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Survey Development for Increasing Integration of Computer Science Principles and Pedagogy into Core Mathematics Instruction

Plan B Project

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By

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Abstract

The urgent need to provide all Wyoming students with quality and comprehensive computer science (CS) instruction is both a matter of compliance and equity. Despite this urgency, a practical plan for systematic and effective implementation has been lacking. This research aimed to address this gap by investigating current practices, barriers, and supports necessary for integrating CS into core mathematics instruction, leveraging the natural overlap between these disciplines.

A survey instrument was developed and piloted to gather actionable data from teachers across Wyoming. The survey aims to measure (a) current practices of integrating CS principles into core mathematics instruction, (b) primary constraints preventing such integration, and (c) perceived supports needed to enhance integration efforts. The scope of this paper encompasses the research, design, and refinement of the survey instrument. Once deployed, the results of the instrument will inform and guide future decisions regarding teacher development and the integration of CS into core curricular instruction, ultimately supporting equitable and effective implementation throughout the state.

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Chapter One

Introduction

The room was filled with middle school mathematics students paired off and engaged in a highly competitive Rock-Paper-Scissors tournament. Between each successive game, students stopped to select one of the buttons on their Micro Bit scoreboards to track their scores accompanied by the usual middle-school smack talk that accompanies such high-stakes play. Prior to the competition, the teacher and students worked together using Make Code block code to program their Micro Bits to store the number of wins for each student, as well as the number of ties. The following is a summary of the debrief that followed the competition.

Teacher: So, who can remind me where each of your scores is stored in our code?

Student: The scores go in the three variable blocks we used. We made Player A, Player B, and Ties.

Teacher: So, what are the variable blocks doing with the score? Tell me more.

Student: They just hold the score in there until we add another point to it or ask what the score is.

Teacher: Oh... so the score will change?

Student: Of course. That is the point of having a score keeper.

Teacher: Right. So, the variable block holds a value that is going to change? It acts like a container that allows us to switch out one score for a new one?

Student: Right.

Teacher: How does that compare to using variables in an expression or equation in math?

Student: Well, I guess variables are like a container that can hold different numbers at different times too. So, we can just use the variable instead of having to go back and rewrite the whole thing each time.

Teacher: Exactly! Just like we could write one statement in our code. We can use a single expression or equation to represent lots of different situations by using a variable. When a value can change, like when we have a table of values, we can write an equation using a variable that will be the container to hold each one of those values at different times.

In the math lesson above, block coding Micro Bit devices to serve as simple scorekeepers was used to both apply and solidify the conceptual understanding of variables used in variable equations in my sixth-grade math classroom. The lesson not only deepened student understanding of an often-difficult abstract concept for students, but it met several of the adopted Wyoming computer science standards (WYCPS, 2021) in the process.

Countries across the globe are adopting new legislation codifying computer science standards to be taught from kindergarten through secondary school in response to the rising Fourth Industrial Revolution[1] impacting all areas of life (McKnight et al., 2016). State Departments of Education, school districts, and educational professionals are being charged to embrace this rapidly evolving technological landscape to better prepare students for the society in which they will live and work (Alismail & McGuire, 2015; Boothe & Clark, 2014; Fact Sheet, 2016; Mouza et al., 2022; Naidoo, 2021).

Additionally, a growing body of research provides evidence of the benefits of using overlapping concepts shared between computer science and mathematics to increase student engagement and foster deeper conceptual understanding in mathematics (Casler-Failing, 2018;

Casler-Failing, 2022). These concepts integrate the use of robotics, coding, and collaborative problem solving in mathematical contexts (Casler-Failing, 2018; Forsstrom, 2020; Rico-Bautista, 2019). While adoption of computer science pedagogy and principles is being pushed by recent legislation, requiring that all mandated computer science standards be taught to all Wyoming students by the 2022-23 school year (WYCPS, 2021), myriad factors impact the reality of this implementation into core mathematics classrooms.

In my own practice, a glimpse of which you read above, I have seen the benefits of using physical computing with students. Simply defined, physical computing is anything combining hardware and software to create an “interactive system that senses and responds to the real world” (Hodges et al., 2020, p. 20). It has increased student engagement and deepened understanding of mathematics for my students of all ability levels. This pedagogical strategy immerses students in the application of core mathematical concepts in real-world problems, requiring them to use problem solving and critical thinking skills, and engaging them in productive struggle (Casler-Failing, 2018; Casler-Failing, 2022). I have discussed the merits of these strategies with fellow mathematics teachers but have consistently encountered resistance from them when encouraging their implementation in their own classrooms. As a teacher certified in both mathematics and computer science, I understand that my perspective is different than that of most of my non-computer science colleagues. However, the rapidly evolving technological landscape, the requirements of new legislation, and the reality of student benefits demand that a practical solution be forged for increasing the accessibility of these pedagogical practices for non-computer science teachers.

The Problem

As both a teacher and a professional development specialist, I have had many interactions with administrators at the state and district level and with teachers across the region. In those interactions, it has become apparent that current practice of Wyoming teachers, except for that of a small group of innovators and early adopters (Rogers, 1962, 2003), does not routinely integrate computer science principles into core mathematics instruction. Precise current data are not available to determine the extent to which this is true, illustrating part of the need for this research. If the empirical evidence and most recent sampling (Code.org et al., 2024) is true, it raises several important questions as to the reasons why teachers are reluctant to integrate computer science principles into their current curricula. Are teachers ill-equipped to employ the use of computer science concepts as a strategy for teaching mathematics? Do in-service teachers need to be informed about the efficacy of these emerging pedagogical practices for all students? Is a lack of training, lack of resources, lack of confidence, lack of local administrative support, or the often-overwhelming competing interests of new curriculum, new district mandates, and new legislation vying for teachers' precious time preventing teachers from integrating computer science principles into core instruction? Is it characteristics of the teachers themselves? (Ronan et al., 2023) Whatever the reason, if there is either an unwillingness or inability to marry knowledge of subject area content and good pedagogical practices with contextually appropriate technological pedagogy (Mishra & Koehler, 2006), then Wyoming students are not reaping the benefits of the integration of these cross-curricular connections and overlapping principles (Boothe & Clark, 2014; Alismail & McGuire, 2015; Gadanidis, 2015; 2017). This project seeks to fill the gap in the research to determine what is both constraining and necessary for Wyoming teachers to implement research-based, effective strategies that utilize computer science principles to enhance conceptual understanding in mathematics.

Purpose and Research Questions

At its core, this research is born out of a desire to increase the integration of computer science principles and pedagogy in core mathematics instruction in the state of Wyoming, increasing student exposure to computer science principles and improving mathematics outcomes. To meet the aforementioned goals, this project seeks to design and pilot test an instrument that measures (a) current integration practices of computer science principles into core instruction by Wyoming teachers, (b) the primary constraints preventing Wyoming teachers from integrating computer science principles into their core mathematics pedagogical practices, and (c) the perceived supports teachers need to increase the integration of computer science principles into their core mathematics pedagogical practices.

The need to provide all students with quality and complete computer science instruction is an urgent issue of both compliance and equity for Wyoming schools. A practical plan for systematic, effective implementation is late in coming and research is needed to determine current practices, barriers and supports needed to move forward. This research develops an instrument to gather actionable teacher data from the state of Wyoming to inform next steps for efficacious support and to design professional development for Wyoming teachers enabling them to integrate CS standards and principles into their core instruction.

Definitions:

Computer Science (CS) Principles

Computer science principles refer to “the big ideas of computer science” (Mouza et al., 2022) or the foundational concepts and practices in the field of computer science including programming, computational thinking, data analysis, impacts of computing, internet, and networking.

Computer Science (CS) Pedagogies

Computer science pedagogies are methods and practices for teaching computer science principles or that use computer science principles to teach other content objectives.

High-Stakes Testing

High-stakes testing refers to assessment whose results carry a high impact or outcome. For example, state testing, assessments to determine qualification for graduation, or other assessments attached to funding or some other significant desired outcome.

Pedagogical Practice

Pedagogical practice encompasses the strategies, methods, and practices used to teach.

Physical Computing

Physical computing is the use of computing devices that interact with their environment using a range of sensors and inputs. Some examples of physical computing devices referenced by the work in this paper include Vernier probes, Micro Bits, LEGO Robots, and Spheros.

Productive Struggle

Productive struggle can be defined as “purposefully reacting to an unclear challenge so that progress is made, or learning is advanced” (San Giovanni et al., 2020, p. 17). It situates students in a place of dissonance, requiring them to build on prior understanding and employ problem solving and critical thinking skills to accomplish a desired outcome.

Pedagogical Content Knowledge (PCK)

This concept was developed by Shulman (1986) and built on by Mishra and Koehler (2006). Shulman described it as “the ways of representing and formulating the subject that make it comprehensible to others” (1986, p. 9). It also includes the understanding of what learners already know and understand about a subject, what makes something easy or difficult to learn, common misconceptions and strategies for addressing them, and multiple different ways of approaching content to develop understanding in the learner.

Technological Knowledge (TK)

Technological Knowledge is the understanding of both hardware and software and their uses. It includes knowledge of the advantages, disadvantages, and contexts for use of different digital tools (Vivian & Falkner, 2019).

Technological Pedagogical and Content Knowledge (TPACK)

TPACK is an acronym developed by Mishra and Koehler (2006). It is the conglomeration of several other acronyms including TK (technological knowledge), PK (pedagogical knowledge) and CK (content knowledge). TPACK is technological pedagogical and content knowledge. It describes the knowledge a teacher possesses as these three types of knowledge intersect. It provides a framework for teachers’ “strategic thinking of when, where, and how to guide students’ learning of the content, such as mathematics with technologies” (Niess & Roschelle, 2018, p. 46).

Technological Content Knowledge (TCK)

“Knowledge of how to use technology within a specific content area” (Orrill & Polly, 2016).

Technological Pedagogical Knowledge (TPK)

TPK "refers to an understanding of how technology can constrain and afford specific pedagogical practice;" it describes the knowledge of strategies and practices for teaching and learning with technology (Vivian & Falkner, 2019, (p. 148).

Chapter 2 Literature Review

Theoretical Framework

I approached my research through the lens of the Diffusion of Innovation Theory Framework (1962, 2003) and the TPACK Framework (2006). The systematic adoption of a new approach to teaching represents a significant change. Regardless of the merit or impetus for change, it is difficult. At its core, this research endeavored the pursuit of understanding how to effect change in the state of Wyoming to increase the implementation of instruction that integrates computer science principles. Roger's (1962, 2003) Diffusion of Innovation Theory has been widely used over the past fifty years to study change and how people respond to the adoption of new ideas. It provided a framework for implementing change, identifying the stages of the innovation-decision process, and delineating the characteristics of distinct types of adopters of change encountered (Rogers, 1962, 2003). I used this framework to help categorize teachers according to their openness for the adoption of new teaching strategies and paradigms and to aid my understanding of how to effectively promote and support the integration of computer science principles and pedagogy into core instruction.

For the purposes of this research, I organized teachers to be surveyed into five categories Rogers described (1962, 2003). These categories classified teachers according to my interpretation of Rogers' theory in the context of mathematics instruction and may be used to interpret results of the instrument developed in this research. Information sought by the instrument developed here will come from teachers identified in categories two through four, understanding that innovators (category one) are eager to adopt and laggards (category five) resist even the best laid plans. Teachers in categories two through four are the teachers most in need of attention to adopt the new desired CS integration practices. Teachers were identified according to these categories in the survey using self-identification and inferences based on questions designed for this purpose. The teacher categories created are outlined below (Adapted from Rogers, 1962, 2003).

1. Innovators: Teachers who seek out and are eager to try new methods, including the integration of computer science principles and pedagogies into their core instructional practice. These teachers will develop and experiment with new methods without external pressure or direction.

2. Early adopters: Influential teachers who are open to changes in their mathematics instructional practice and can influence others to do the same. These teachers are leaders in the adoption of newly recommended practices and are willing to take risks, seeking to grow and improve outcomes.

3. Early Majority: Teachers who adopt new practices after seeing their benefits, adopting slightly earlier than the average. This category of teachers comprises “approximately one-third of the population” (Rogers, 2003, p. 284). These teachers are well-connected and interactive among their colleagues but seldom hold positions of leadership. Their buy-in to the adoption of change is critical as they build momentum for the change on a wider scale, normalizing it for later adopters who require peer pressure and demonstrated systemic change before adopting themselves.

4. Late Majority: More skeptical teachers who need convincing evidence and external pressure before considering change of any kind. These teachers require more time, pressure, and support to initiate change, but they are willing when these needs are met. This category, like the early majority, comprises approximately one third of the population of teachers and must be convinced for widespread adoption to occur.

5. Laggards: These teachers are highly resistant to change regardless of evidence and rely heavily on traditional methods or what has worked in the past. These teachers are last to adopt and generally do so only by compulsion if at all.

The instrument questions developed in this research focused on identifying and meeting the needs of adopter categories two through four outlined above. Additionally, questions were designed to inform Rogers' knowledge stage of innovation, specifically "how-to-knowledge" and "principles-knowledge" (Rogers, 2003, p. 173). In other words, what did teachers need to know to adopt the use of computer science principles and pedagogies into their practice.

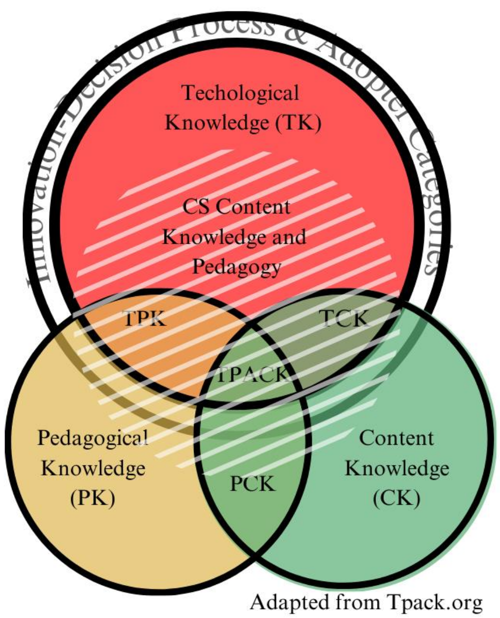
The second stage of Rogers' innovation-decision making process persuasion (1962, 2003), focused on attitudes toward a particular change which was another important part of the instrument development, determining initial affective disposition toward integration of computer science principles and pedagogy. These two stages of the theoretical framework, as well as an evaluation of the current social system—school or district's culture, policies, and support systems-- were significant in the survey design and are discussed further in the methodology section of this paper.

