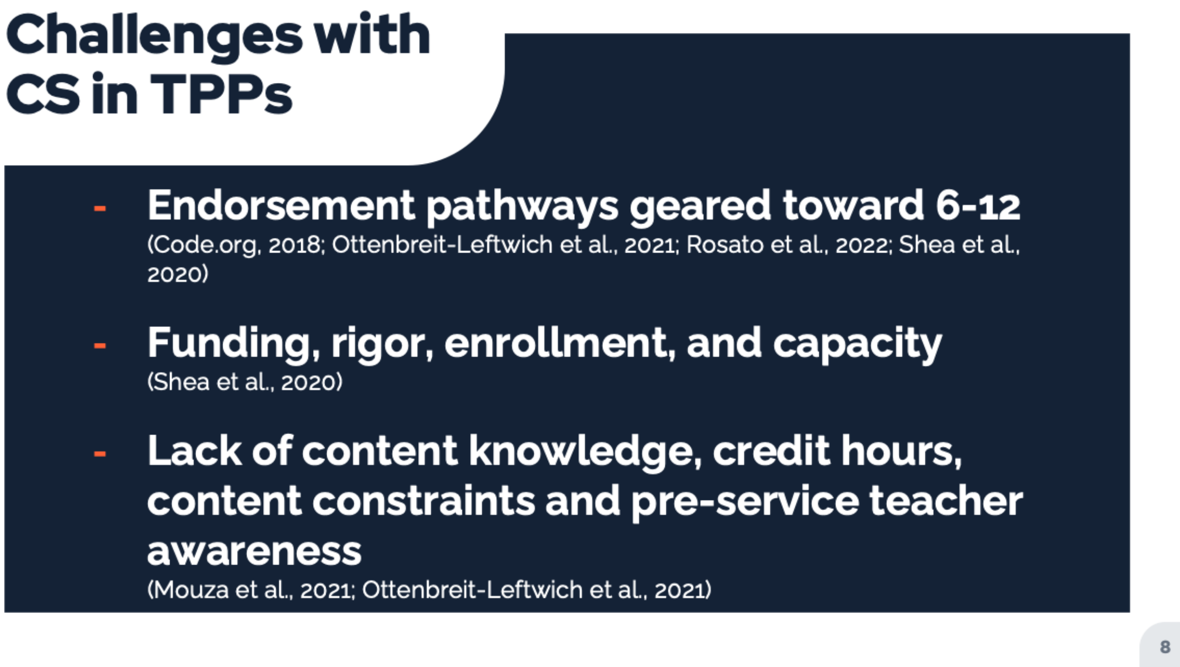
Speaker notes:

- In 1984, CS education found its way into high schools through Advanced Placement (AP) prep classes for the AP CS exam introduced by the College Board.
- In 2003, the Computer Science Teachers Association released a model curriculum for CS in K-12 as a roadmap they hoped state departments of education and school districts would use to incorporate CS into their curriculum.
- In 2010, Running on empty: The failure to teach K-12 CS in the digital age report was released. That report launched a variety of initiatives including a week devoted to K-12 computer science education, the CSforAll movement which aims to make CS education available at every grade level for all K-12 students, and an initiative to recruit and train 10,000 CS educators.
- In 2013, computer science became an integral part of the science and engineering practices of the Next Generation Science Standards
- In 2018 - a national coalition outlined 9 policy recommendations for states to follow to expand their CS education initiatives including the need to define CS standards, implement clear CS endorsement pathways for teachers, and create preservice programs in CS at Institutions of Higher Education



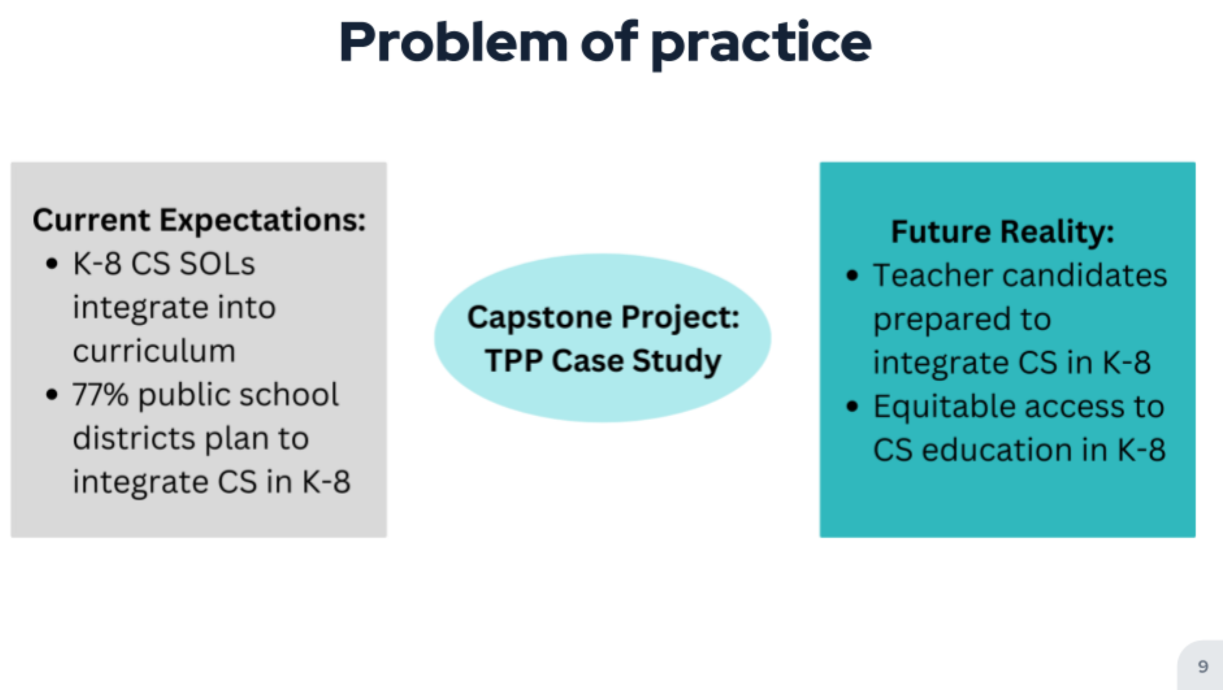
Speaker notes: There are 3 primary challenges facing CS education in K-8:

