Jl. of Technology and Teacher Education (2021) **29**(2), 165-193

Designing a Model of Computer Science Professional Development for Elementary Educators in Inclusive Classrooms

AMY HUTCHISON
George Mason University, USA
ahutchi9@gmu.edu

JAMIE COLWELL
Old Dominion University, USA
jcolwell@odu.edu

KRISTIE GUTIERREZ
Old Dominion University, USA
kgutierr@odu.edu

ANYA EVMENOVA
George Mason University, USA
aevmenov@gmu.edu

JEFF OFFUTT
George Mason University, USA
offutt@gmu.edu

VALERIE TAYLOR
Old Dominion University, USA
vstaylor@odu.edu

New computer science standards are being rapidly introduced at the elementary level but little is known about how to prepare teachers to learn and teach the content of these standards, or how to support students with disabilities in learning computer science. Accordingly, we designed and studied the

Inclusive Computer Science Model of Professional Development to prepare teachers to integrate computer science for students with disabilities. This paper presents results from this design-based study to understand the factors that inhibited and enhanced teachers' participation in the professional development and how participation in the professional development influenced teachers' instruction and perceptions about teaching computer science to students with disabilities. Results revealed two inhibiting factors and one enhancing factor for participation. Further, although teachers did increase their integration of computer science for students with disabilities, it was challenging for teachers to learn and apply new computer science content and approaches for supporting students with disabilities at the same time. Future professional development efforts should focus on careful scaffolding and release of responsibility when preparing teachers to support students with disabilities in learning computer science.

Keywords: computer science education, coding, computational thinking, professional development, students with disabilities, universal design for learning

INTRODUCTION

Computing, with its basis in computational thinking and its technical core in computer science, is continuously affecting all aspects of life in the twenty-first century. Coding is increasingly considered an essential literacy skill (Scratchjr.org, 2015; Vee, 2017), and computing in its broadest sense is emerging as a fourth problem solving approach alongside mathematics, science, and engineering (Barana, et al., 2017). Computational thinking (CT) is an essential skill for professionals ranging from coaches to chefs to soldiers to delivery drivers to teachers to software engineers. As millions of people need these skills to thrive, it is imperative that every student learn computing, and no student should be bypassed because of lack of monetary resources, the schools they attend, or physical, mental, or emotional challenges (Hutchison, 2020)

In response to this urgent need, in 2016, the commonwealth of Virginia passed a bill mandating the inclusion of computer science (CS) as a mandatory part of the curriculum of all public schools in grades K-12. To date, 32 states have followed suit by adopting similar CS standards, some mandatory and some not, and some targeted at specific grades (Code.org, 2019). These new standards create a need for significant changes in elementary grades instruction (Hutchison et al., 2016). This is particularly true in states such as Virginia where the standards are written to indicate that CS should be integrated into existing content area instruction such as literacy, math, and science, rather than taught as an isolated subject.

Further exacerbating this challenge is that we know little about how to best teach CS concepts to elementary grade students, particularly students with disabilities who are at risk of being left behind in this new wave of educational innovation (Hutchison, 2020). To address these challenges, we designed and studied a model of professional development (PD) aimed at preparing elementary school teachers to integrate CS into content area instruction, with an emphasis on supporting students with high-incidence disabilities. High-incidence disabilities are the most common disabilities, including learning disabilities, emotional and behavioral disorders, mild intellectual disabilities, high-functioning autism, and attention-deficit hyperactivity disorder.

This paper presents results from a design-based implementation research study aimed at understanding how elementary educators respond to a model PD for learning how to integrate CS into content area instruction for students, including those with high-incidence disabilities.

Coding as a New Literacy

Literacy has increasingly become an ever-evolving term over the last two decades. As new technologies emerge, so do the ways in which we read, write, and communicate (Leu et al., 2013). A recent shift is that the ability to implement algorithms in a programming language (coding) has moved beyond a necessary skill for high demand fields, to include elements of expression, collaboration, and creativity. Vee (2017) has compellingly argued that coding includes many communication skills that are important in everyday life, just as others have argued that coding is a new type of literacy that helps students organize their thinking and express their ideas (scratchjr.org, 2015). We contend that as coding increasingly becomes a necessary form of communication, it also becomes an essential literacy skill for students (Hutchison et al., 2016). The importance of coding as a way to communicate is highlighted by new educational standards that encourage the use of coding and CT to illustrate thoughts, ideas, and stories. These standards mean that students cannot be literate without being coding-literate, making CT and coding essential to education. Thus, it is imperative that all students develop coding literacy, regardless of ability, socioeconomic status, or geographic location. This is why we emphasize the inclusion of students with high-incidence disabilities in the current study. We describe the importance of inclusive CS education next.