The integration of computer science principles and pedagogies by non-computer science teachers requires the acquisition of new knowledge about technological pedagogy and content by teachers. "Quality teaching requires developing a nuanced understanding of the complex relationships between technology, content, and pedagogy, and using this understanding to develop appropriate, context-specific strategies and representations" (Mishra & Koehler, 2006, p. 1029). Mishra and Koehler's Technological Pedagogical Content Knowledge (TPACK) Framework (2006) was developed as an extension of the categories outlined in Shulman's work "Those Who Understand: Knowledge Growth in Teaching" (1986). This expanded paradigm served as the context for discussing current levels and deficits in technological knowledge (TK) and technological pedagogical knowledge (TPK) of Wyoming teachers.

The TPACK framework has been extensively researched as a model for delineating the complex knowledge needed by teachers in technology-rich environments. Harris et al. (2009) emphasized that TPACK represents the synthesis of technical and pedagogical expertise required for effective technology integration, contrasted with treating these as separate knowledge domains. For mathematics specifically, Niess (2011) demonstrated that teachers progressed through distinct developmental stages when acquiring TPACK, moving from recognizing the potential of technology to transforming their practice through its integration. This progression is particularly relevant for Wyoming teachers adapting to newly codified computer science integration requirements. Figure 1 represents the combination of frameworks used as the lens through which this research was conducted.

Figure 1

Adapted TPACK and Roger's Diffusion of Innovation Theory Lens



Note: A large-scale version is available in Appendix D.

Chai et al. (2013) found that targeted professional development focusing on the specific intersections of technology, pedagogy, and content knowledge resulted in significant improvements in teachers' abilities to design technology-enhanced lessons. Furthermore, TPACK development is highly contextual, influenced by subject matter, grade level, and available resources. These factors vary widely across Wyoming schools and have an impact on teacher's self-efficacy in technology integration in their classrooms (Williams et al., 2023). A five-year longitudinal study by Archambault and Crippen (2009) revealed that teachers generally rated their content and pedagogical knowledge higher than their technological knowledge and the integrated TPACK components, suggesting this to be a potential area to address in future professional development initiatives in Wyoming.

Historical and Current Context

Legislative Impetus

In 2016, President Barrack Obama issued his *Computer Science for All* initiative in his State of the Union address. The goal of the initiative was to provide computer science education to all students, declaring computer science literacy to be a new "basic skill" that all students must be taught (Fact sheet, 2016, p. 1). Funding for programs and partnerships with industry leaders propelled computer science into the spotlight across the nation as state departments of education and districts had to determine how their states were going to meet the challenge laid out by the White House.

The skills needed for 21st century workers were dramatically different than those of the 20th century worker, so many nations began radical reforms of their standards, curricula, and assessment to meet the changing needs of students (Tican & Deniz, 2019). The 21st century skillset necessary for students to be successful in the marketplace had not been universally defined but references to these essential skills often included creativity, critical thinking, problem solving, oral and written communication, collaboration, and information and technology literacy (Alismail & McGuire, 2015; Niess & Roschelle, 2018; Tican & Deniz, 2019; Wagner, 2008). Organizations like the International Society for Technology in Education (ISTE) compiled sets of standards for both teachers and students to guide instruction for developing 21st century learners to be able to learn, teach, and lead with technology. The ISTE frameworks have been adopted by many countries around the world to better prepare students for the needs of the modern world and workplace (ISTE,n.d.-a; ISTE, n.d.-b; ISTE, n.d.-c).

In the 2001 case of the *State, et. al., v. Campbell County School District, et al.*, the Wyoming Supreme Court ruled, “We have reached the point where we can no longer allow the youth of Wyoming to be denied their constitutional right to an education ‘appropriate for our times’.” This ruling, in conjunction with the 2020 Computer Science Wyoming Content and Performance Standards (WYCPS, 2021) document mandating new computer science standards be taught in every school by the 2022-2023 school year, created a critical mandate for Wyoming schools. The WYCPS stated, “Computing is fundamental to understanding and participating in an increasingly technological society, and it is essential for every Wyoming student to learn as part of a modern education” (2021, page 2). These documents required time to be allocated to teach and assess the new suite of computer science standards to all students by grade band with multiple opportunities being given for students to demonstrate proficiency for all students in every school. According to the 2024 State of CS Education Report put out by an alliance between Code.org, Computer Science Teaching Association (CSTA) and Expanding Computer Science Pathways (ECEP), this was particularly challenging for small and rural schools.

Challenges of Implementation

Beyond the ever-critical issue of time was the need for teachers equipped to deliver the content to all students (Basu et al., 2021). Many teachers did not possess the knowledge, skills, or experience to incorporate computer science or integrate technology into their classrooms (Mouza et al, 2022; Sahin, 2011). One measure taken by the state of Wyoming to remedy the shortfall of certified computer science teachers was the creation of a micro-credentialing program funded by the Innovation and Modernization Grant, a Perkins V program, as part of the Boot Up Wyoming initiative intended to increase the number of certified computer science teachers in the state (Edge, 2019). This program yielded 24 new elementary teachers eligible for computer science certification and sixteen secondary teachers who completed the micro credentials required for certification. Only nine of those sixteen secondary teachers passed the required Praxis exam to make them eligible for computer science certification as of December 2024 (S. Priest, personal communication, December 2, 2024).

The State of CS Education Report also cited increasing access to computer science being reported by Wyoming schools (Code.org et al., 2024), but it further demonstrated that the legislative mandate of 2022-23 as a deadline for all Wyoming students to be receiving computer science education was not being met as of the publication of the 2024 report.

As Warner et al. (2021) discussed in the article, "Quantifying Disparities in Computing Education: Access, Participation, and Intersectionality," issues of equity for students are not merely answered with access to elective computer science courses, but with participation in them. A "virtual segregation" has developed putting students at a disadvantage relative to their peers by not ensuring these essential skills be learned (Ronan et al., 2023). Therefore, work must be done to ensure broader participation of all students in computer science courses. In the 2023-24 school year, the 2024 State of Computer Science Education (Code.org et al., 2024) reported Wyoming to have 74% of high school students with access to foundational computer science curriculum courses but only 8.4% of students participated in them. Additionally, only 38% of reporting elementary schools and 60% of reporting middle schools offered computer science. Statistics may have been higher since not all schools reported, but evidence supported that not all Wyoming schools provided access to foundational computer science instruction. Comprehensive participation of students in computer science will either require computer science principles to be taught in core content courses in which all students participate or implementation of required computer science courses for all students, elementary through secondary. Scheduling, sufficient funding and access to qualified certified CS teachers are a few of the barriers schools faced for the latter option (Code.org et al., 2024).

Benefits of Integration of CS Principles and Pedagogy

Legislative pressures have had implications and consequences demanding attention, but legislators are not professional educators. Top-down mandates alone, whether legislative or administrative, have done little to impact the hearts and minds of teachers in the classroom (Burner, 2018). Teachers need “motivation and justification” to change (Burner, 2018, p. 130) They must be convinced of the educational benefit to their students (*principle-knowledge*) and the practical feasibility of teaching computer science in their core instruction (*how-to-knowledge*) before lasting change will even be considered (Koh et al., 2014; Rogers, 1962, 2003).

The integration of CS has provided transformative learning experiences that engage students in learning that was previously impossible (Boothe & Clark, 2014; Forsström & Afdal, 2020). Increased student interactivity fostered by using student-centered learning strategies and technology has increased student engagement and improved outcomes (Boothe & Clark, 2014;

Leow & Neo, 2014). Experiences like virtual field trips, problem-based learning, applied robotics, and collaboration beyond the walls of the classroom provided students with learning opportunities that engaged them in authentic tasks with meaningful, real-world applications of their learning (McKnight et al., 2016). Multiple studies using robotics for teaching different mathematics concepts have shown increased student engagement and deepened student learning resulting in better overall learning outcomes (Casler-Failing, 2018). Forsström and Afdal's study (2020) supported that these types of learning experiences were highly engaging and opportunities for what they called "expansive learning" (p.36); however, they determined some qualifications were necessary for the use of robotics for formal mathematics instruction.

Due to the large degree of student decision-making involved in these types of learning experiences, Forsström and Afdal (2020) stipulated that these activities must be designed in such a way as to necessitate the formal math instruction for students to achieve their desired goals. They concluded that traditional teacher-led formal instructional methods would not work in this context but found students were highly motivated to receive direct instruction that served their needs. This resulted in students being much more likely to apply new learning to the task. Other studies supported this conclusion, arguing that the use of technology and integration of CS principles had the potential to transform learning roles for students to become constructors of their own learning, shifting traditional student and teacher roles (Alismail & McGuire, 2015; McKnight et al., 2016; Niess & Roschelle, 2018). Teachers became facilitators of active student learning rather than content specialists from whom all knowledge was disseminated and passively received (Boothe & Clark, 2014; McKnight et al., 2016).

Other benefits of integration of CS into core math instruction were discussed by Rico-Bautista et al. (2019), in their article about using robotics and collaborative work as a learning strategy to teach mathematics. They asserted that students who participated in collaborative robotics activities in mathematics showed increased motivation, including a more positive attitude toward mathematics in both students and students' parents. Their study, which demonstrated that student math scores increased, challenged the idea that the use of robotics to teach mathematics is taking away time from important content needed to perform well on high stakes testing. They used a control group to show the resulting development of cognitive and social skills improved mathematical problem solving, creativity, communication, and overall performance in addition to bringing math to life for students through its practical application in robotics. Casler-Failing's study (2018) had comparable results with students showing greater retention of the mathematical concepts longitudinally than students not involved in the study.

Studies like Rico-Bautista et al. (2019) and Casler-Failing (2018) help to build *principle-knowledge* for teachers, encouraging the adoption of new practices (Rogers, 1962, 2003). Current information is not available to determine the extent to which Wyoming teachers possess such knowledge. The pressures of high stakes testing and challenges to meet content standards can easily deter teachers from adopting these practices if an understanding of their benefits in successfully achieving their pre-existing goals is not clear (Koh et al., 2014).

Overlap Between Mathematics and Computer Science Concepts

Many areas of overlap between mathematics and computer science have been found to create entry points for teaching CS in core mathematics classrooms and understanding these is important to the development of teachers' *how-to-knowledge* (Rogers, 1962, 2003). Computer science concepts like sequencing, variables, inputs, outputs, and algorithms are closely tied to mathematics (Gadanidis, 2015; 2017). Gadanidis (2015) contended that that use of low-floor, high-ceiling software applications like Scratch and Logo created opportunities for younger learners to participate in combined mathematics and coding activities that helped them to access more abstract mathematical concepts at a younger age. This study focused on pairing math and coding using “complex and interesting math and coding concepts” to create learning experiences that ignited student interest and sneaked in mathematics like the storied Trojan Horse (p. 171). Computational thinking, modeling, and the creation of abstractions are other general areas of overlap for exploration pairing CS principles and mathematics instruction. A pedagogical approach that grafts these overlapping ideas has incredible potential for a synergistic relationship in the classroom both improving student outcomes in mathematics and providing more students with instruction in computer science standards (Gadanidis, 2017).

It is also important to note that integration of CS into mathematics instruction provides opportunity for collaborative problem solving and productive struggle, a practice known to engage students in deeper levels of mathematical thinking (Baker et al., 2020; Foulger et al., 2008). The ability for students to persevere through productive struggle in problem solving is an important skill in mathematical learning and increasing attention has been paid to this concept in pedagogical practices used in mathematics (San Giovanni et al., 2020) To achieve productive struggle a student must be challenged beyond their current understanding with problems that are neither “immediately apparent”, nor “beyond [their] mathematical reach” (Baker et al., 2020, p. 366) or zone of proximal development, ZPD (Vygotsky, 1978). Creating learning experiences with multiple access points for students of varying ability levels while offering a high ceiling for growth and depth of learning can be challenging. The incorporation of computer science principles and pedagogical practices like the use of physical computing or robotics provides just these types of opportunities. Researchers such as Gadanidas (2015, 2017) have attested to the benefits of CS principles for creating learning opportunities such as these. Through collaborative problem solving, experimentation, and exploration students constructed their own learning and the job of finding solutions was placed back on them (Alismail & McGuire, 2015; Boothe & Clark, 2014; Rico-Bautista et al., 2019).

Challenges and Potential Solutions

The Problem of Time

Any new instructional approach or paradigm requires time to learn and implement. Time must be afforded to teachers in a two-fold manner. Teachers need time to learn how to integrate computer science principles and pedagogies into their instruction, and time in the school day is required to deliver this type of instruction. In fact, lack of time was often the most cited reason for teacher resistance to change (Ronan et al., 2019; Van Bodegraven, 2015). Burner (2018) noted that many other countries did a much better job than the U.S. of integrating the time for tasks and training needed for effective educational change into teacher and teacher leaders' schedules. Such integration removed the expectation from teachers to independently find time somewhere else in their schedules for changes that may not be clear or even desired by them. Respecting teacher time and factoring it into plans for adopting new practices facilitated change (Burner, 2018).

Another consideration found to be important for sustaining change was creating time for and value of reflection by teachers on new practices (Burner, 2018). Burner's study argued that providing a mechanism and opportunity for feedback was important to address issues of concern, improve practice and demonstrate value of teachers on the front lines of educational change. Furthermore, it stated, "*Change agents* [must be] humble, not thinking or giving the impression that they know the *right* answers" (p. 130). By valuing the roles and feedback of all stakeholders, change was more likely to be embraced.

Teacher Attitudes about Computer Science

The intersection of teacher beliefs and attitudes about CS with pedagogical and content area competencies has been arguably significant to understanding the adoption of a proposed paradigm of integration (Ronan et al., 2023). Teacher attitudes not only impacted their own willingness to adopt change (Burner, 2018; Mishra & Koehler, 2006) but were closely tied to their students' attitudes toward computer science. The positive disposition toward computer science by teachers was believed to be an indicator of the same in their students (Ronan et al, 2023).