- There is a disconnect between expectation in state-wide policies for K-8 teachers to integrate CS into their core content and the reality that most K-8 teachers do not have prior experience with CS content or pedagogy. A 2018 national survey from Banilower et al. found that only 6% of elementary school teachers and 4% of middle school teachers felt prepared to teach CS.
- 39 states have adopted K-12 CS standards, but there is no national CS curriculum and standards vary by state. The resulting landscape of curricula is a hodgepodge of providers scrambling to meet a variety of needs. Most K-8 CS curricular resources have a focus on CS content and/or the tool they are supporting, and it appears they often do not address integration, assessment, or cultural diversity (Foster, 2022).
- An underlying theme behind raising the profile of K-12 CS education is addressing the gender and racial gaps that currently exist in CS education specifically and technology fields more broadly (DuBow, W. & Gonzalez, 2020). Interest in and knowledge of CS is still relatively low for students who identify as female, Black, and/or Latinx (Cerf & Johnson, 2016).

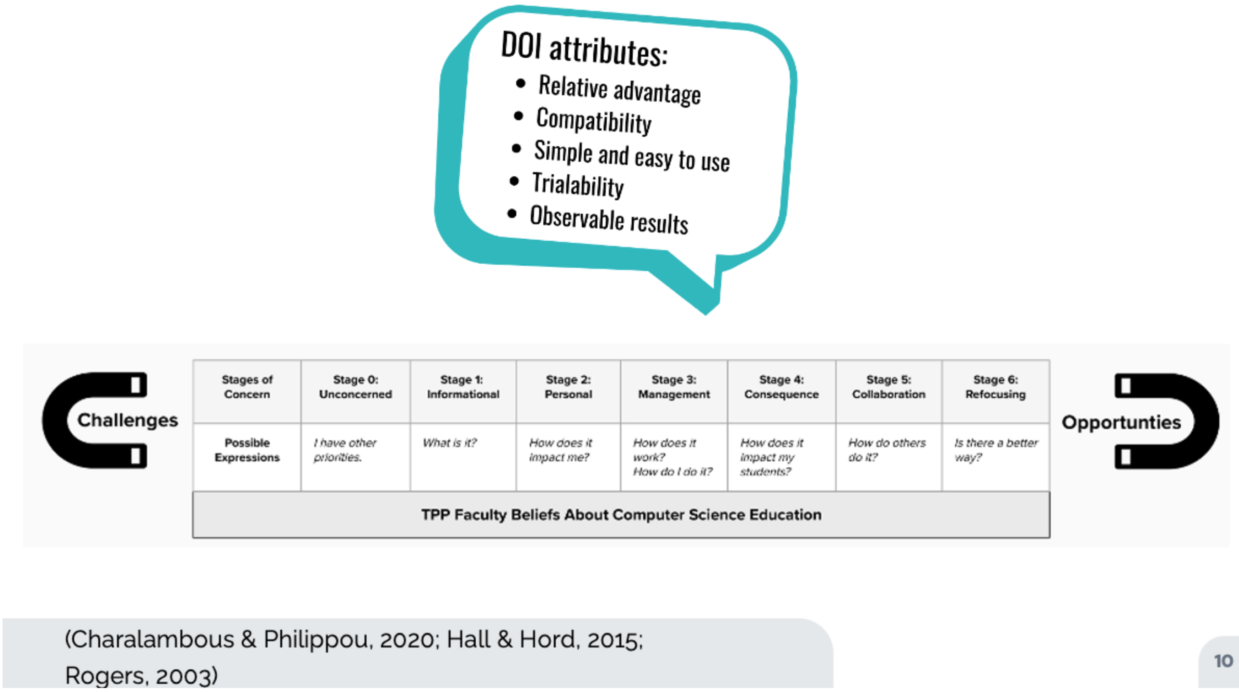


Speaker notes: There are 3 primary challenges with integrating CS education in K-8 in teacher preparation programs:

- Endorsement pathways are generally geared toward 6th through 12th grade. For instance, Virginia only has a 6-12 endorsement pathway and no endorsement requirements for teachers integrating CS in K-8. The content knowledge needed for the 18 hours of CS credit or the CS praxis is more advanced and does not take into account pedagogical knowledge needed in K-8 settings where CS is integrated into the curriculum.
- Teacher preparation programs look at the challenges differently than public school districts and worry about things like funding, rigor, enrollment and capacity
- A recent survey of Teacher preparation programs identified challenges related to the lack of content knowledge of faculty, a lack of credit hours and resulting content constraints in courses, and a lack of pre-service teacher awareness of CS education