The Importance of Inclusive CS Education

Virginia's law mandating K-8 computer science integration was passed to support the growing demand for qualified workers in CS. In 2019, Pfeiffer estimated that 700,000 technology-related jobs were unfilled in the United States. To fill this gap, employers need all students, regardless of race, gender, or ability, to be educated in CS. Despite increasing attention to the field of CS and the increase in programs and education that enable historically underrepresented groups, such as women and people of color (Code.org, 2018), to participate in CS, there is still a significant need to better integrate CS into schools and to include students with disabilities. This is particularly true for the early grades since most CS programs have been targeted at students in the upper grades (e.g. exploringcs.org, girlswhocode.com). Although it is unknown how many K-8 teachers integrate CS into their instruction, there is evidence to suggest that integration occurs much less often in the elementary grades (Fanscali et al., 2018) than in the upper grades. Consequently, it is important that elementary grade students with high-incidence disabilities have the opportunity to participate in CS. Further, it is unfair if students who learn differently do not have the same opportunities to learn skills that could increase their economic and social mobility (Wille et al., 2017).

Wille et al. (2017) argue that overlooking the needs of students with high-incidence disabilities

> ...means the computing field misses out on their creativity and talent. Because they learn differently, these students often generate novel approaches to tackling complex problems. However, the chance to benefit from their views is lost because they can't fully participate in many CS opportunities as they're currently presented (p. 41).

Communication challenges that students with high-incidence disabilities often face, and are likely to face in learning CS, include difficulty in processes such as attention, memory, sequential processing, higher order cognition, visual-spatial functions, and language (Baker et al., 2003; Graham et al., 2017; Gregg & Mather, 2002). These students may also have difficulty planning, generating text, and making meaningful revisions (Graham et al., 2011). Accordingly, these challenges should be addressed in CS instruction that is intended for all learners.

Preparing Teachers to Integrate Computer Science and Support Students with Disabilities

Although little is known about how to prepare elementary grade teachers to integrate CS into instruction, much is known about effective forms of PD and approaches to supporting students with high-incidence disabilities. Thus, in the current study we designed a model of PD that is strongly supported by existing literature. First, we drew on what is known about high-quality PD. In an analysis of technology-related PD, Lawless and Pellegrino (2007) emphasized the importance of PD that is longer in duration, provides access to needed resources for teaching and learning, engages teachers in relevant activities for their individual contexts, promotes peer collaboration, and leads to a clearly articulated and common vision for student achievement. Additionally, a situative approach to PD, in which the activities that occur as part of the PD support individualized opportunities for teachers to apply new knowledge to their contexts, structures, and routines, has been shown as essential for helping teachers apply what they learn through PD (Hutchison & Woodward, 2018; Kopcha, 2012). Relatedly, Postholm (2012) noted the importance of learning within one's own school context so that appropriate exploratory and reflective work can take place. Also, Kopcha (2012) found that situative PD can lead to sustained changes in teachers' practices since it is designed to be responsive to teachers' needs and the demands of their classroom contexts. Thus, a situative perspective of teacher learning was applied to the design of our PD.

Further, there is a small, but growing number of studies that report on PD that is specific to helping elementary grade teachers instruct students in CS concepts. For examples, Hestness et al. (2018) found that when it comes to unfamiliar concepts such as CT, it is important for teachers to themselves engage in CT learning to gain practical understandings of CT-infused instruction and to better anticipate the challenges of enacting such instruction. They also found that it was important for teachers to participate in a community of practice for CT integration to help them better understand how CT concepts could be applied to their individual curricula and schools. Additionally, Rich et al. (2017) found that regular, ongoing PD can positively affect teachers' beliefs about computing, but recommend that these experiences provide ample opportunity for teachers to share their experiences around teaching computing so that a positive culture can be established. They also found evidence, consistent with the existing literature, that teachers' beliefs about the importance of the content and their ability to teach it are critical to successful implementation of new content and approaches. Thus, each of these perspectives played a critical role in the design of our PD.