Teacher attitudes and beliefs were important in other ways as well. Teachers were more open to development of their technological pedagogical content knowledge (Mishra & Koehler, 2006) when they believed it helped them to meet their instructional goals (Koh et al., 2014). It was therefore important that teachers knew and understood how integration of computer science into mathematics instruction improved outcomes in mathematical conceptual understanding and practice. Therefore, developing teachers' *principle knowledge* (Mishra & Koehler, 2006) was necessarily included in plans for increasing integration of CS into core instructional practice.

Additionally, Dr. S.L. Casler-Failing (personal communication, October 10, 2024) shared insight for addressing negative dispositions and fear of integrating technology when training in-service teachers to use robotics with their math students. Casler-Failing stated that it was necessary to simply "get [teachers] to the table to try it" themselves. This issue of lacking teacher confidence also applied to new teachers from the *net generation* as many of these teachers were savvy with personal use of technology but not with its integration into the classroom (Roulston et al., 2019). Offering a supportive environment to struggle productively through the process of using computer science principles and pedagogy to teach students mathematics was key to building teacher confidence and developing positive teacher attitudes toward these practices (Casler-Failing, 2024).

According to Koh et al. (2014), there were two factors that commonly impacted teachers' TPACK confidence (Mishra & Koehler, 2006) and therefore had implications on teacher attitudes and integration of computer science principles into core instructional practices. The factors included years of teaching experience and grade band taught. Veteran teachers—teachers with more years of teaching experience— and teachers of elementary students were found to have the lowest TPACK confidence. It was not surprising that teachers who had more experience teaching in another way would have the least confidence in trying a novel approach. To address these factors, Koh argued that teachers first needed training in technological pedagogical knowledge (TPK) to help them understand how technology could be used to change teaching strategies (Mishra & Koehler, 2006). Once equipped with this foundational understanding, they would be able to combine it with their existing professional knowledge of content and pedagogy to begin to apply the entire TPACK framework to their core instruction lesson planning (Koh et al., 2014).

Administrative Support and Culture

Studies have suggested that one of the most significant factors impacting teacher willingness to adopt change is administrative support (Burner, 2018; McKnight et al., 2016). For example, teachers were resistant to change due to school-specific or district-specific directives that placed requirements on them for different and competing practices or pedagogies (Koh et al., 2014). Furthermore, an administration that frequently changed from one directive to another discouraged adoption of new practices by overloading teachers, encouraging them to simply wait out the current directive until the next was presented (Burner, 2018). Another study argued that for technology to make a difference in learning, administrative support was an essential component (McKnight et al., 2016). Moreover, teachers in the McKnight et al. (2016) study credited their successful implementation of technology integration into their classroom instruction and improved student outcomes to a focused but flexible leadership structure that prioritized student learning and supported teacher autonomy during implementation.

Of significant importance when adopting new practices was an environment that supported risk-taking and trust. A culture of trust that valued teacher agency and reflective feedback was conducive to change while coercion and top-down micromanagement by administration had the opposite effect (Van Bodegraven, 2015). Established, continuous feedback loops between teachers and administrators were essential not only in fostering environments conducive to change but for determining the effectiveness of professional development strategies being implemented for continuous improvement and support of the desired outcomes (Desimone & Garet, 2015).

One strategy for building a culture supportive of pedagogical risk taking was outlined by the work of Niess and Roschelle (2018). This study endorsed the use of long-term supportive “knowledge-building communities” for mathematics teachers to work through pedagogical shifts collaboratively, implementing and reflecting on new practices together. They asserted that “knowledge-building communities integrated with classroom teaching experiences were more likely to engage teachers in relearning, rethinking, and redefining teaching and learning to take advantage of new and emerging technologies and methods for teaching mathematics” (Niess & Roschelle, 2018, p. 45). Their work attempted to determine the key features for online learning for teachers desiring to reframe their current pedagogical knowledge. Moreover, it sought to determine how teachers might address challenges of this type of classroom learning and how they might design classroom-based learning experiences for applying new ideas for teaching mathematics with technology.

Niess and Roschelle (2009) also provided a helpful summary of the five stages of Roger's Diffusion of Innovation theory as it traced the development of TPACK in the context of a knowledge building community of mathematics teachers adopting new pedagogical practices with technology in the following steps.

1. Recognizing (knowledge), where teachers were able to use the technology and recognize the alignment of the technology with mathematics content yet did not integrate the technology in teaching and learning of mathematics.
2. Accepting (persuasion), where teachers formed a favorable or unfavorable attitude toward teaching and learning mathematics with an appropriate technology.
3. Adapting (decision), where teachers engaged in activities that led to a choice to adopt or reject teaching and learning mathematics with appropriate technology.
4. Exploring (implementation), where teachers actively integrated teaching and learning of mathematics with appropriate technology.
5. Advancing (confirmation), where teachers evaluated the results of the decision to integrate teaching and learning mathematics with an appropriate technology (Niess et al., 2009, p. 9; Niess & Roschelle, 2018, p. 47).

Niess and Roschelle's (2018) vision of successful knowledge-building communities relied on inquiry-based activities and provided a platform for shared development of understanding. They were highly reflective, problem-solving, collaborative communities where teachers created, discussed, and reformed their thinking about teaching mathematics in an asynchronous or blended online platform. Their work yielded positive results for impacting teachers' TPACK development, but they also encouraged the use of learning experiences where teachers explored mathematics using technology as students themselves. Receiving instruction about the use of innovative technologies while experiencing the learning in the same context as their students was suggested to be a valuable piece of TPACK development for teachers.

The TPACK framework continues to evolve as a critical model for understanding teacher knowledge in technology-integrated environments. Tondeur et al. (2020) demonstrated that TPACK development requires not only individual teacher growth but also supportive institutional structures—a key consideration for Wyoming's statewide implementation efforts. In the mathematics context specifically, Njiku et al. (2022) argued that teachers' TPACK significantly influenced their ability to implement technology-enhanced mathematics instruction, with self-efficacy serving as a mediating factor in this relationship. This is particularly relevant to the work of supporting Wyoming teachers as they navigate computer science integration requirements.

Professional Development

Beyond the implementation of long-term, ongoing collaborative communities of support (Foulger et al., 2008; Mouza et al., 2022; Niess & Roschelle, 2018), teachers needed timely, relevant professional development opportunities to develop TPACK (Mishra & Koehler, 2006). Five specific characteristics of effective professional development (PD) included a focus on content, active learning, coherence, collaboration, and sustained duration (Desimone & Garet, 2015; Mouza et al., 2022). The focus on content was especially important for teachers new to CS as they needed opportunities to learn the content associated with CS and the effective pedagogical strategies specific to CS. PD needed to actively engage teachers in observing, practicing and reflecting on the content and strategies they would be using with students (Mouza et al., 2022). They needed to help create connections between teachers' current understanding, relevant content materials and goals, and current practice with the content and skills being fostered by the PD opportunity, as well as opportunities for collaboration during the professional development and beyond (Desimone & Garet, 2015). Professional development opportunities that were directly tied to specific lessons that would be taught were most effective, especially when coupled with specific daily procedures and routines (Desimone & Garet, 2015). Finally, effective professional development opportunities needed to extend over multiple days in the school year with a minimum of 20 contact hours and ongoing access to support beyond the experience (Basu et al., 2021; Desimone & Garet, 2015; Mouza et al., 2022).

When moving beyond these five characteristics (Desimone & Garet, 2015) to determine the specific format of professional development opportunities, there were many options. Workshops, conferences, online coursework in asynchronous, synchronous, or blended environments were common approaches discussed (Boothe & Clark, 2014). Unfortunately, studies were not definitive with respect to the effectiveness of specific formats. Vivian and Falkner (2019) found teachers' TPACK development increased after completion of an online course, while Garcia et al. (2018) cited the ineffectiveness of some methods of professional development. Short, single-session workshops have become less popular in the U.S. as their effectiveness for significantly impacting change has been unsubstantiated (Desimone & Garet, 2015). Mentoring, peer-collaborations, online forums, and virtual professional learning communities leveraged social networking, collaboration, and knowledge sharing by groups of people rather than the more traditional instructional courses or teaching sessions. A similar method was peripheral participation through observation of videos and focused discussion. These formats of professional development showed promise for positively impacting instructional practice and were preferred by teachers in some studies over district-provided PD sessions (Garcia et al., 2018; McKnight et al, 2016). The use of video for observation, reflection, and evaluation of practice, as well as provision of resources through video libraries, was also a rising trend in professional development in the U.S. (Desimone & Garet, 2015).

Two additional factors considered in designing professional development opportunities to sustain change in educational practice were the integration of collaboration and the integration of the professional development for teachers and teacher leaders into teachers' regular schedules (Burner, 2018). Collaboration was suggested to be significant in the adoption of change and transformation of educational practice as it developed a collective experience from which all participants benefitted (Niess & Roschelle, 2018; Van Bodegraven, 2015). Van Bodegraven (2015) asserted the use of collaboration for more experienced teachers was found to be most impactful on adoption of technological innovation, while collaboration was least helpful for new teachers who desired more direct instruction on how to use the technology.

Another professional development strategy harnessing the experience of local teachers was discussed by Boothe and Clark (2014). The "bottom-up" (p. 3) efforts in the West Ada District in Idaho focused on teachers already actively integrating digital tools and pedagogies into their instructional practice, asking them to create model classrooms for the type of 21st century learning the district desired to promote. Beginning with five teachers who developed comprehensive plans for their classrooms, the program blossomed to 80 committed classrooms, multiplying the teachers who had caught a vision for these practices sixteen-fold. Leveraging the professional resources that existed in the district and giving voice to teachers who were embracing the desired practices was successful in growing change in practice, allowing other teachers to see the possibilities for change in action.

Differentiation was also an important consideration in designing professional development opportunities since teachers with differing levels of experience required different things to implement new practices with technology (Desimone & Garet, 2015; Van Bodegraven, 2015). Differentiation better optimized valuable teacher time than a one-size-fits-all approach. A menu of opportunities provided to meet a specific area of weakness (Desmone & Garet, 2015) or a scaffolded approach to building specific skills and information and technology (ICT) competencies (Roulston et al., 2019) presented intriguing models for approaching differentiation of professional development. A defined progression of learning for teachers to navigate over time provided a framework for professional development as well as a pathway for identifying mentor teachers who possessed the knowledge, experience and ability to model the desired pedagogical practices to less confident teachers (Roulston et al., 2019). Differentiation was not intended to individualize PD to the detriment of meaningful peer collaboration, however; it needed to provide opportunities for targeted groups with similar needs to grow together (Desimone & Garet, 2015). When discussing differentiation in the context of the integration of CS into core instruction, it was particularly important for teachers with more extensive TPACK to be provided with time for collaboration as part of the adoption process (Van Bodegraven, 2015).

Professional development aimed at changing pedagogical approach and content knowledge was shown to be more challenging than PD designed to develop discreet skills or tasks (Desimone & Garet, 2015). Therefore, since the interest of my research is focused on fostering the adoption of a change in pedagogical approach to core instruction by integrating CS principles and pedagogies into core mathematics instruction, it follows that professional development will prove challenging. A range of opportunities available to teachers that follow the five research-based characteristics (Desimone & Garet, 2015; Mouza et al., 2022) and these opportunities must not only be received positively by teachers but result in classroom application and implementation of CS integration into core instructional practice (Mouza et al., 2022).

Availability of Resources

According to Roulston et al. (2019), two of the four “school-level” barriers to effective integration of CS into pedagogy cited were related to lack of accessible resources and technical support (p. 378). Access to technology was the greatest complaint. Inadequate hardware and deficient technical support were also cited (Roulston et al., 2019). While it was possible to teach computer science principles in contexts that did not require the use of digital tools (Vivian & Falkner, 2019), reliable access to technology was an obvious foundational need for teachers to address many CS standards (WYCPS, 2021).

The state of Wyoming already began actively promoting implementation of computer science standards and integration of technology through programs like the Boot Up Wyoming initiative intended to increase the number of certified computer science teachers in the state (Edge, 2019). Even more recently, Wyoming’s Future of Learning Partnership promoted project-based learning initiatives through training and encouragement of collaboration with the

Powering Project-Based Learning Project (Harper, 2024). Project-based learning has been described as an excellent way to integrate computer science principles and practice (McKnight et al., 2016), and the Powering Project-Based Learning Project has provided a mechanism for sharing resources from Wyoming colleges and the University of Wyoming. Perhaps an expansion of this type of program to connect human and material resources between districts across the state is possible.

Sharing material resources such as personal devices and physical computing resources for implementation of computer science standards may help alleviate some shortfalls of resources in the state, particularly in smaller districts where resources are limited. However, little research on this type of resource sharing is available. Galvin et al. (1986) explored the idea of inter-agency sharing of resources based in an educational setting using the model seen in the business world. His study documented attempts at sharing resources between school districts in New York where there were numerous small rural districts without the ability to afford resources independently. The study focused on voluntary agreements between two or more school districts to combine resources, specifically human resources, to provide richer opportunities for students in both districts. The study argued that for sharing agreements to be successful, they had to be mutually beneficial and essential, meaning there was no other way for the shared resource to be acquired. Districts had to view what they were giving up in the agreement as less valuable than what they were gaining in it. Another challenge to sharing agreements was anticipated if districts were competing for the same resources, and some resource sharing arrangements turned out to be “more competitive than mutually rewarding exchanges” (Galvin et al., 1986, p. 4). The study further cited that successful agreements were more likely with support from the state to manage and incentivize agreements, as well as help districts create formal contracts outlining the parameters for sharing resources when both districts were competing for a single resource. When sharing physical computing devices or specialized technology services desired by both parties, this issue was important to consider.