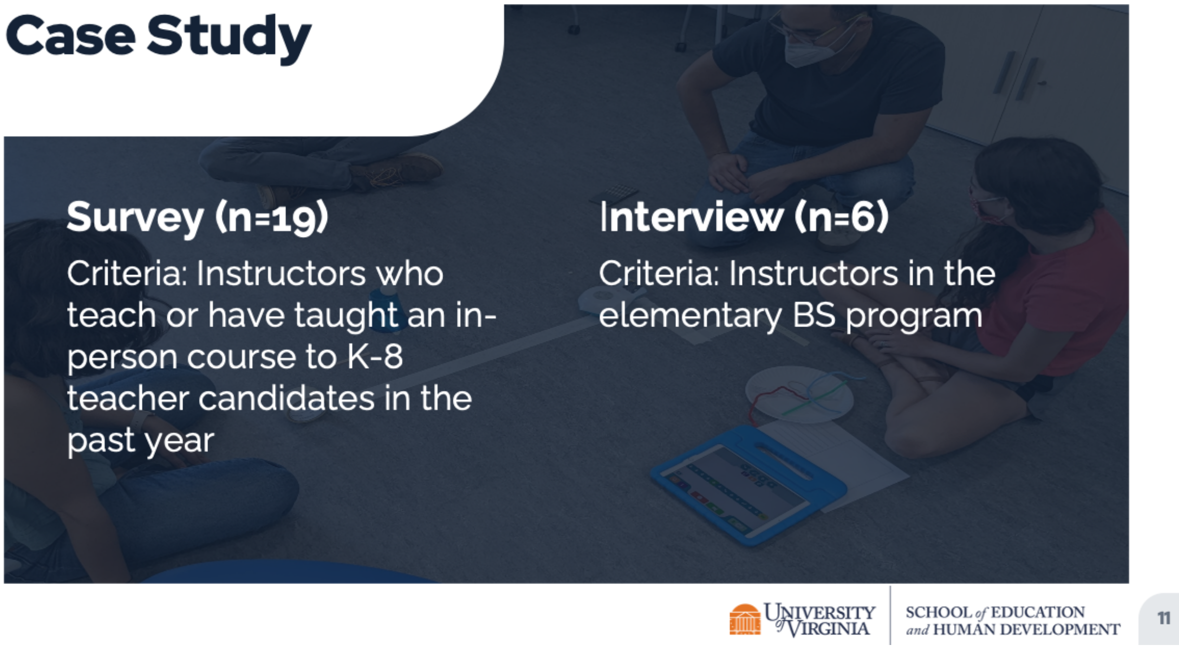


Speaker notes: The problem of practice for my Capstone project was situated in this teacher preparation program where the state department of education expects the CS standards to be integrated into K-8 classrooms (Board of Education Commonwealth of Virginia, 2017) and where 77% of the public school districts plan to adopt the CS standards through integration in K-8. Currently, there is a gap between these expectations and state regulations which do not mention CS education in K-8 and the preparation of K-8 pre-service students to integrate CS into their teaching practice.



Speaker notes: I approached the idea of integrating CS in the K-8 TPP curriculum as an educational innovation. A product, idea, or practice is considered an innovation when it is perceived as something new by the individual or institution who is looking to adopt it. For my Capstone study, I adopted elements from two innovation-related theoretical frameworks into my conceptual framework.

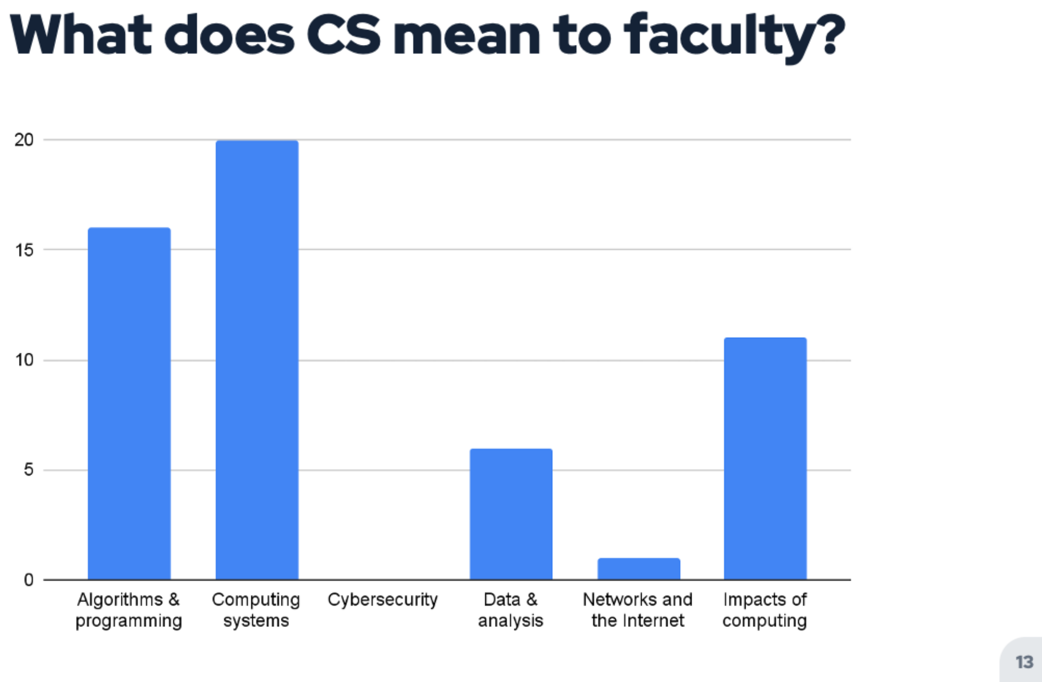
- One is the Stages of Concern (SoC) from the Concerns-based Adoption Model (CBAM) which was developed as a theoretical framework for facilitating the complex process of change in education. Studies that have employed the stages of concern confirm that there is generally a sequential nature to teacher concerns.
- Because of the interrelationship between teacher concerns and beliefs (Charalambous & Philippou, 2010), the stages of concern in my conceptual framework rest on the foundation of faculty beliefs about CS education.
- The other framework is from the Diffusion of Innovation theory which seeks to describe how innovations are taken up by a potential population of users so that appropriate interventions can be crafted (Dearing, 2009; Rogers, 2003; Robinson, 2009). I view the diffusion of innovation attributes of relative advantage, compatibility, simple and easy to use, trialability, and observable results as potential interventions to help faculty move across the stages of concern.
- Finally, perceived challenges identified by TPP faculty have the potential to hamper movement across the SoC and perceived opportunities have the potential to stimulate adoption of the innovation.