Nevertheless, to our knowledge, there are no existing models of PD for elementary grade teachers that include the known elements of high-quality PD to integrate CS concepts into content area instruction and also address how to support students with high-incidence disabilities. Consequently, in addition to designing our PD to be ongoing, situative in nature, and to include professional learning communities for teachers, this study also relied on the Universal Design for Learning (UDL) Framework. UDL is a scientifically based framework for curriculum development to support all learners introduced by the Center for Applied Special Technology (CAST) in the 1990s (Edyburn, 2013). UDL is used to consider learner variability while proactively planning the instruction around three major principles: 1) providing multiple means of engagement, 2) providing multiple means of representation, and 3) including multiple means of action and expression. Building on the redundancy effect of flexible choices and scaffolds, UDL principles offer diverse learners options for engagement and motivation, options for how content is presented, and options for how students demonstrate what they have learned (Rose et al., 2005). UDL-based instruction minimizes the need for individual accommodations, thus supporting learning for students with various abilities and needs, backgrounds, and learning preferences (Rao & Meo, 2016). Accordingly, teachers in this project purposefully integrate the three principles of UDL to make their instruction accessible to all learners while also integrating CS into their literacy lessons.

METHOD

This work was conducted using a design-based implementation research ([DBIR]; Penuel et al., 2011) approach to developing and refining a model of PD for integrating CS into literacy instruction, called the Inclusive Computer Science (ICS) Model of PD. Our initial model was developed based on a previously published high-quality model of PD called the Technology Integration Planning Cycle Model of PD (Hutchison & Woodward, 2018). DBIR falls under the broader umbrella of design or design-based research (e.g., Cobb et al., 2003; Reinking & Bradley, 2007). Unlike other research approaches, DBIR investigates how valued pedagogical goals can be achieved through specific interventions, using systematic data collection and analysis aimed at identifying what factors enhance or inhibit an intervention's success. Iterative modifications are made and studied in micro-cycles and in macro-cycles across studies to generate design or pedagogical principles (Cobb et al., 2003) in diverse contexts. Our DBIR work is organized into the five phases of Design, Delivery, Refinement, Extension & Scale-up, and Retrospective Analysis. This paper reports on the first three phases: design, delivery, and refinement (see Table 1).

Table 1
Phases of Intervention

Phase	Defining Features
1. Design	• Determine goals for the design of the PD model and materials • Determine an initial developmentally-appropriate instructional sequence for integrating CT and coding concepts into instruction • Develop instructional materials and examples of integration, with an emphasis on support systems for students with disabilities
2. Delivery	*Phases 2 & 3 are overlapping and cyclical as the PD model and materials are delivered and refined, based on data analysis* • Delivery begins with a Summer Institute for elementary grade teachers. • Delivery continues into the following academic year as teachers integrate their learning from the Summer Institute into instruction. • PD is sustained throughout the school year
3. Refinement	• Refinement occurs throughout the delivery phase through iterative data collection and analysis and subsequent modification of PD

The overarching goals of this study were to determine how teachers respond to a model of PD, to determine what factors inhibit and enhance participation, to determine what modifications should be made to maximize teachers' participation and increase responsiveness to the model of PD, and to determine how participation in the PD influenced teachers' perceptions about teaching CS to students with disabilities. These goals are represented in the following research questions (RQs) that guided this study:

(1) RQ 1: What factors inhibit and enhance teachers' participation in the professional development activities?
(2) RQ 2: Based on these factors, what modifications maximize participation?
(3) RQ 3: In what ways does participation in the ICS Model of Professional Development influence teachers' instruction and perceptions about teaching computer science to students with disabilities?

Participants

Eleven total participants from our partnership school division in a mid-Atlantic state committed to participate in the year-long PD opportunity. All but one of the schools in which our participants taught receive federal Title I funds to support students from families who are economically disadvantaged. All participants were associated with an elementary school setting, either at primary level (K-2nd: *n* = 6), intermediate level (3rd-5th: *n* = 2), or across all grade levels within the school (K-5th: *n* = 3). Three of the participants working across multiple grade levels were not working in a traditional classroom capacity; rather they were positioned as a gifted educator, problem-based learning and STEM instructor, or an instructional technology resource teacher. Most participants were female (female *n* = 10, male *n* = 1), and 45% reported working in their current schools for less than five years. The ages of the participants were evenly distributed from 26 to 55 years of age. Teachers partnered in professional learning communities (PLCs) to promote collaboration and support in once monthly meetings, as well as unstructured throughout the month. PD participants were compensated for PD-related tasks. Larger, more time-consuming tasks resulted in higher compensation (e.g., Summer Institute attendance = $250.00), while smaller tasks such as monthly PLC attendance and weekly email responses garnered less.