Rajgopal (2021) discussed different models for sharing resources across districts. Resources included personnel, physical resources, transportation, and specialized services. The study noted examples of districts sharing professional development resources and mobile units equipped with a teacher, tools, and workspace. This study asserted that the general outcomes of sharing resources between districts include reduced costs for school districts, improved student and community outcomes, as well as improved teacher performance due to increased access to quality professional development and collaboration. Additionally, sharing resources reduced the need for districts to consolidate due to financial strain and inability to provide necessary staffing or programs. On the other hand, it pointed out that districts feared that these cooperatives could result in diminished control over programming. Additional challenges found in the study included inconsistency due to turnover of staff in charge of administering the agreements and difficulty managing scheduling of resources needed by both districts.

An intriguing approach to provision of ongoing technical support was cited in the work of Mouza et al. (2022). After participation in a week-long summer institute, teachers were given access to undergraduate students to provide ongoing classroom support. The undergraduate students were part of a service-learning course entitled *Field Experience in Teaching Computer Science* that had a pre-requisite of a prior college course in CS. The service-learning course combined college class meetings with field visits to classrooms throughout the semester to assist teachers in adapting their content area lessons to integrate CS principles and pedagogies with available resources. Teachers involved in this study reported that the summer institute was helpful for building their knowledge of CS content and pedagogy, but the access to and involvement of the undergraduate students throughout the semester was critical to their success and change in practice. This access to undergraduate student visits was limited by geography for some teachers, but it provided an interesting potential solution to begin to address this essential need.

Surveys Consulted

Sahin (2011) created a survey instrument to determine teachers technological pedagogical and content knowledge, or TPACK as defined by Mishra and Koehler (2006). The survey had seven subscales including all the overlapping categories created on the TPACK graphic (see Figure 1) including TK, PK, CK, TPK, TCK, PCK, and TPACK. For my project's purposes, I will borrow from questions used in the TK, TCK, TPK and TPACK subscales (see Table 1). The survey shows statistically significant reliability in the study and therefore is an appropriate source of questions for determining TPACK for teachers (Sahin, 2011). By surveying existing TPACK knowledge of Wyoming teachers, extensions and inferences may be made about teachers' foundational background knowledge necessary to teach CS principles and standards.

A second survey I resourced was the Ronan et al. survey (2023) designed to measure in-service teachers' CS attitudes and beliefs. This study was conducted through the lens of Social Cognitive Career Theory (Lent et al., 1994) and focused on creating a tool that would identify, and analyze teacher attitudes and beliefs so that the mediating impact of teachers on CS learning might be explored. The development of this survey emphasized four categories that it found

Table 1

Appendix A (Adapted from Sahin, 2011, p. 105)

Subscale	I have knowledge in...
Technology Knowledge (TK)	Solving a technical problem with the computer Knowing about basic computer hardware (ex., CD-ROM, motherboard, RAM) and their functions Knowing about basic computer software (ex., Windows, Media Player) and their functions Following recent computer technologies Using an electronic spreadsheet program (ex., MS Excel) Communicating through Internet tools (ex., e-mail, MSN Messenger) Using a presentation program (ex., MS PowerPoint) Using area-specific software
Technological Pedagogical Knowledge (TPK)	Choosing technologies appropriate for my teaching/learning approaches and strategies Using computer applications supporting student learning Being able to select technologies useful for my teaching career Evaluating appropriateness of a new technology for teaching and learning
Technological Content Knowledge (TCK)	Using area-specific computer applications Using technologies helping to reach course objectives easily in my lesson plan Preparing a lesson plan requiring use of instructional technologies Developing class activities and projects involving use of instructional technologies
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Technological Pedagogical and Content Knowledge (TPACK)	Integrating appropriate instructional methods and technologies into my content area Selecting contemporary strategies and technologies helping to teach my content effective Teaching successfully by combining my content, pedagogy, and technology knowledge Taking a leadership role among my colleagues in the integration of content, pedagogy, and technology knowledge Teaching a subject with different instructional strategies and computer applications

common in professional documents in CS: an equity orientation, teacher growth mindset, key beliefs about career outcomes and epistemology of CS. Therefore, this survey was organized according to these categories (see Table 2). It provides a frame for my survey questions around these topics, addressing the goal of determining barriers to integration of CS as they relate to existing teacher attitudes toward CS and integration of CS into instructional practices.

Table 2

Items from Teacher Attitudes and Beliefs in Computer Science: Development and Validation of a Teacher Survey Instrument (Abridged and Adapted from Ronan et al., 2023, p. 18:9-18:14)

Category	Survey Item Wording
Equity Items (p. 18:9)	(-) Students have to be very smart to study CS. (-) Computer programming instruction is appropriate when students are older but not at the level I teach. (+) While students come to my class with very different levels of prior experience with computers and technology, all students can learn computer science. (-) CS is not an important subject for students like mine. (+) It is important to expose all students—especially female students and students of color to CS early in their academic careers. (+) I believe that with instruction all students can meet the CS objectives of the curriculum. (-) Most students in my building will not see the value in learning CS. (-) Students who show an early affinity for technology are most likely to succeed in CS (+) Students who show an early affinity for technology are most likely to succeed in CS
Epistemology Items (p. 18:10)	(-) CS is useful for solving problems but it's not a way to express yourself creatively. (+) Computer Science can be applied to many areas both within and outside of STEM. (-) Skills that my students will learn in CS will not contribute to my students' standardized test scores. (-) Many schools lack the equipment/budget to effectively teach CS. (+) The principles and practices of computer science are essential components of a good education.
Growth Mindset Items (p. 18:12)	(+) It's essential for teachers to seek out professional learning opportunities in the areas they teach (-) It's essential to always know the answers to students' CS questions. (-)Teaching CS is something teachers in my role should not be asked to do.

	(+) If it's good for my students, I'm excited to learn about new educational programs and tools. (-) CS is yet another topic that will not fit into an already full day. (+) When I know something is good for my students, I find a way to make it happen. (-) I would prefer that my school have fewer initiatives.
Career Outcome Items (p. 8:13)	(+) CS skills will expand career options for students due to high demand in computing fields. (+) If students have opportunities to learn CS they will have more opportunities for their future. (+) Many kinds of jobs will require CS skills. (-) My students are unlikely to pursue CS-centric careers. (+) CS strategies will help my students to keep up with new technological developments in their future careers. (+) Learning CS skills now will empower my students to impact the world my students will live in. (+) Understanding core CS concepts enables students to positively cooperate with others, even though they might not choose CS as their main career path (+) CS problem-solving skills will help students in careers requiring creativity and innovation.
Self-efficacy Items (p. 8:14)	(+) My colleagues consider me a technology resource. (-) I don't feel confident assessing my students' CS skills. (+) I know how to select materials to plan a CS lesson. (-) I do not understand a lot of the terms used in Computer Science. (-) Technology changes too rapidly for me to remain a competent CS teacher. (+) I am effective in helping students understand the processes of problem-solving and design. (+) I do not teach CS as well as I teach other subjects. (-) Effectively teaching CS requires detailed subject knowledge that I do not have. (+) I know enough about CS to teach it effectively.

Note: (+) indicates a positive response; (-) indicates a negative response.

Beyond the use of questions borrowed from these surveys addressing current TPACK and teacher attitudes and beliefs about computer science, questions will be developed to probe other factors known to impact the integration of technology for learning including school factors like leadership and technological support and culture for innovation; program factors like digital devices and support for technology and pedagogy; student factors including engagement, technology access and use; and current teacher instructional models including project-based learning and blended learning (McKnight et al., 2016).

This research explored the literature for considerations needed to optimize conditions for adoption of new pedagogical practice, specifically integration of computer science principles and pedagogy into core mathematics instruction. It furthers the current research by providing an instrument focused on determining the factors currently inhibiting integration of computer science principles and pedagogies into core math instruction and the support needed to promote this successful integration. Results of the survey designed in this research will provide actionable data for members of the educational community in Wyoming who are creating professional development and resources for Wyoming teachers to assist in CS integration into core mathematics courses. As was stated earlier in this chapter, professional development for the purpose of adopting a change in pedagogical approach is challenging. This research and survey results will help to inform the range of opportunities needed for teachers that follow the five research-based characteristics discussed (Desimone & Garet, 2015; Mouza et al., 2022).

In addition, this research will provide information for administrators at the state and district level to consider as they seek to build a positive, supportive school cultures and relationships between stakeholders conducive to the changes desired in Wyoming. Careful consideration of the feedback of Wyoming teachers on the front lines of change is needed to promote a positive rapport between the teachers of Wyoming and the powers that be who are making decisions impacting the daily lives of students and teachers in the state.

Chapter 3 Methodology

This research was part of the groundwork for a larger project being conducted to support Wyoming teachers in integration of computer science principles across all content areas. Additional content-area specific questions for content areas outside of mathematics will be added to the survey by collaborating content area experts prior to final distribution. The intended survey distribution is for a cross-sectional, email survey of Wyoming teachers from the list of Wyoming teachers currently in the Wyoming Department of Education database. Since all Wyoming teachers have regular access to email, this type of survey administration was chosen as it ensured access to all teachers, preventing coverage error and providing appropriate probability sampling (Sue & Ritter, 2012, p. 35). An email survey was considered the best approach as it afforded a rapid turn-around without great expense or hindrance due to geographical expansiveness, enabling the project to move forward in a timely manner while gathering the most data possible (Sue & Ritter, 2012).

Survey Objectives

The purpose of this survey development was to create an instrument to evaluate (a) current practice of Wyoming teachers for integration of computer science principles and pedagogy in mathematics (b) the factors hindering teacher integration of computer science principles and pedagogies into core mathematics instructional practice and (c) perceived teacher needs to increase integration of computer science principles and pedagogies into core mathematics instruction. These objectives provided valuable information for prioritization of needed resources, professional development, and support to be developed for Wyoming teachers to increase integration of computer science principles into core content area instruction.

The distribution, analysis, and validation of the survey results are beyond the scope of this project.

Survey Development

Considerations for Survey Design

The survey was written according to recommendations made by Sue and Ritter (2012) to optimize participation and completion of the survey and to maximize collection of valid data. General design considerations were outlined here. To begin, question construction and wording was critically reviewed. "Questions need to be self-explanatory, easy to understand and answer, free of jargon, and visually appealing" (Sue & Ritter, 2012, p. 52). Moreover, all questions were vetted to be sure they directly met one of the outlined survey objectives and measured what was desired, providing valid data (Sue & Ritter, 2012).

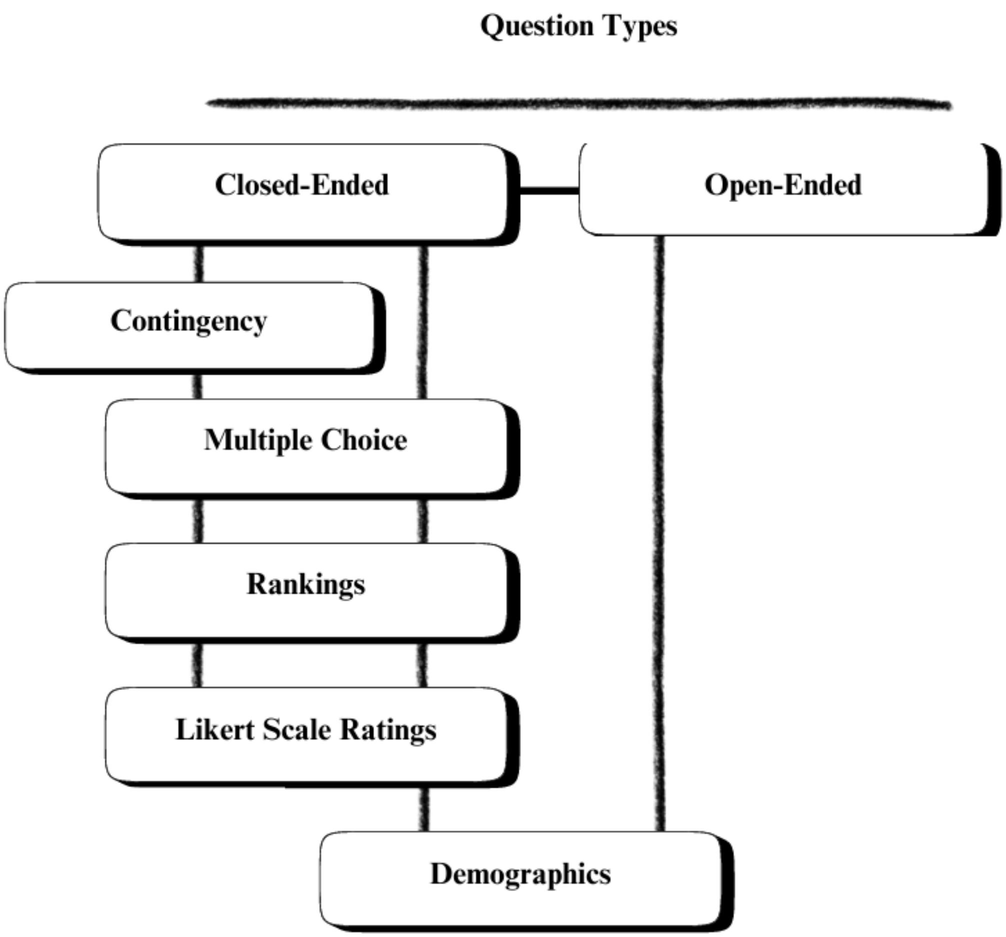
This survey was written with consideration for common threats to survey completion and validity. Avoiding participant frustration due to survey length, unclear language, online buffering due to overly complicated survey design, and failure to include all possible answers on closed-ended questions was an important consideration (Sue & Ritter, 2012). Survey length was addressed through contingency questions where possible. For example, questions were branched according to grade-band and content area taught on the final survey administered to teachers across content areas. Moreover, qualifying questions were asked to determine whether a participant should be included in or excluded from more detailed follow-up questions. Finally, question format was considered to increase the survey's compatibility for mobile users. Recommendations made by the Qualtrics platform included decreasing the number of matrix questions and reducing the number of responses on Likert scales where possible.