Speaker notes: The survey results were anonymous, but the participants were asked to provide their demographic information at the end of the survey. All K-8 subject areas were represented.

The interview participants have been at the TPP from 4-20 years. They teach subjects including early childhood education, special education, elementary methods, science, math, and language arts. Their roles at the TPP include being PhD students, program coordinators, associate professors, and research scientists.

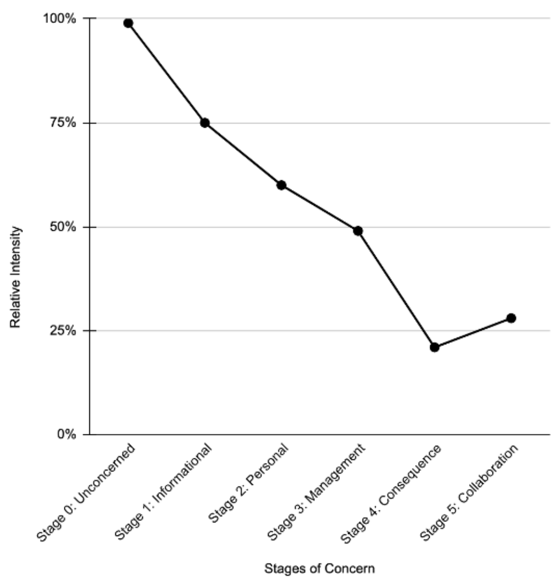
Speaker notes: The idea of integrating CS in K-8 is fundamentally a new way of doing things in K-12 schools, so I looked at potential pathways for adoption by TPP faculty through the lens of innovation.



Speaker notes: One of the first things I wanted to establish, both in the survey and interviews, was what CS education meant to the TPP faculty. I used the CS strands from the standards of learning to code their responses. I then looked at how many times each strand was represented in their responses. The faculty recognized some key components of CS especially related to the CS SOL strands of computing systems, algorithms & programming, and impacts of computing. However, they also held some common misconceptions like the focus of CS being on learning how to use technology (Gallup, 2020), conflating CS with coding (Yadav et al., 2014), and having the stereotype that age impacts CS ability (Broady et al., 2008).

Data from the interviews show a lack of awareness of CS SOLs and their integration to be integrated in K-8. However, faculty understood the importance of CS through the lens of societal impact of technology and generally believed it was important for all K-8 students, all K-8 teacher candidates, and themselves to learn some level of CS.