Procedure and Data Sources

Phase One: Design

The purpose of Phase 1 of our study, the design phase, was to elicit systematic feedback on the design of our initial proposed model of PD. We began with a baseline model of PD that was developed based on a previously published model of PD called the Technology Integration Planning Cycle Model of PD (Hutchison & Woodward, 2018). We modified Hutchison and Woodward's (2018) model in the following ways: 1) Replaced half-day PD sessions with a four-day Summer Institute; 2) Added four Challenge Saturdays; and 3) Added online modules that the teachers would participate in throughout the academic year. Making all of these changes to the PD model resulted in the baseline model shown in Table 2, which we call the Inclusive Computer Science Model of PD (ICS Model of PD).

Table 2
Initial Model of Professional Development

PD Component	Explanation of PD Component
Summer Institute	Designed to: • Introduce basic CS skills & CS Standards of Learning • Define concepts in standards; demonstrate sample lessons and provide sample instructional materials • Introduce CS and UDL instructional design approaches • Provide collaboration and planning time
Challenge Saturdays	During four Saturday sessions throughout the academic year, teachers participate in Challenge Saturdays, to include programming and design challenges and reflection on their CS teaching practice.
Online Modules	Designed to continue incrementally increasing teachers' knowledge of content and pedagogy related to integrating CS into instruction.
Long-range planning	Designed to encourage teachers to think about the integration of CS as an ongoing, skill-building, and long-term activity.

PD Component	Explanation of PD Component
Professional Learning Communities (PLC)	Designed to build teachers' skills to successfully introduce digital literacy in disciplinary learning, PLCs will meet online or face-to-face twice monthly with the goal of continuing their professional learning.
Weekly digital tool resources with sample lesson plans	Designed to further develop and supplement teachers' abilities to effectively integrate CS into their instruction. Project participants receive weekly emails that provide digital resources, tips, and sample lessons.
Online Video Library	Access to online videos that model concepts, and sample instructional activities for integrating CS into instruction.

Once our initial PD model was finalized, we systematically sought feedback on the model through focus groups and classroom observations. This feedback served as the basis for refinement of the model. The purpose and description of each data source are described subsequently.

Focus groups. Focus groups were conducted with teachers and staff from the school division. In the first two focus groups conducted, we presented and solicited feedback on each component of the PD model through a series of structured questions. Based on the results of the first two focus groups, we revised the components of the PD model and presented the revised model to participants in the third focus group for feedback.

Classroom Observations. Classroom observations were conducted to gain information about any instruction related to CS that was already occurring in elementary classrooms in the division. We also wanted to observe the structure, setup, and activity in elementary grade classrooms in the school division in order to consider the kind of supports or activities that might be essential as part of our PD model.

Phases Two and Three: Delivery and Refinement

Phases 2 & 3 occurred concurrently as DBIR approaches to refinement require consistent and iterative data collection and analysis to determine modifications. Table 3 outlines the components of each phase and how the model has been refined through the DBIR process.

Table 3
Outline of Each Phase, its Components, Data Sources, and Refinement

Delivery Phase and Length/ Frequency	Data Sources Analyzed	Refinement Period/Approach and Purpose
Time Period 1 components (summer): **Summer Institute** (4 days)	• Institute completion rate • Questionnaire on readiness for CS • Pre-Institute focus group interviews • Daily exit tickets • Post-Institute focus group interviews	Data analyzed daily during the Summer Institute to determine minor modifications to be made during the Institute. All data collectively analyzed after the Institute to determine need for modifications to the content and delivery of future Institutes and to determine module content
Time Period 2 components (academic year): **Informal individual teacher interviews** (Once every 3 months) **Weekly Emails** (Each week) **Modules** (monthly) **Professional Learning Community (PLC) Meetings** (Once a month)	• Interviews transcripts • Email response rate • email reflection • Module completion • Module reflections • PLC attendance rate • PLC meeting transcripts • Verbal feedback provided by teachers during meetings	Interview transcripts analyzed once/three months to inform email, modules, and PLC data analysis Email data analyzed weekly to consider modifications to content to increase participation Module data analyzed once/month to determine need for modifications PLC data analyzed once/month to determine need for modifications

Baseline Data. Reinking and Bradley (2007) suggest that a quantitative measure be used to determine a baseline for participants' progress toward a pedagogical goal. We administered a questionnaire to gather baseline data about teachers' perceptions of their readiness to teach CT and coding in general and to use UDL to teach CS to students with high-incidence disabilities. Responses were analyzed descriptively to gather an overall "snapshot" understanding of participants readiness and understanding of computational thinking, coding, and UDL.