Both closed-ended and open-ended questions were used (see Figure 2). Most questions were closed-ended as they were easier for respondents to complete quickly, while providing

Question Development

Figure 2

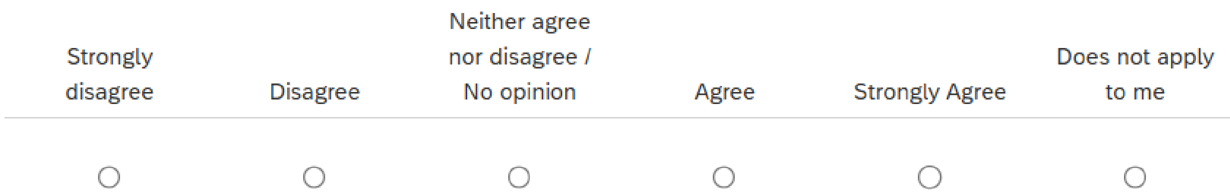
Question types used in survey development



reliable measurement (Sue & Ritter, 2012). Closed-ended questions included multiple-choice questions, sliders, and rating questions using Likert scales. The scales used included a simple three-digit scale, a standard five-digit scale, and an expanded six-digit scale (see Figures 3 and 4). While the three digit Likert scale does not allow for as much nuance as the larger scales, it is more user friendly for mobile devices which Qualtrics recommended to increase completion rates.

Figure 3

Expanded Likert Scale of Agreement



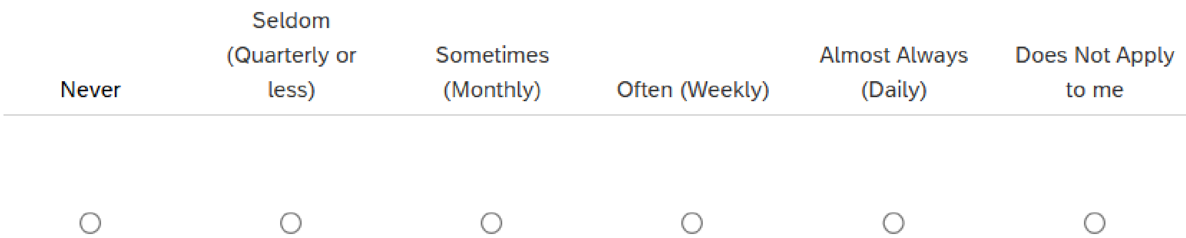
E.g. Skills that my students will learn in CS will NOT benefit my students' standardized test scores.

Note: Screenshot taken from Qualtrics Survey

The two primary Likert scales used included one to measure degree of agreement and the other to measure frequency of practice. The scale for degree of agreement was adapted on a few items to include the additional option "Does not apply to me" (See Figure 4). This option provided participants with varying degrees of agreement, as well as the possibility that the statement did not apply to them in their current role. Where possible, the scale was reduced to a three-point scale to increase Mobile user friendliness (see Figure 5). This method was used to limit the risk of overload and frustration of survey participants (Sue & Ritter, 2012) that can lead to survey abandonment.

Figure 4

Expanded Likert Scale of Frequency

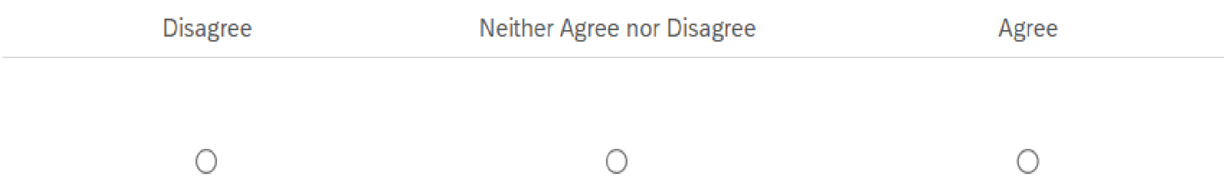


E.g. I use digital technology to provide current, quality learning resources for my students.

Note: Screenshot taken from Qualtrics Survey

Figure 5

Reduced Likert Scale of Agreement



E.g. I am knowledgeable of math-specific computer applications (apps) I can use with my students.

Note: Screenshot taken from Qualtrics Survey

Open-ended questions were used to provide opportunity for all possible responses to be collected, increasing the data's validity (Sue & Ritter, 2012). However, open-ended questions were limited to short-answer questions. By limiting the open-ended questions, participants were forced to provide more concise responses, and greater ease was afforded for coding responses during analysis. Fewer open-ended questions have been determined to be less intimidating to survey participants, resulting in fewer skipped questions (Sue & Ritter, 2012).

Demographic questions were included in the survey to assist in analysis of the data, but individual personal responses in the final survey will remain confidential. Demographic questions included gender, years of teaching experience grouped by range of years, age grouped by range of years, school size, and self-identification according to Roger's Diffusion of Innovation Theory (2003) adopter categories.

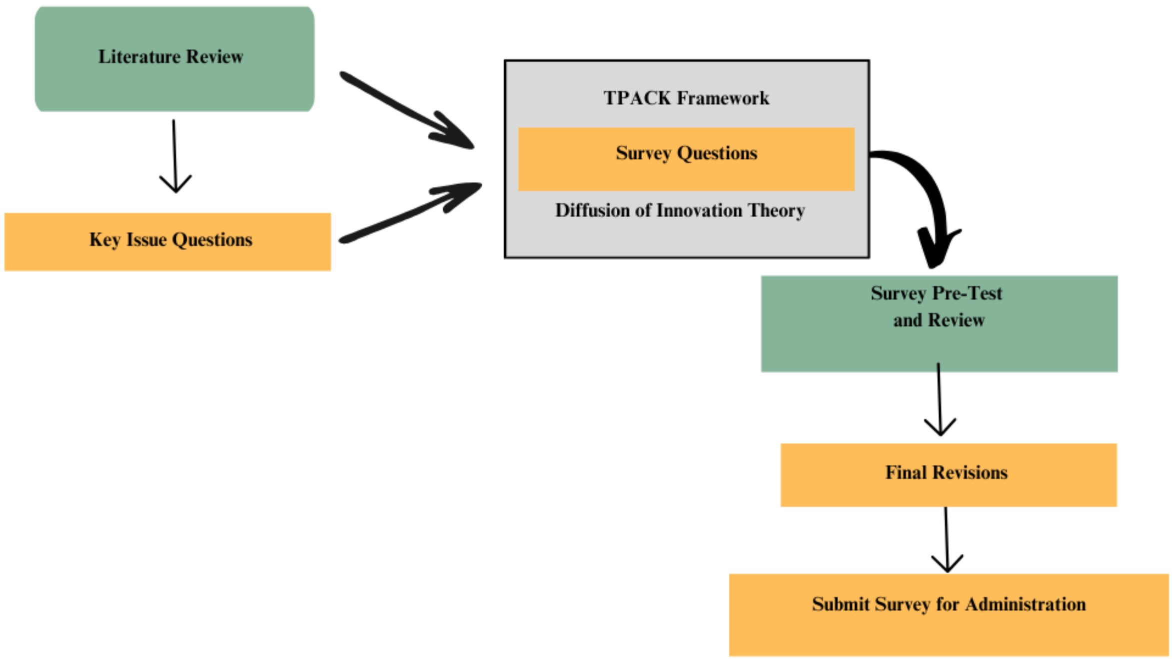
Literature Defined Key Issues

Common themes found in the literature regarding factors that impeded or enhanced integration of technology into instructional practice informed categories of the final survey questions (See Figure 6). Question categories focused on key areas of interest identified in the literature review including current practice, time constraints, available resources, professional development, and systems of support. While the integration of computer science principles and pedagogies is not synonymous with integration of technology into instructional practice, it might be considered a sub-category of the latter. This provided a starting point for determining barriers and needs experienced by non-computer science teachers in conjunction with the TPACK questions outlined earlier.

The article "Teaching in a Digital Age: How Educators Use Technology to Improve Student Learning" (McKnight et al., 2016) was informative in my question development in two ways. First, the instructional strategies and tactics listed were helpful in developing survey questions about teachers' current technological pedagogical practices. The strategies outlined in that study involved direct instruction of content; access and accommodations; research, exploration and creativity; collaboration; assessment and feedback; and communication and

Figure 6

Flowchart of methodology used in survey development



information management. Each strategy was broken down into specific tactics to use with students to increase engagement and improve learning. These tactics were used in survey question development. Second, this study provided a list of six factors known to impact integration of technology which aided in the categorical organization of my questions. They were identified as school factors, program/initiative factors, student factors, student learning activities, teacher instructional model/practices, and teacher factors. The explanations of each category provided specific topics to explore in survey questions aiming to determine potential barriers to integration of technology in general.

Finally, the TPACK framework (Mishra & Koehler, 2006) and the Diffusion of Innovation Theory (Rogers, 1962, 2003) adopter categories and stages of adoption were used to organize and frame questions. These questions were intended to clarify current practice as well as to identify participating teachers' adopter categories outlined in the Theoretical Framework portion of this paper.

Questions and answer choices were refined to focus the survey to provide actionable feedback. This important process of narrowing questions for the final survey intended to minimize the survey's overall length, desiring to reduce non-participation, survey fatigue, abandonment, and overall error (Sue & Ritter, 2012). A few open-ended, short-answer questions were included on the final instrument to ensure the opportunity for all responses from the population sample.

Question Review and Revision

Once the survey was drafted, it was built in Qualtrics, providing a functional digital platform for online deployment via email. It was then distributed to be reviewed by a group of nine education professionals for pilot testing. The grade level experiences of the nine pilot testers are delineated in Table 3. Some pilot testers had experience in more than one grade band.

Table 3

Grade Band Experience of Pilot Testers

Grade Band	Percentage	Count
K-2	50	5
3-5	60	6
6-8	60	6
9-12	70	7

Pilot testers' experience also spanned multiple disciplines illustrated in Table 4. One teacher specialized with gifted and talented students and two served as special education teachers. Four worked as instructional coaches. Administrative experience included a state-level administrator and technology coordinator, K-5 Gifted and Talented Facilitator, and two executive directors of professional learning. Additionally, all nine pilot testers were experienced consultants as professional learning specialists facilitating professional development experiences for K-12 educators across the United States in technology integration.

Table 4

Disciplines of Pilot Testers

Discipline	Percentage	Count
Math	27	3
English Language Arts	36	4
Science	27	3
Social Studies	36	4
Computer Science	18	2
Special Education	18	2
Other Student Support Services	18	2
Administrative Role, Instructional Coach or other non-teaching role	36	4

This pilot test served a four-fold purpose. First, it provided a range of time required to complete the survey, essential information for me to provide to future survey participants (Figure 7). Second, it provided feedback on question clarity. It identified any points of confusion about what a question was asking and identified technical language that needed to be addressed or eliminated. Third, I asked for feedback about question construction and comprehensiveness. I provided participants with a form to annotate while completing the survey to provide feedback on questions that had insufficient answer options and to suggest additional questions that reviewers felt were missing. Fourth, and finally, the feedback informed me about any potential technical difficulties experienced during the survey. Once the pilot test was administered, I followed up with any necessary revisions, outlined in chapter four of this document, and submitted the survey for its next steps and administration.

Limitations and Delimitations

This research was conducted expressly to address the need for computer science instruction in the state of Wyoming. The creation of an instrument to gather data from Wyoming teachers was necessary to gain much needed information that does not exist elsewhere in the research. Determining the practices, barriers and support needed by Wyoming teachers is important groundwork to addressing the current deficit of computer science education in the state. Wyoming is the least populous state in the United States while it is the tenth largest geographically (Wyoming - 2021 - III.B. Overview of the State, n.d.). Its rural nature and geographical dispersion of the population across the state creates some unique concerns for Wyoming that may not translate elsewhere. Geographical isolation, small schools, potentially limited access to technological and human resources, and the independent Wyoming culture are simultaneously reasons why this research is needed and why it may not apply universally to other contexts.

Additionally, this research focused previous studies integrating computer science with mathematics instruction. Some literature was more generalized in scope, but additional study would be warranted to explore the specific impacts of integration of computer science principles on performance in other content areas.

The instrument developed by this research is intended for distribution by email. While there are limitations inherent to this type of deployment, it was considered the best option for the population it is intended to survey. Email surveys are potentially easy to ignore resulting in some non-participation error (Sue & Ritter, 2012), but measures were taken in survey development, as outlined above, to minimize potential for these common errors. I do have some lingering concerns about the length of the survey, but I believe the information each question provides is important and therefore worth asking. A detailed description of the data anticipated to be collected and the revision process undergone to test the survey for content validity are outlined in the chapter to follow. Regardless of the risk or error, I anticipate that the measures taken will result in a response rate high enough to determine the confidence level of survey results according to the design of the final survey.

Chapter 4 Conclusions

The legislative mandate to provide CS education for every student in every school in Wyoming (WYCPS, 2021), coupled with the increasingly technocentric world in which we live makes the need for a viable plan for computer science education paramount to the success of Wyoming students (Alismail & McGuire, 2015; Boothe & Clark, 2014; FACT SHEET, 2016; Mouza et al., 2022; Naidoo, 2021). Accurate data are not available to determine the extent to which the WYCPS (2021) are being taught, but evidence confirms that it is far from comprehensive (Code.org et al, 2024). Additionally, studies have yielded positive results about educational outcomes of integration in the naturally overlapping areas of mathematics and computer science (Alismail & McGuire, 2015; Boothe & Clark, 2014; Casler-Failing, 2018; Casler-Failing, 2022; Forsstrom, 2020; Gadanidis, 2015; Gadanidis, 2017; McKnight et al., 2016; Rico-Bautista, 2019). This research sought to build an instrument to gather data from Wyoming teachers, providing a foundation from which to build toward integration of CS principles into core mathematics instruction. It is important due to the characteristics of Wyoming teachers that make them unique to teachers in other places around the country. Wyoming is a rural state, with teachers geographically dispersed in such a way that makes access to resources and face-to-face collaboration challenging. The geographic dispersion also contributes to Wyoming's independent mindset that can be resistant to change. As a state whose economy is tied heavily to mining and agriculture, teachers and learners may not see computer science as valuable and applicable to students' futures. However, exposure to CS would help students to see how CS skills can elevate ranching practices, support mining, and open opportunities for advancement in these fields.

Based on the current research, the instrument posed questions to establish current practices of or conducive to integration, existing barriers to integration, and necessary support and training to promote integration. The integration of CS principles into mathematics instruction is a first step toward comprehensive and equitable CS education for Wyoming students, serving as the model and impetus for broader integration across disciplines.