Stages of concern faculty profile



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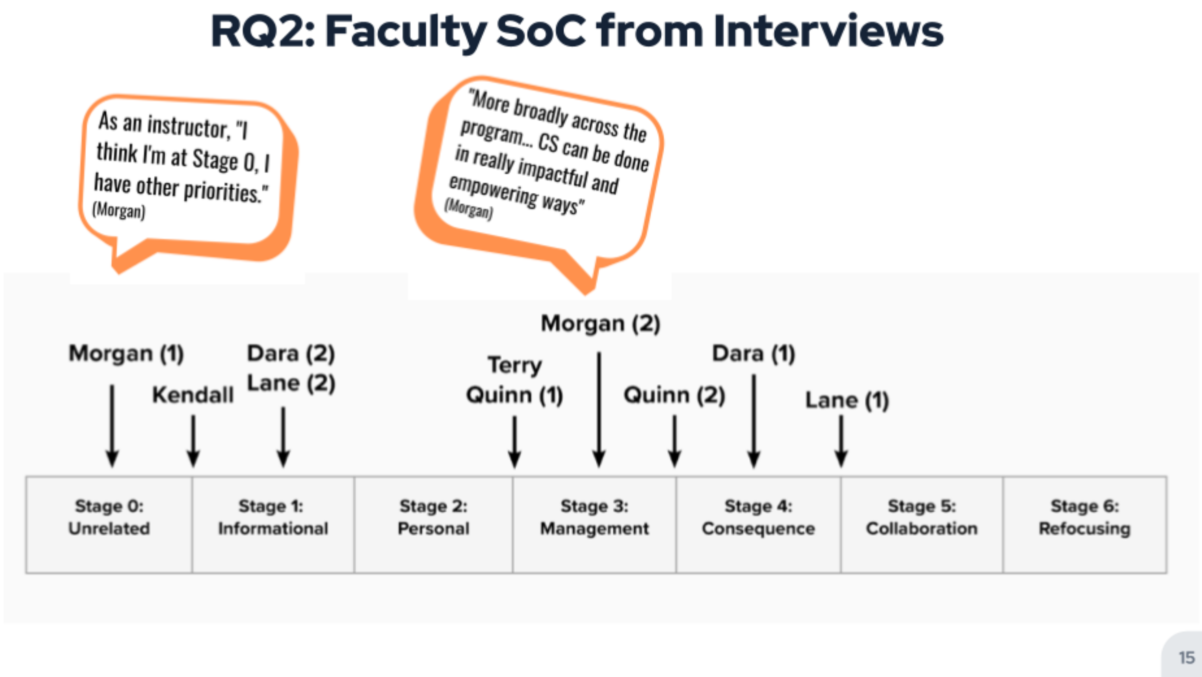
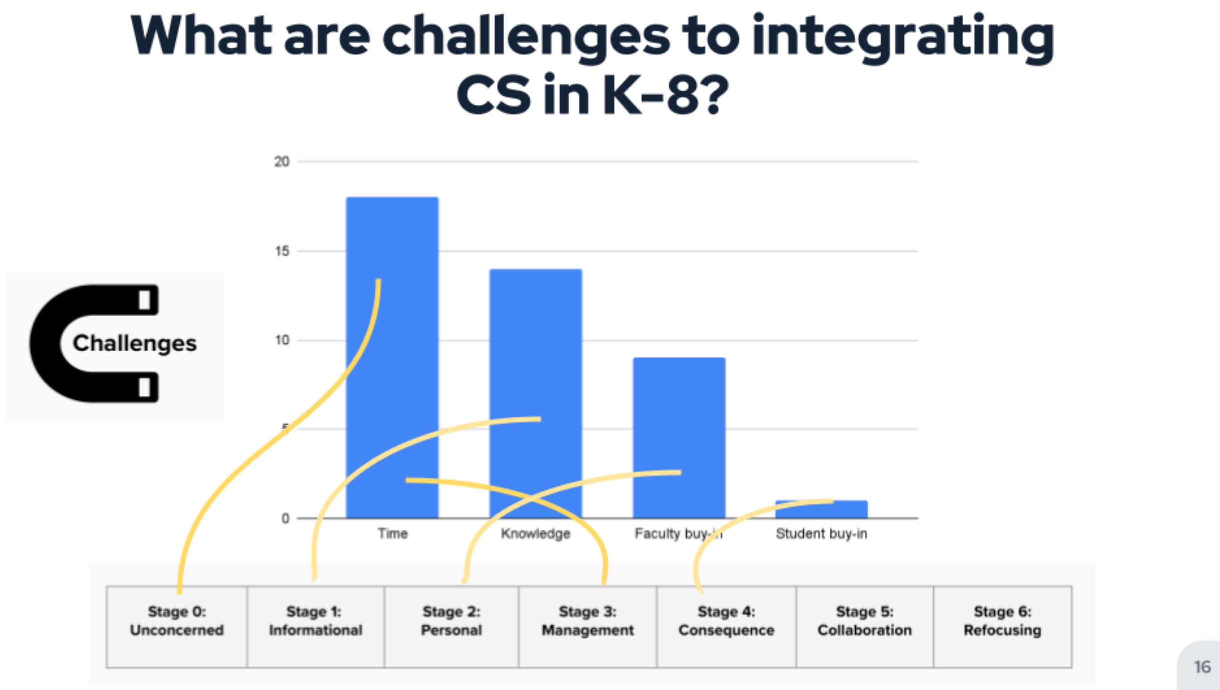
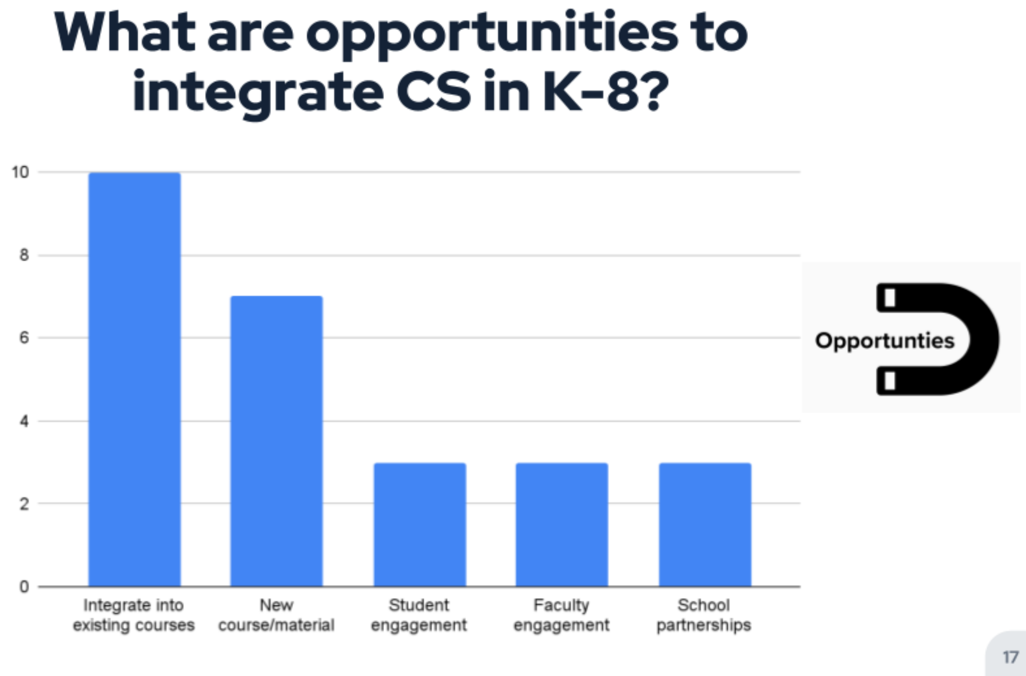
Speaker notes: The SoC Faculty Profile is typical of those who are not familiar or have no previous experience with the innovation and are open to learning from others through collaboration. This openness to collaborate was also reflected in the interviews. Other priorities and limited knowledge of CS were rated as the highest concern statements.