Data Analysis

Due to the pragmatic nature of DBIR, where improvement on the design of a usable intervention or model such as PD is the primary goal, qualitative approaches to analysis are common (Cobb et al., 2016), and a large number of data sources are employed. Per Cobb and colleagues' recommendation, we structured this research as a series of iterations in which to collect data to "compare the performance of a single group of participants [i.e., the teachers and ITRTs] at successive points in time to assess whether the current iteration of the design supports learning as conjectured" (p. 210). After each iteration, data were read holistically to search for common trends, either in the form of inhibiting or enhancing features (Reinking & Bradley, 2007), to determine if or what modifications might promote further progress toward the design of a useable and appealing PD model to support elementary teachers' integration of CS standards.

Due to the small sample size, results from the questionnaire were analyzed descriptively to look for trends about teachers' perceptions of their readiness and the extent to which they perceived they could teach CS to students with disabilities. Post-interviews in which teachers reflected on their entire experience were analyzed using a general inductive approach to qualitative data analysis (Thomas, 2006), which allows research findings to emerge from the frequent, dominant, or significant themes in the data. Analysis began with an initial examination of verbatim transcripts from all interviews. After an initial analysis of each interview, researcher memos were created to reflect the dominant ideas reflected in the data. From these memos, seven categories emerged and a coding framework was created based on these initial categories. The data were then coded according to these categories and the frequency of each code was counted. As a result of this analysis, four codes were collapsed into other codes due to similarity to eliminated due to low frequency within the data. This process resulted in three remaining categories. Data were then re-analyzed utilizing these categories, which led to the emergence of the three broad themes presented in the results.

RESULTS

What factors inhibit, and what factors enhance teachers' participation in the professional development activities?

Inhibiting Factor 1: Demands of the Profession

The first inhibiting feature focused on the time demands placed on teachers. Teacher time and demanding workloads are well-known obstacles in PD (Evers et al., 2016). Thus, the PD model was specifically designed to limit the amount of time required for participation. Nevertheless, our original model did not fit within the work demands and context of this school division. Although teachers indicated that they saw the potential value of Challenge Saturdays, they were opposed to participating and viewed weekends as off-limits for PD. Teachers discussed Challenge Saturdays in this focus group exchange (all names are pseudonyms).

Interviewer:	Are there any activities that you are opposed to participating in and why?
Molly (teacher):	You're not gonna see me on a Saturday.
Roxanne (teacher):	I guarantee that too Molly.
Molly:	It sounds really cool.
Roxanne:	It really does. It's gonna be a challenge to have that additional time on a Saturday. But I love that you've already planned what your goals are for those, but yeah Saturdays are tough.
Molly:	I would rather condense and make my Monday through Friday a little bit longer and do whatever I need to do to have Saturdays belong to me.

This exchange is representative of the conversations about Challenge Saturdays from all three focus groups. Thus, we removed Challenge Saturdays from the PD model.

Additionally, these demands affected teacher participation in the monthly modules. Teachers were given a month to complete the first module, which was estimated to take no more than on hour to complete. Although teachers were sent regular reminders to complete the module, only 1 out of 11 teachers completed the entire first module. Five of the teachers never created an account on the website where the modules were hosted. Consequently, we sought feedback from teachers about their experience with the first module.

Four of the teachers who completed any portion of the first module ranked the overall usefulness of the module. On average, these participants rated the overall usefulness of the module as 4.5 out of 5. This high average score indicates that teachers who accessed the module found it useful. Still uncertain about why so few teachers completed the module, we interviewed a sample of four teachers to solicit feedback. Teachers offered two primary reasons for not completing the module: 1) feeling overwhelmed by school duties, and 2) having to access an unfamiliar website to complete the module. The first reason aligns directly with previous data collected in the focus groups and further illustrated the limitations of teachers' time due to the school demands. Yet, the second reason illustrated a nuanced perspective on creating PD opportunities for teachers. Even slight barriers, such as using an unfamiliar web platform that requires any additional time may be insurmountable. Thus, we concluded that it was important to change how the content was presented and accessed to increase participation.