Final Survey Questions

The final survey (see Appendix A) was composed of 41 multiple choice questions, eight Likert scales with 68 statements, one sliding scale and three open-ended short answer questions (Table 5).

Table 5

Question Breakdown

Questions	Category
2.1-2.6	Demographics
3.1-3.2	Adopter identification
4.1-4.3	Teacher’s primary mode of instruction
5.1-5.4, 55	Student factors of engagement, access to technology and use
6.1-6.3	Teacher factors
7.1	School factors of leadership support and innovation culture
8.1-8.4	Professional Learning Communities
9.1-9.9	School or district programs and initiatives
10.1-10.11	Current practices of integration
11.1-11.6	Technology support
12.1	Professional Development
13.1-13.3	Barriers and needs to support CS integration

While the survey will be conducted anonymously, six multiple choice demographic questions were posed in block two. The demographic information will help to inform future decisions about professional development offerings and supports to be provided to teachers in the state of Wyoming. Additionally, the question about content areas taught will determine whether teachers continue with this instrument as designed or an alternate instrument adapted for content areas other than mathematics. This instrument will be adapted by specialists in other core content areas in the coming months to tailor it to the specific areas of interest and needs of those content areas. Distinguishing between the needs of elementary and secondary teachers or teachers of different core content areas is essential to the overall goals behind this project, increasing computer science integration in core content instruction in Wyoming. Additional information about age, years of teaching experience and gender may also provide insight about trends and patterns for future study.

In addition to basic demographic information, two multiple choice questions provided teachers with the opportunity to self-identify in one of the adopter categories identified earlier in this paper adapted from Roger's Diffusion of Innovation (1962, 2003) adopter categories. The answer choices described different dispositions the teacher might have toward both integration of CS standards into their core practice as well as their desire to try new, research-endorsed methods. The survey data collected by this instrument will be used by a larger project at the University of Wyoming and that project will be most interested in data from adopter categories two through four. These are the individuals who will most benefit from additional support and who are most likely to respond to that support by increasing their computer science integration into core practices. The ability to correlate the needs of these participants to other data will be extremely beneficial to future decision making.

Question block four gathered data about teachers' current primary modes of instruction. The questions were designed to determine the extent to which student-focused inquiry learning experiences and project-based learning experiences existed in current practice. These models provide opportunities for successful technology and computer science integration (McKnight et al., 2016), so data about the current use of these practices is helpful to determining potential entry points for computer science integration. The state is already investing resources to promoting project-based learning with the Future of Learning Partnership and Powering Project-Based Learning Project (Harper 2024), so this may provide an access point for computer science integration where change is already occurring.

The impact of teacher beliefs on their students and on the successful adoption of new practices is profound (Casler-Failing, 2024; Rogers, 1962, 2003; Ronan et al., 2023). Positive dispositions of teachers toward technology and computer science create positive dispositions in their students, and negative dispositions transfer equally (Ronan et al, 2023). Understanding these attitudes and their consequences is foundational to successful integration of computer science as they can derail implementation if not addressed. Questions about student factors were asked to gain an understanding of teacher attitudes and beliefs about their students' use of technology, as well as student access to educational technology at home and frequency of access in the classroom. To develop a plan of integration, issues of access must be assessed; this is explored further in another section of the survey. Furthermore, these questions offer insight about student engagement levels when using technology, teacher and student attitudes toward the use of technology and choice in learning experiences.

The next set of questions, block six, focused on specific teacher factors beyond attitudes and beliefs, measuring teachers' self-efficacy and TPACK (Mishra & Koehler, 2006). It explored participants' comfort and knowledge about basic integration and use of technology in the classroom and lesson planning. Self-efficacy for CS integration will vary from context to context within the state (Williams et al., 2023) but it is important to measure as teacher self-efficacy is crucial to effective teaching. Participants were asked to self-rank their knowledge of computer science skills and standards ranging from novice to expert. Studies have shown that most teachers will rank their technology knowledge lower than their pedagogical and content knowledge (Archambault and Crippen, 2009) but establishing a baseline of technology knowledge and skills is helpful to determining where to begin with building essential TPACK and teacher self-efficacy for integrating CS into core mathematics instruction (Njiku et al., 2022). Differentiation is an important consideration for professional development and assessment of current TPACK will inform that differentiation. These questions will also provide feedback about teachers' understanding of the natural overlaps between math and CS standards and skills, an understanding that is foundational "principles-knowledge" (Rogers, 2003, p. 173) for why the marriage mathematics and computer science works so well.

Question block seven inquired about factors of school leadership and innovation culture in participants' current teaching environments. Since administrative support and a culture that supports and celebrates risk-taking and innovation is key to successful adoption of new practices and integration of CS into instruction, this is essential measure (Burner, 2018; McKnight et al., 2016; Niess & Roschelle, 2018; Van Bodegraven, 2015). Administrators must demonstrate trust in the professional decision-making of their teachers if they want them to feel safe to attempt new pedagogical strategies. The risk of failure when implementing new and unfamiliar strategies in a critical and unsupportive environment will prevent otherwise willing teachers from attempting to integrate CS. Time must be allocated to teachers to understand and develop these new skills and strategies. Furthermore, teachers must be confident their feedback will be valued (Desimone & Garet, 2015) as a new path of integration is forged and that they will neither be blamed for inevitable hurdles to be navigated, nor left to figure out solutions to them on their own. Understanding the culture for innovation established by leadership, the level of trust for teachers demonstrated by leadership, the time invested in training teachers to meet new expectations, and the trust of leadership by teachers is important data. The best resources and perfectly designed professional development opportunities cannot overcome barriers of unsupportive leadership and culture. An accurate gauge of these factors will inform necessary systemic change required to implement integration of CS into core instruction at any level.

Four multiple choice questions asked participants to reflect on their experiences with and attitudes toward professional learning communities. Reflective and collaborative learning communities have been demonstrated to successfully support adoption of new pedagogical practices and have positively impacted teacher's TPACK development (Niess & Roschelle, 2018). Professional learning communities (PLCs) are not new to Wyoming, and it is likely that Wyoming teachers are experienced with them on some level. However, it is not known how teachers currently perceive them. As decisions about future offerings for professional development and modes of support are made, this data will be informative about the use of learning communities as a strategy and any additional scaffolding that may be needed to build effective, ongoing learning communities moving forward.

The programs and initiatives portion of the survey explored participants' views of the programs and initiatives currently being mandated or supported by their schools and districts. Understanding the load of change already being implemented and the toll this takes on teachers' willingness and ability to adopt something more is critical (Burner, 2018; Koh et al., 2014). The questions delve further into teachers' level of understanding about the 2021 Computer Science Wyoming Content Performance Standards (WYCPS) mandate and programs offered in Wyoming to train teachers in CS principles and pedagogies. It is unclear how familiar teachers are with the WYCPS mandate standards or with the programs offered by the state for teacher development. Teachers many not be aware of the WYCPS requirements. Data about the knowledge teachers have of the standards and state level programs are instructive when considering how to offer future professional development. Perhaps change is needed at the state level to better communicate with teachers about learning opportunities available to them in Wyoming. Furthermore, increasing teachers' *principles knowledge* (Roger's 1962, 2003) about the reasoning behind state initiatives may be an issue to be addressed in the future.

These questions ascertain the current level of direct CS instruction students are receiving in their schools and by whom that instruction is being delivered. This data is important as comprehensive data about delivery of CS instruction in the state does not exist. Current available data does indicate that the 2022-2023 mandate (WYCPS, 2021) of CS for every student in every school is not being met, but it is unclear to what degree the deficit extends. For Wyoming students to be competitive changemakers in the future, this educational inequity must be remedied.

One of the primary objectives of the instrument developed in this research is to determine current practices for integration of computer science principles. Therefore, a series of statements regarding current practices were evaluated by Likert scales in block 10. General categories of statements included use of quality resources, accessibility, practices of remediation and differentiation, use of technology for student research and teaching of specific application or technology skills. Statements about the use of robotics, coding, and physical computing in core mathematics instruction were also posed. These statements do not cover all computer science principles but offer a foundation from which to build. In addition, this set of questions gathered data about use of both the ISTE standards and WYCPS in lesson planning and general familiarity with the TPACK model (Mishra & Koehler (2006). Similar to the TPACK model, the ISTE standards dovetail with the WYCPS and would be helpful to a teacher attempting to plan instruction with integrated CS principles. Gauging the current level of understanding of these models as well as the WYCPS itself provides helpful measures of current practice and a baseline from which to begin. All the questions in this section focus on key practices for integration of CS principles and provide data about the scope of the practices currently in use.

An essential factor for successful integration of CS is technology support. Block eleven sought feedback about the current availability of both human and material technological resources as well timely technological support. A great divide exists between those who know how technology works and those who do not. When the latter are tasked with using technology without timely, effective support when something goes wrong, it is disastrous. Teachers may possess knowledge of innovative resources and practices but refuse to integrate them into their own practice because they have had too many bad experiences being stuck without timely support when it was needed. Similarly, millions of dollars can be spent on new curriculum adoptions promising interactive digital platforms that go untouched because they just do not work with the technological resources that teachers have in the classroom. Flexibility is necessary, but those experiences must be the exception and not the norm if teachers are going to be willing to adopt new practices that integrate technology and CS principles. This section of questions will ascertain what resources are available, what strategies are currently being used to share resources and what needs exist regarding technological support. Not all CS principles require technology, but teaching CS comprehensively does. These deficits must be identified and rectified for current mandates to be met.

The data gathered by this instrument will be used to develop professional learning strategies and resources for teachers in the state; therefore, a series of questions were posed about current practices and preferences regarding professional development. Research supports differentiation of PD to optimize effectiveness (Desmone & Garet, 2015) over a one-size fits all approach. Several studies asserted that scheduling PD for multiple sessions over time with access to follow up support is effective (Desimone & Garet, 2015; Foulger et al., 2008; Mouza et al., 2022; Niess & Roschelle, 2018), but the actual mode of delivery of PD might look different according to teacher preference. Quality professional development worthy of limited teacher time and designed to meet teachers' desires and felt needs is one of the intended byproducts of this instrument. Therefore, questions about differentiation, scheduling and mode of PD were included in the instrument to complement data collected about needed content to equip teachers for CS integration.

The final three questions on the survey were open-ended questions meant to provide an opportunity for participants to share anything they had not previously been able to share. They seek input about the barriers to CS integration participants face and the support they need to successfully integrate CS into their core instruction.

The data provided by this battery of questions will be instructive in future decision making to increase CS integration for all students in the state of Wyoming increasing their equitable access to necessary skills for the 21st century.

Pilot Test Feedback

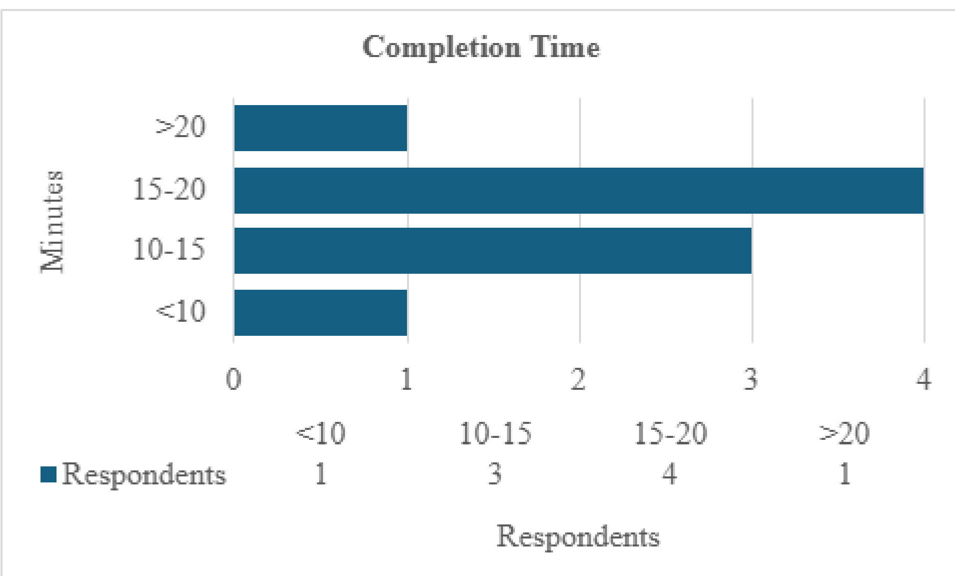
Feedback was requested to (a) ascertain the amount of time participants should expect to spend completing the survey (b) identify any needed clarification in question wording (c) offer suggestions regarding question construction and comprehensiveness and (d) identify any technical issues experienced during survey access or completion.

Time Required for Survey Completion

Pilot testing provided a measure of time required for completion of the survey ranging from less than ten minutes to over twenty minutes (Figure 8). The survey was completed by 78% of respondents in between 10 and 20 minutes with the median response time being 15-20 minutes. Based on this feedback, the survey introduction will inform survey participants that the survey will require approximately 15 minutes to complete. The survey will be completed anonymously to help ensure honest responses and protect participants, so the survey will require completion in a single session. The recommendation was made to eliminate any questions that were not essential to shorten the length of the survey if it was possible to still gather the needed data. This consideration was made prior to pilot testing and therefore additional questions were not eliminated during revision. Skip logic was applied to two additional questions to save time. These revisions are itemized in Table 6.

Figure 7

Survey Completion Time



Revisions to Final Instrument Questions

Revisions were made to survey questions based on feedback by pilot testers to validate the content of the survey. Changes ranged from issues of simple mechanics to inclusion of definitions of terms. All revisions are outlined in Table 6 below by question number.