Speaker notes: During the interview, I shared the stages of concern with participants and and asked them where they thought most of their concerns about integrating CS in the K-8 TPP curriculum would fall. None of the interview participants landed on just one stage. One interesting thing that came up in the interview discussion is that faculty can feel differently about the stages depending on what “space” or “hat” they are wearing. For instance, as an instructor, Morgan identified with Stage 0, but thinking about the TPP overall, she sees the value in integrating CS and so she’s thinking about Stage 3 concerns.



Speaker notes: The challenges identified by the faculty in the survey and interviews fell into four categories: needing more time (18), needing more knowledge (14), faculty buy-in (9), and student buy-in (1). These challenges are reflected in the SoC Faculty Profile with needing more time reflected in Stage 0: Unconcerned and Stage 3: Management, needing more knowledge in Stage 1: Informational, faculty buy-in in Stage 2: Personal, and student buy-in in Stage 4: Consequence.



Speaker notes: The opportunities identified by the faculty in the survey and interviews fell into five categories including: Integrating CS into existing courses (10), creating new courses and/or materials for CS education (7), CS education as a way to increase student engagement (3), CS education as a way to increase faculty engagement (3), and school partnerships (3).

Attributes that would best stimulate adoption

1. Compatibility
2. Observable Results, Relative Advantage and Simple and Easy to Use
3. Trialability

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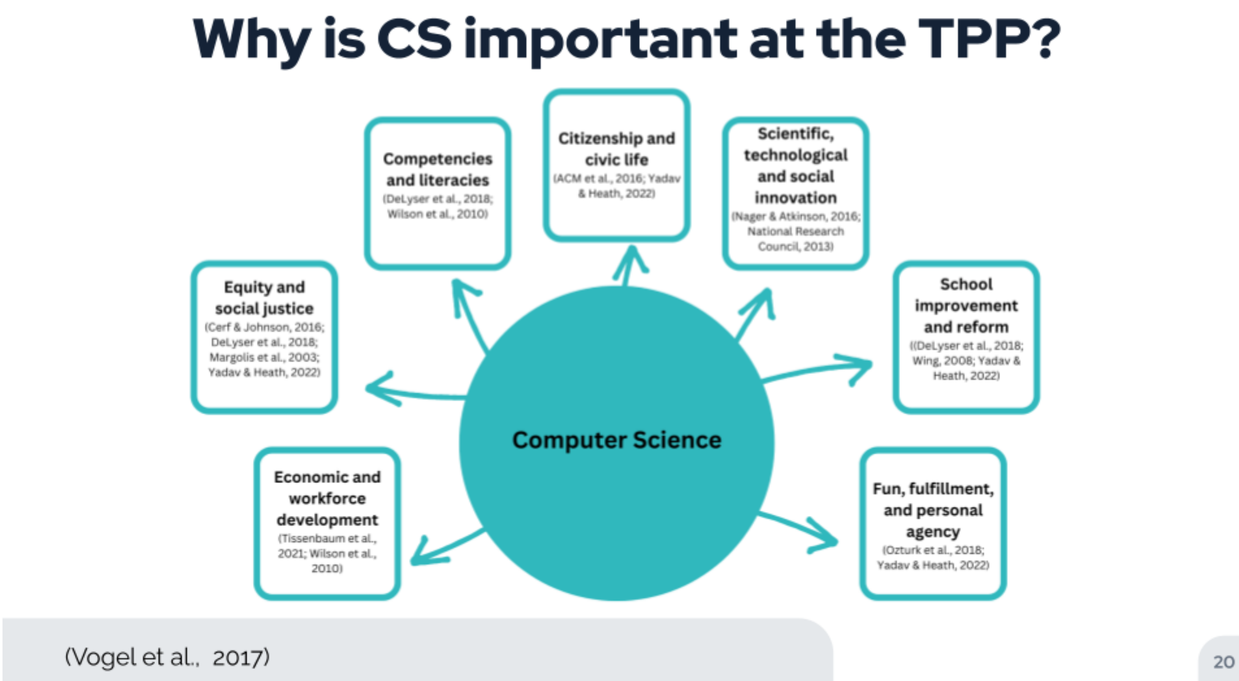
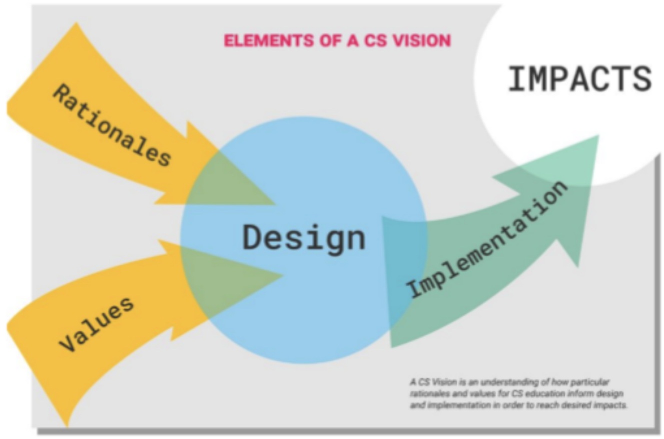
Speaker notes: From the interviews, Compatibility was ranked as the most important DOI attribute when considering the adoption of an innovation. Decisions around integrating CS into existing courses or creating new coursework will need to take current values and practices at the TPP into account. Compatibility could also be important for the TPP to be in synch with their school partners. Observable Results, Relative Advantage and Simple and Easy to Use were tied for second rank. Observable Results could impact student and faculty engagement as results from early adoption can encourage wider adoption. Because the SoC Faculty Profile is typical of inexperienced or nonusers of the innovation, consideration needs to be given to where Observable Results can be found. Simple and Easy to Use and Relative Advantage both also play an important role in faculty and student engagement.