Recommendations for Additional Questions or Answer Choices

It was suggested that a question be added to ask specifically about students' integration of technology to create or problem solve. The purpose of this addition would be to differentiate the types of use of technology teachers may integrate into their lessons. In other words, are they simply using technology as a substitution for other available resources or to administer online assessments, or is technology being used to spark imagination and facilitate problem solving and critical thinking? To understand the need for this question, it is helpful to think about the issue through the lens of Dr. Ruben Puentedura's SAMR model (2006). The SAMR model provides a four-level framework to help educators effectively integrate technology into their teaching. The levels include Substitution, Augmentation, Modification, and Redefinition. Substitution uses technology as a direct replacement for a non-technological tool without providing any functional change. For example, a digital textbook is used in place of a traditional textbook. The next step, Augmentation moves beyond simple substitution to providing some sort of functional change. Perhaps the textbook hyperlinks to definitions of terms or animations of processes being described in the textbook. Modification, the third step provides significant redesign of the task. It uses technology to transform the learning experience. For example, students may use an online interactive application like Desmos or GeoGebra to create and manipulate graphs in real-time, immediately seeing how changing a function affects its graph. Redefinition takes this even further by designing a learning experience that could not have

Table 6

Itemized Revisions to Survey Questions

Question	Revision
2.1	Skip logic was added to this question to take any participants that do not directly teach students to the end of the survey.
2.5	This question was revised to include the word *total*, clarifying the total number of years' experience of the respondent.
4.1	The question was simplified by removing inductive learning. A definition was added to the question to clarify the meaning of inquiry. The question defined student inquiry as putting the responsibility of the process of learning on the student through guided and increasingly independent development of their own questions, research, discussion and synthesis of ideas to arrive at their own understanding (Queens University, 2024).
5.2, 5.4	A definition was added to these questions to clarify the meaning of educational technology. Educational technology can include any technology that improves overall learning. Examples might include digital textbooks, educational apps, and access to learning management systems or virtual classrooms. (Kurt, 2017).
6.1	Clarification was made that computer applications would be synonymous with "apps". I do not understand many of the terms used in Computer Science was amended to include the "or in computer science standards."
6.2	*Office suites* was revised to *office software* to avoid confusion with Microsoft Office Suite proprietary software.
7.1	Made category headers bold to increase contrast between header and questions.
8.3	Text entry box was added to allow for elaboration "other".
9.2	Clarification was added as to whose expectations were being referenced in the question.
9.7 & 9.8	Phrasing was changed to qualify which instruction was being referenced with this instruction. Wording was altered to "this regular direct CS instruction."
9.9	Display logic was altered on this question so it will only appear for a "No" response on question 9.6.
10.9	Question was edited to make students plural.
6.1, 10.1 & 12.1	Question was edited to clarify core mathematics instruction rather than core instruction.

existed before without technology. For example, students might use augmented reality applications to explore 3D geometric concepts by placing virtual solids in real environments to measure their dimensions, calculate volume and examine cross sections interactively. This model helps to demonstrate how all uses of technology in the classroom are not equal. Therefore, it is important to ask questions that help to differentiate the types of learning experiences students are having with technology as teachers may believe they are using it in ways they are not. Teachers who are already transforming learning experiences with technology are likely already integrating some computer science standards into their core instruction and may simply need better understanding of the standards to meet them completely, whereas a teacher using technology to save resources at the photocopier presents a significantly greater learning curve for integration of technology and computer science principles. This question will offer additional clarification about current practices and TPACK (Mishra & Koehler, 2006) needs of teachers who respond that they are already integrating technology in the classroom.

An additional response was added to question 4.2, “How often do your students participate in project-based learning (PBL)?” The additional answer choice would allow for an option between PBL as the primary mode of instruction and PBL being incorporated at least once per year. Greater specificity will provide additional insight into openness to the use of PBL as a regular pedagogical model.

Three reviewers suggested that a question be added to specifically ask teachers about their willingness to integrate CS or teach CS principles if they had more time. They suggested that lack of time and the overload of other responsibilities was a key component in their own districts for teachers’ unwillingness to adopt new practices like integration of CS principles. Therefore, a statement was added to question 6.3 as follows, “I would be willing to integrate CS standards into my teaching if I had more time or if something else was taken off my plate.” Other questions in the survey do address teacher overload and other specific issues of time constraints teachers face, but this question will ascertain a teacher’s disposition toward CS integration if time were not a factor.

A final additional question was added at the end of the survey following question 13.2 which asked participants to identify their greatest need to feel equipped to integrate CS principles into their core instruction. A follow up question was added to ask what the participant would envision as the ideal support system to meet the need identified in question 13.2. This question allows for a last opportunity for participants to share any thoughts not previously expressed about what is needed to support them in the pursuit of the integration of computer science principles into core mathematics instruction.

Technical Issues

Eight of nine respondents indicated no technical issues with the survey. One respondent was prompted for login information when attempting to access the survey on an iPhone; they were able to access and complete it on their personal computer without incident. Additional testing was conducted with iPhones to see if the problem replicated when trying to access the survey on that platform. The problem was not replicated, and the survey was able to be accessed and completed without prompting for additional login information.

Conclusions

Wyoming students are lacking in computer science education and both legislation and awareness of the 21st century marketplace dictate that action must be taken to address the shortfall. Myriad factors, particularly prevalent in rural areas, impact access and quality of CS education currently available for Wyoming students making a new approach necessary. The integration of CS into core mathematics instruction eliminates some of the barriers to access and equity by reducing the need for specialized CS classes and staffing concerns. Additionally, the overlapping areas of mathematics and computer science provide logical access points for teaching specific CS principles, benefiting students in both CS and mathematics understanding. The success of this proposed integration requires accessible, effective, differentiated, and ongoing training and resources for Wyoming teachers in supportive, collaborative environments. The survey created through this study provides means for a preliminary step toward integration—identifying the barriers and dispositions of teachers present at the classroom level where integration would be implemented. The data collected by this survey will provide a starting point for the important work of supporting Wyoming teachers in the necessary integration of CS principles into core instruction. Our students can no longer afford to wait for change; it is needed now. Without a comprehensive plan to effectively implement CS instruction for all students, the Wyoming promise of computer science education as a basic skill is empty (*State, et. al., v. Campbell County School District, et al.*, 2001).

Next Steps

The next step for this research is the deployment of the survey to Wyoming teachers through email. Results of the instrument will be analyzed and validated by the project team seeking to use the data to strategically provide support and professional development for Wyoming teachers to increase integration of CS principles and pedagogy in core mathematics instruction across the state. Future research should be conducted on the fidelity of strategies and resources provided by the project team, the growth of teacher self-efficacy in CS integration, and their influence on the adoption and compliance with the legislative mandates of the WYCPS (2021).

Research into areas of overlap and access points for integration of computer science in other content areas is also needed. A team will be working to adapt the instrument developed in this research for teachers of other content areas. The work of delivering CS education to students in the state spans content area and grade level. More study must be done to determine best practices for integration along with most likely access points for CS integration in core content areas outside of mathematics.

Finally, additional exploration of current curricula available or in development by publishers meeting the needs determined by survey results will be necessary. Analysis of the data will be required to identify and address gaps in available resources and to reveal potential areas for further research. Work must be done to develop differentiated, easily accessible resources for professional development. Discussion and collaboration must also be done at the state level to truly develop a comprehensive path forward. Where change is needed, the state must lead not simply by mandate but by opening its coffers, communicating its vision, and striking a path forward as the Equality State- for every student in every school.

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Appendix A

Survey Questions

Introduction

In the state of Wyoming, there are current and growing demands on schools to provide computer science instruction for every student in every school. This survey is designed to gather information from Wyoming teachers about their current practice, potential barriers to integrating computer science into core instruction and needs for resources, support and future professional development in this area. Your honest answers are confidential as your name will not be attached to your responses. You will provide much needed insight as we forge ahead. Your time is greatly appreciated. This survey should take approximately 15 minutes to complete and must be done in a single session.

Demographics

To allow for greater understanding of Wyoming teachers and their specific needs, the survey will include the following demographic items. Responses in this survey will remain confidential.

2.1 Select the subject areas you currently teach. Select all that apply.

- 2.1.1 Math
- 2.1.2 English Language Arts
- 2.1.3 Science
- 2.1.4 Social Studies
- 2.1.5 Computer Science
- 2.1.6 World Language, Art or Music
- 2.1.7 Health or Physical Education
- 2.1.8 Special Education

2.1.9 Other student support services

2.1.10 Other Elective Courses

2.1.11 Administrative Role, Instructional Coach or Other non-teaching role

2.2 Grade bands taught. (Select all that apply.)

2.2.1 K-2

2.2.2 3-5

2.2.3 6-8

2.2.4 9-12

2.3 Teacher Age

2.3.1 18-24

2.3.2 25-34

2.3.3 35-44

2.3.4 45-54

2.3.5 55-64

2.3.6 65 and over

2.3.7 Prefer not to say

2.4 What is your gender identification?

2.4.1 Female

2.4.2 Male

2.4.3 Non-binary

2.4.4 Prefer not to say

2.5 Years of Teaching Experience

2.5.1 0-3 years

2.5.2 4-7 years

2.5.3 8-11 years

2.5.4 12-15 years

2.5.5 16-19 years

2.5.6 20 years or more

2.6 To the best of your knowledge, how many students are currently enrolled in the school where you teach? If you teach in multiple schools, please select the population size of the largest school you serve.

2.6.1 Fewer than 100 students

2.6.2 100-250 students

2.6.3 251-500 students

2.6.4 501-750 students

2.6.5 751-1000 students

2.6.6 1001-1500 students

2.6.7 1501-2000 students

2.6.8 Over 2000 students

Adopter Identification

Teachers will self-identify their current position about integrating the teaching of CS standards in their core instruction and their openness to new research-backed teaching methods.

3.1 Remembering the results of this survey are confidential, which description would you say best describes you when it comes to integrating computer science (CS) standards or principles into your core instruction?

3.1.1 I am currently integrating the Wyoming CS standards and pedagogy with my students in deliberate ways.

3.1.2 I am open to integrating CS standards into my core instruction and willing to help other teachers do the same. I may or may not need support in knowing how to do that well.

3.1.3 I would be willing to integrate CS standards into my core instruction if I understood how doing so benefited them and was equipped with the knowledge I need to do it well.

3.1.4 I am skeptical about integrating CS standards into my core instruction. I am not equipped to do it and/or do not believe it should be done outside of a computer science class. I would need to be convinced that it was both necessary and profitable for my students in my content area to consider it.

3.1.5 I am not willing to teach CS standards to my students and will do whatever I can to avoid this mandate.

3.2 Which description would you say **best** describes your *desire* to try new, research-endorsed teaching methods with your students?

3.2.1 I am eager to try new research-based methods with my students and frequently do so.

3.2.2 I am happy to try new research-based teaching practices with my students.

3.2.3 I am willing to try new research-based methods once I have seen their benefits.

3.2.4 I am skeptical of new methods and usually need convincing evidence for why change benefits me and my students before I will consider trying a new method.

3.2.5 I am satisfied with my current methods and do not see the point in changing anything. I will only consider new methods if I am forced to do so.

Teachers' Instructional Model and Practice

4.1 How often is student inquiry used in your instructional practice?

Define student inquiry as putting the responsibility of the process of learning on the student through guided and increasingly independent development of their own questions, research, discussion and synthesis of ideas to arrive at their own understanding (Queens University, 2024).

4.1.1 Daily

4.1.2 2-3 times a week

4.1.3 Once a week

4.1.4 Less than once a week

4.1.5 Never

4.2 How often do your students participate in project-based learning (PBL)?

As defined by PBLworks.org, project-based learning is "a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge."

4.2.1 PBL is my primary mode of instruction

4.2.2 I incorporate PBL at different times throughout the year

4.2.3 I incorporate a PBL experience at least once during the school year.

4.2.4 I am unable or unwilling to use the PBL model in my current position.

4.3 Approximately what percent of your mathematics instruction uses the following practices?

4.3.1 Direct Instruction

4.3.2 Project-based learning

4.3.3 Student Inquiry

4.3.4 Other

Student Factors (Engagement, Access and Use of Technology)

5.1 My students use technology to access current resources as part of my instructional design.

5.1.1 Yes

5.1.2 No

5.2 How many of your students do you believe have access to educational technology at home?

Educational technology can include any technology that improves overall learning. Examples might include digital textbooks, educational apps, and access to learning management systems or virtual classrooms.

https://educationaltechnology.net/definitions-educational-technology/

5.2.1 All

5.2.2 Most

5.2.3 Some

5.2.4 Few, if any.

5.3 Do your students enjoy activities that require the use of technology?

5.3.1 Definitely not

5.3.2 Only occasionally

5.3.3 More often than not

5.3.4 Definitely yes

5.3.5 I have no idea

*55. Are your students ever required to use technology creatively or to problem solve in your classes? Note: Use of a calculator would not be considered problem solving.

55.1 Yes, regularly

55.2 Yes, at least once during the school year

55.3 No, this in not a requirement

5.4 How often do students in your classes have access to educational technology? Educational technology can include any technology that improves overall learning. Examples might include digital textbooks, educational apps, and access to learning management systems or virtual classrooms.

5.4.1 Always

5.4.2 Most of the time

5.4.3 About half the time

5.4.4 Sometimes

5.4.5 Never

Teacher Factors

6.1 Please select your level of agreement with the following statements regarding your personal comfort and proficiency using technology.

Definition: Instructional technology refers to the tools and methods used to design and deliver educational content. Examples might include videos or interactive software.

Likert Scale: Disagree, Neither Agree nor Disagree, Agree

6.1.1 I feel equipped to select and use technologies that help me in my teaching career.

6.1.2 I can evaluate the appropriateness of new technology for teaching and learning.

6.1.3 I am knowledgeable of math-specific computer applications (apps) I can use with my students.

6.1.4 I am comfortable using computer applications (apps) to support student learning

6.1.5 I am knowledgeable in how I can use technologies in my lesson plans to help me reach course objectives.

6.1.6 I regularly prepare lesson plans requiring the use of instructional technologies.

6.1.7 I am confident in my ability to develop class activities and projects involving my students' use of instructional technologies.

6.1.8 I seek opportunities to integrate appropriate instructional methods and technologies into my core math instruction.