Speaker notes: The findings from this case study suggest that there are a variety of potential interventions that could help foster the adoption of integrating CS in the K-8 TPP curriculum to support their teacher candidates.



Speaker notes: The first thing the TPP should establish is why it is important to integrate CS in the K-8 TPP curriculum. TPP faculty have already identified the societal impact of technology as an important reason, but this is balanced against the challenges they identified like needing more time and knowledge. Some faculty members identified opportunities to integrate CS into existing methods courses. Other faculty members identified the opportunity to create a new STEM course that focuses on integration across multiple subjects, where multiple faculty collaborate across disciplines to bring the course to life. Another recommendation was to create a CS-specific course.

CS Visions Toolkit



(Santos, et al., 2019)

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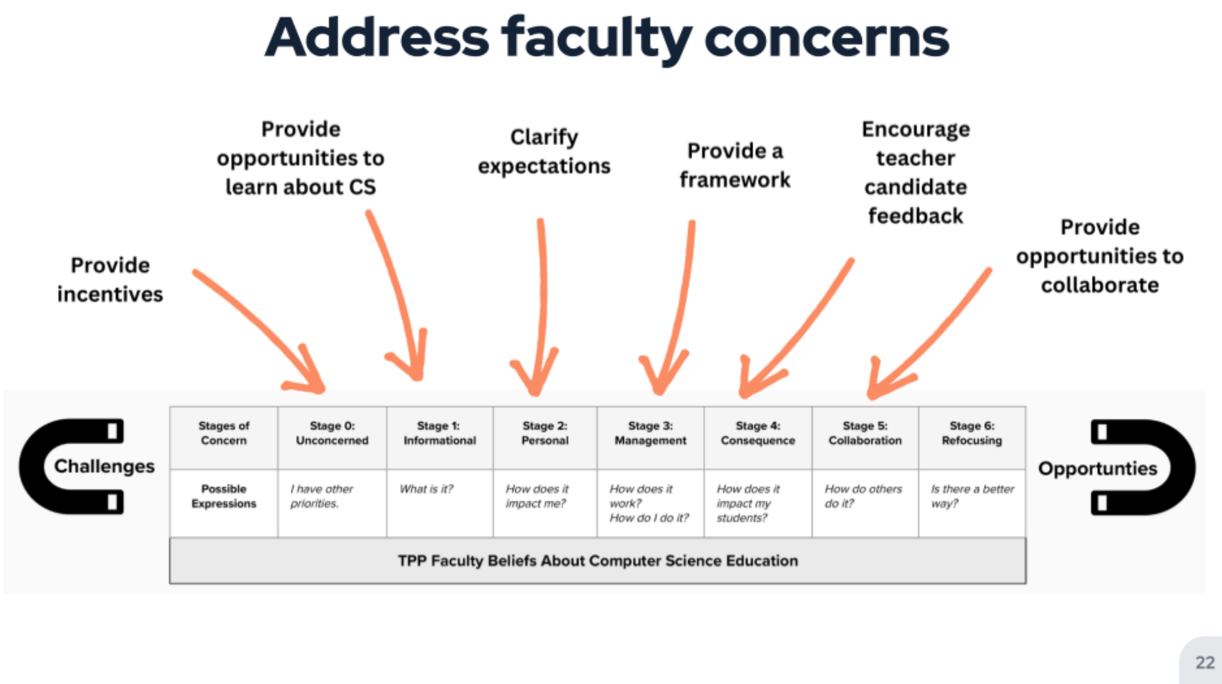
Speaker notes: The TPP should help faculty establish why it is important for them to integrate CS in the K-8 TPP curriculum by facilitating a discernment. One place to start is the CS Visions Toolkit developed by CSforAll that includes an interactive activity for fostering reflection, debate, and discussion about the purposes of CS education with the mission of helping educators make informed decisions about what kind of CS learning experiences they want to facilitate and support. Going through the process of answering the question of why integrating CS in the K-8 curriculum is important to the TPP also addresses the DOI attribute of Compatibility and ensuring the way the innovation is envisioned aligns with current values and practices at the TPP.