6.1.9 Others characterize my teaching as successfully combining my content, my pedagogy, and my knowledge of technology.

6.1.10 I take a leadership role among my colleagues in the integration of content, pedagogy and knowledge of technology.

6.1.11 My colleagues consider me a technology resource.

6.1.12 I do NOT understand a lot of the terms used in Computer Science and computer science standards.

6.2 Using a scale from novice to expert, how would you rate your personal knowledge of or abilities in the following areas:

Scale: Novice, Emerging, Proficient, Expert

6.2.1 Solving a technical problem with a computer.

6.2.2 Basic computer hardware (ex., mother-board, RAM, CPU) and their functions.

6.2.3 Basic computer software (ex., operating systems, web browsers, and office software) and their functions.

6.2.4 How to use an electronic spreadsheet program like MS Excel, Google Sheets or Apple Numbers.

6.2.5 How to use a presentation program (ex., MS PowerPoint, Google Slides, Canva)

6.2.6 How to communicate through internet tools (ex., email, discussion boards, messaging).

6.2.7 How to use the features of my school/district learning management system (ex., Canvas, Google School, Blackboard).

6.2.8 How to select materials to plan a computer science lesson.

6.2.9 Assessing my students' computer science skills.

6.3 Please indicate your level of agreement with the following statements about computer science (CS).

Likert Scale: Strongly Disagree, Disagree, Neither agree nor disagree/No opinion, Agree, Strongly Agree, Does Not Apply to Me

6.3.1 CS instruction is important and appropriate for the students I teach.

6.3.2 CS relates to the curriculum areas I teach.

6.3.3 CS involves problem solving and other important academic skills related to my curricular objectives.

6.3.4 Skills that my students will learn in CS will NOT benefit my students' standardized test scores.

6.3.5 Teachers must know the answers to their students CS questions.

6.3.6 Teaching CS is something teachers in my role should not be asked to do.

6.3.7 I know enough about CS to teach it effectively.

6.3.8 I would be willing to integrate CS standards into my teaching if I had more time or if something else was taken off my plate.

School Factors: Leadership Support and Innovation Culture

7.1 Indicate your agreement with the following statements about administrative support and culture in your current position.

Likert Scale: Disagree, Neither Agree nor Disagree, Agree

7.1.1 I feel supported by my administration.

7.1.2 My administrators trust my professional decision-making.

7.1.3 I am provided enough time for instructional planning.

7.1.4 I have easy access to support from individuals with more experience and knowledge in the areas I am expected to teach.

7.1.5 My school/district seeks and honors teachers' feedback and reflection.

7.1.6 I am provided with timely support when sought to help me accomplish what is expected of me by my supervisors.

7.1.7 I trust the decisions being made at the state level regarding state standards.

7.1.8 My school culture promotes innovation and risk-taking as a teacher.

7.1.9 My administration honors teachers' intentions in the classroom.

7.1.10 My administration supports my personal professional growth.

Professional Learning Communities

8.1 I am a part of at least one professional learning community that I find valuable and believe helps me improve my practice.

8.1.1 True

8.1.2 False

8.2 How would you describe your overall experience with professional learning communities?

8.2.1 Positive

8.2.2 Negative

8.2.3 Neither Positive nor Negative

8.3 How do you participate in professional learning communities? Select all that apply.

8.3.1 In person

8.3.2 Virtual Meetings (Zoom, Teams, etc.)

8.3.3 Online discussion boards or member forums

8.3.4 Social Media Platforms

8.3.5 Other ____________

8.4 How often would you voluntarily connect with a professional learning community that you found valuable to improving your practice?

8.4.1 Weekly

8.4.2 Every other week

8.4.3 Monthly

8.4.4 Quarterly

8.4.5 Never

Programs and Initiatives

9.1 How would you characterize the number of new programs or initiatives introduced in your school/district?

9.1.1 Too many

9.1.2 About right

9.1.3 Not enough

9.2 Do you feel you are able to meet the requirements of new programs and initiatives introduced by your school/district to the level of your administration's expectations?

9.2.1 Never

9.2.2 Sometimes

9.2.3 About half the time

9.2.4 Most of the time

9.2.5 Always

9.3 Do you believe your school/district introduces new programs/initiatives with a thoughtful and systematic approach?

9.3.1 No

9.3.2 Yes

9.4 Have you received training in the 2020 Computer Science Wyoming Content and Performance Standards (WYCPS), mandating new CS standards be taught in every school to every student by the 2022-23 school year?

9.4.1 Yes

9.4.2 No

9.5 Are you familiar with the Computer Science (CS) micro credential program, part of the Boot Up Wyoming initiative, available to teachers to increase understanding of CS principles and pedagogies.

9.5.1 Yes, I have participated in this micro credential program by completing one or more micro credentials in CS.

9.5.2 Yes, I am aware of and interested in this program but have not yet participated in it.

9.5.3 Yes, I am aware of this program, but I do not have any interest or intention to participate in it.

9.5.4 No, I do not know anything about this program.

9.6 All students in my school receive regular direct CS instruction as part of the core curriculum.

9.6.1 Yes

9.6.1.1 (Skip Logic 9.7) How often do students participate in this regular direct CS instruction as part of the core curriculum?

9.6.1.1.1 Daily

9.6.1.1.2 2-3 times a week

9.6.1.1.3 Once a week

9.6.1.1.4 Every other week

9.6.1.1.5 1-2 time per month

9.6.1.1.6 Other ________

9.6.1.2 (9.8) Who is responsible for this regular direct CS instruction?

9.6.1.2.1 Certified Computer Science Teacher

9.6.1.2.2 Certified Teacher Specialist (non-computer science)

9.6.1.2.3 Non-certified technology specialist

9.6.1.2.4 Paraprofessional

9.6.1.2.5 Other

9.6.2 No

9.6.2.1 (Skip Logic 9.9) If students do not participate in regular direct CS instruction as part of the core curriculum, why not?

9.6.2.1.1 It is not an expectation of our administration.

9.6.2.1.2 This expectation has been made clear to teachers, but it is not happening in all classrooms.

9.6.2.1.3 This has been suggested to teachers by the administration but is not an expectation

9.6.2.1.4 I don't know.

9.6.3 I don't know

Current Practice

10.1 The following questions are intended to explore your current practice using technology in your core mathematics instruction. Your honest input is important and personal responses are confidential. Please answer according to the frequency of each statement in your current practice, not what you might aspire to do. Answer for the current school year.

Use of Quality Resources

10.1.1 I use digital technology to provide current, quality learning resources for my students.

10.1.2 My students use technology to access current resources as part of my instructional design.

10.1.3 I know how and where to find quality digital resources (e.g. Videos, online experiments, demonstrations, etc.) to provide richer learning opportunities for my core students.

10.1.4 My students participate in virtual field trips.

Remediation and Differentiation

10.1.5 I use computer technology as a tool for remediation for students needing additional instruction or practice.

10.1.6 I use technology as a tool to provide choices for my students to personalize their learning and have control over a specific learning opportunity.

10.1.7 I use self-paced learning programs with my students that adapt to student readiness levels (computer-based assessment, differentiated instruction based on student-level, computer games, etc.)

10.1.8 My advanced students have access to resources and technology where I provide deeper learning opportunities, differentiating their needs.

Research

10.1.9 My students conduct online research to answer questions or to learn about a topic for my class.

10.1.10 I teach my students how to conduct online searches to research questions or to learn about a topic.

10.2 I teach my students to use specific technology skills/applications in my core math classes. Check all that apply.

10.2.1 Spreadsheets

10.2.2 Graphing Software

10.2.3 Video Editing

10.2.4 Presentation Software

10.2.5 Coding

10.2.6 Other (Please specify)

10.3 At some point during the school year, my students used robots to apply or explore core mathematics concepts in my core math classes.

10.3.1 Yes

10.3.2 No

10.4 At some point during the school year, my students participated in a coding experience as part of my core math instruction.

10.4.1 Yes

10.4.2 No

10.5 At some point during the school year, my students used physical computing devices such as sensors, probes or other appropriate devices to collect real world data to be used in core math instruction.

10.5.1 Yes

10.5.2 No

10.6 I have integrated the International Society for Technology in Education (ISTE) standards into my lesson plans.

10.6.1 Yes

10.6.2 No

10.7 I have attempted to integrate the 2020 Computer Science Wyoming Content and Performance Standards (WYCPS) into my lesson plans.

10.7.1 Yes

10.7.2 No

10.8 I am familiar with the TPACK model (Technological Pedagogical and Content Knowledge) developed by Mishra and Koehler (2006) and know how to use it in my lesson planning.

10.8.1 Yes

10.8.2 No

10.9 Do your students have opportunities to share their work with people outside the walls of their classroom using technology?

10.9.1 No

10.9.2 Yes, less than once a week.

10.9.3 Yes, weekly or more

10.10 Do your students use technology to work collaboratively with other students or teachers? Examples might include pair programming, discussion boards, google docs, Office 365 collaborative docs, etc.

10.10.1No

10.10.2Yes, less than once a week

10.10.3Yes, 1-2 times per week

10.10.4Yes, 3-5 times per week

10.11 Please select your level of agreement with the statements below according to your current practice.

Likert Scale: Disagree, Neither agree nor disagree/No opinion, Agree

Teaching Digital Skills

10.11.1Teaching positive digital citizenship and responsible use of technology is part of my regular plans and responsibilities as a classroom teacher.

Accessibility

10.11.2 I have a good understanding of what digital tools are available for my students with special needs and how to access them.

10.11.3 My students have appropriate access to digital tools for accessibility needs.

10.11.4 I know how to use voice-to-text features for my students.

10.11.5 My students have regular access to adaptive technology in my classroom.

11.1 Indicate your level of agreement with the following statements about technology and technology support.

Likert Scale: Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly Agree, Does not apply to me

11.1.1 I am satisfied with the current technology available to me in my building.

11.1.2 I am frustrated with some aspect of the technology I am currently expected to use in my practice.

11.1.3 My school lacks the equipment/budget to effectively teach computer science.

11.2 Do you receive timely technological support when you need it?

11.2.1 Rarely

11.2.2 About half the time

11.2.3 Most of the time

11.3 Does your school share computer science staff with another school or district?

11.3.1 Yes

11.3.2 No

11.3.3 Unsure

11.4 Does your school share technology (computer labs, devices, or other physical technology) with another school or district?

11.4.1 Yes

11.4.2 No

11.4.3 Unsure

11.5 Would you consider having an undergraduate student assist you in the classroom with computer science (CS) integration into your lessons or other CS related questions?

11.5.1 Yes

11.5.2 No

12.1 Please indicate your level of agreement with the following statements about professional development in your current role.

Likert Scale: Strongly disagree, Disagree, Neither agree nor disagree, Agree, Strongly Agree, Does not apply to me

12.1.1 My school/district schedules professional development into my regular schedule.

12.1.2 My school/district differentiates professional development opportunities to provide appropriate training for teachers of different skill levels and experience.

12.1.3 My school/district provides adequate training prior to implementing a new program or initiative.

12.1.4 The professional development opportunities provided by my school/district include ongoing, accessible support.

12.1.5 My school/district/state values and utilizes the skills of its own teachers in providing in-house professional development.

12.1.6 Teachers must seek out professional learning opportunities in the areas they teach throughout their careers.

12.1.7 If it benefits my students, I am excited to learn about new practices and tools to use with them.

12.1.8 I prefer professional development that I can access at my own pace in a virtual environment.

12.1.9 I prefer professional development that I can access at my own pace in a virtual environment.

12.1.10 I would like access to video demonstrations of how teachers integrate CS into core mathematics instruction.

12.1.11 I would be open to participating in a monthly collaborative learning community either virtually or in person to improve my ability to integrate CS into my core math instruction

13.1 What are the greatest barriers for you to integrate computer science principles into your core instruction?

13.2 What is your greatest need as a teacher to feel equipped to integrate computer science principles into your core instruction?

13.3 What do you envision as the ideal support system to meet this need?

*Asterisk indicates question added in revision stage and therefore out of original numerical question order.

Appendix B

Pilot Test Instrument Feedback Letter

Dear Colleague,

Thank you for your willingness to provide feedback on the instrument I am developing for my Master's project through the University of Wyoming. This survey will be deployed to Wyoming teachers to gain actionable data for a team through the University of Wyoming working to develop resources, supports, and professional development intended to increase integration of computer science principles in core instruction. The survey desires to answer three questions.

1. What is the current practice of Wyoming teachers regarding integration of computer science principles and pedagogy into core mathematics instruction?
2. What are the primary constraints preventing Wyoming teachers from integrating computer science principles into their core mathematics pedagogical practice?
3. What are the perceived supports teachers need to increase the integration of computer science principles into their core mathematics pedagogical practices?

Your participation in this pilot survey will provide critical feedback on the following:

1. Time- You will provide a range of time required to complete the survey. Please time yourself as you answer the questions, stopping the timer as you complete the survey feedback form, and report back the total time it took you to complete the original survey questions.
2. Question clarity- I am looking for any points of confusion about what a question is asking, or jargon that should be eliminated or defined. On the linked digital form, please note the question number and the issue needing clarification or revision.

3. Question construction and comprehensiveness- If you believe a question needs additional or different options for multiple-choice answers or if there is a question you believe is lacking/missing, please note the question number and the additional answer or question you are recommending on the digital form.
4. Technical difficulties- Please note any technical difficulties related to the survey that you experienced on the linked form. Feel free to contact me by cell at any time to assist with issues preventing you from accessing or completing the survey.

Again, thank you so much for providing this valuable feedback. Please complete the survey and the linked feedback form by **March 21, 2025**.

Survey Link

Feedback Form Link

Heather Kolde

Cell: 307-*******

Email: HeatherKolde@gmail.com

Appendix C

Instrument Feedback Form

Reviewer Information:

Name:

Best method of contact:

Past and Current Educator Roles:

Survey Completion Time

*Please do your best to include **only the time required to complete the survey itself**. Do not include time taken to complete this feedback form.

__ Less than 10 minutes
__ 10-15 minutes
__ 15-20 minutes
__ More than 20 minutes

Please fill in the tables below, adding rows as needed.

Question clarity and Jargon		
Question #	Clarity or Jargon	Recommendation

Question Construction: Missing answers, additional options needed	
Question #	Recommendation

Additional Questions Recommended

Technical issues related to the survey	
Question #	Issue experienced

Other recommendations or considerations:

Appendix D

Figure 1: Adapted TPACK and Roger's Diffusion of Innovation Theory Lens