Speaker notes:
My conceptual framework incorporates the SoC from the CBAM. Addressing faculty concerns towards integrating CS in the K-8 TPP curriculum is important to help them move across the different stages of concerns towards implementation (Charalambous & Philippou, 2010; Hall & Hord, 2015). With the introduction of an innovation, teachers typically express intense concerns related to the Informational and Personal stages (Van den Berg & Ros, 1999) and these lower stages of concern need to be addressed before resolving higher stage concerns (George et al., 2006). The bulk of TPP faculty concerns were revealed to be at Stage 0: Unconcerned and Stage 1: Informational, so addressing these concerns should be the top priority, but the TPP should also plan for the interventions needed at later stages:

- Stage 0 Interventions - Other priorities are preventing faculty from engaging with CS education, so the TPP needs to raise awareness about the importance of CS education and provide incentives to encourage adoption into the K-8 TPP curriculum.
- Stage 1 Interventions - Faculty feel they have very limited knowledge of CS education, so the TPP needs to provide opportunities and safe spaces for learning more about it. Interventions at this stage should also focus on the DOI attribute of Simple and Easy to Use. One way to do this is to provide support for faculty in the form of a CS knowledgeable facilitator and coach (Atkins & Vasu, 2000).
- Stage 2 Interventions - Faculty need to understand exactly what the expectations are with regard to integrating CS in the K-8 TPP curriculum. The TPP needs to work with faculty to foster a sense of ownership around the innovation. Interventions at this stage should also focus on DOI attributes of Compatibility and Relative Advantage related to the innovation.
- Stage 3 Interventions - The TPP needs to take a system level approach to addressing the innovation and provide a framework for implementation across the K-8 TPP curriculum (Taylor et al., 2018). Interventions at this stage should also focus on the DOI attribute of

Observable Results. One way to do this is to connect TPP faculty with in-service K-8 teachers who have experience integrating CS into their curriculum.

- Stage 4 Interventions - The TPP should encourage teacher candidates to provide input into and feedback about the innovation adoption. Interventions at this stage can focus on the DOI attribute of Trialability.
- Stage 5 Interventions - The TPP needs to provide opportunities for faculty to collaborate on implementing the innovation.

Short-term plan

Preliminary steps:

- Provide low stakes opportunities to start learning CS
- Emphasize expectations around CS integration in K-8 from VDOE
- Highlight current RPP and other grant work and opportunities for faculty to get involved
- Identify early adopters
- Review syllabi and other curricular materials

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Speaker notes: While the discernment process is happening, there are steps that can be taken now to begin addressing faculty beliefs and self-efficacy towards CS:

- Provide informal experiential learning experiences to introduce CS concepts in a low stakes and safe environment (Rich et al., 2021). A research lab at the TPP already offers informal experiential learning for pre- and in-service teachers and could craft specific learning opportunities for the TPP faculty based on findings from this study.
- Highlight the expectations around CS integration in K-8 from the VDOE.
- Highlight current RPP and other grant work with local school districts to emphasize the importance of CS education to school partners.
- Identify early adopters who can be champions and share their experience and enthusiasm.
- Review syllabi and other curricular materials to find areas where integrating CS does not take away from but enhances subject knowledge.

Long-term plan

Create a long-term phased approach for formal integration:

- Start with the K-8 courses in the in-person BS program.
- Build on existing PD models for in-service teachers.
- Consider and outline a phased approach to adoption of the innovation.

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Speaker notes: Once expectations are set around the integration of CS in the K-8 TPP curriculum, then the TPP will need to offer more formal, in-depth PD for faculty. This could include reaching out to St. Scholastica to learn from their experience and establish a pilot program. PD opportunities same lab has designed more in-depth PD to help K-8 teachers create equitable CS experiences and this PD could be customized for TPP faculty and delivered in person or online. Another option is to encourage a cohort of TPP faculty to join a new online course being launched by the VDOE in June that is all about helping K-8 teachers learn about integrating CS into a variety of subject areas.

Lead by example

- Create a CS K-8 pathway for pre-service teachers
- Collaborate with partners: CS department, current RPPs, and Global Center for Equitable CS Education
- Advocate with VDOE to adopt a K-8 CS pathway
- Share research

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Speaker notes: There is a mismatch where on the one hand current state-approved regulations for primary, elementary, and middle education that do not mention CS education and on the other hand, the state department of education expectation that CS standards will be integrated in K-8. In addition, the only CS endorsement pathway for K-12 teachers is for 6-12 which requires advanced content knowledge of CS but does not address the content knowledge and pedagogical practices needed by K-8 teachers integrating CS into their classrooms (Rosato et al., 2022; Shea et al., 2020). Working in collaboration with the CS department at the University, current RPPs working on PD for in-service K-8 teachers, and the recently launched global center for equitable CS education, the TPP can take the lead in developing a CS pathway for K-8 pre-service teachers that builds on the tenets from Yadav et al. (2021), to provide education faculty with meaningful PD and school connections. Research from this work can be published so others can learn from the successes and challenges of integrating CS in the K-8 curriculum at this TPP.

Questions