Modification 1: Streamlining Content

As a result of teachers' feedback on the original design of our PD model, we eliminated Challenge Saturdays from the model and instead added content to the modules and PLC meetings. Further, to increase the number of teachers who accessed the content intended as part of the modules, we instead offered the same content through weekly emails. Table 4 provides an example of the content that was sent through emails rather than provided as a module.

Table 4
Example of Module Content Transferred to Weekly Emails

Date and Module Theme	Topic/Content and Response Prompt
October: Week 1, Pattern Recognition	Content: Video about pattern recognition as a part of CT Response Prompt: Click on the picture below to watch a short video. Then, share one way you discuss pattern recognition in your classroom OR one question that you still have.
October: Week 2, Pattern Recognition	Content: Sample lesson plan Response Prompt: Look at your curriculum and planning guide for the upcoming two weeks. Identify a topic that you are teaching (in any content area) that would involve pattern recognition. How could you integrate an activity such as this one to emphasize pattern recognition?

Date and Module Theme	Topic/Content and Response Prompt
October: Week 3, Pattern Recognition	Content: A review of UDL and how to apply it to lesson design Response Prompt: What are some barriers students with disabilities may experience during the pattern recognition lesson we shared last week? What are a few different ways the student could show what he or she learned in the lesson?

This change from online modules to weekly email responses resulted in an immediate and sustained change in participation. As can be seen in Figure 1, in the first week participation increased from one to seven teachers responding, and increased even more in the following week. Although the number of teachers responding to the weekly emails fluctuated, participation in the email responses was never as low as it was in the online module. This finding led us to conclude that continuous learning and reflection through email instead of online modules was a modification that enhanced participation.

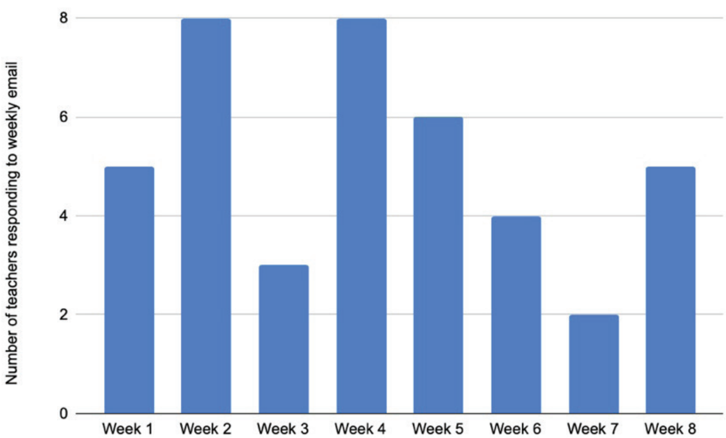

Figure 1. Number of teachers responding to weekly emails over time.

Also of note, a close analysis of response patterns revealed that the number of responses to the weekly emails was related to the complexity of the response task. Fewer teachers responded to the emails during weeks where the response task would likely require a greater time commitment. For example, eight people responded to this prompt: “Look at your curriculum for the upcoming two weeks and identify a topic that would involve pattern recognition. How could you integrate an activity such as this one to emphasize pattern recognition?"

By contrast, only two participants responded to this Week 7 prompt: "This lesson plan is purposely missing Potential Constraints and Instructional Considerations. Think about your students and UDL and come up with some ideas about the best way to plan for and integrate a lesson plan like this in your classroom. Hint: Examples can be found in the November 15 weekly email." Upon reviewing these tasks, we noted that the second prompt requires teachers to integrate multiple ideas from previous weeks, asks them to come up with original ideas, and asks them to cross-reference a previous email. We estimated that responding to the first prompt (Week 2) would require about 10 minutes, whereas responding to the second prompt (Week 7) would require about 30 minutes. Consequently, we concluded that the modification of soliciting responses through emails instead of modules is only an enhancing factor when the time- and effort-commitment remain low.

Inhibiting Factor 2: Mandatory Attendance at the Summer Institute

Based on the perspectives of teachers in the focus groups, we held the Summer Institute one week after the academic year ended and required that teachers attend all four days of the Institute. Teachers could not participate in any other part of the PD model if they did not attend the Summer Institute since this was the primary place that teachers would learn the necessary content. During our initial recruitment, 58 teachers indicated interest in the Summer Institute. However, as the Summer Institute approached, we received many inquiries from teachers about whether they had to attend all four days of the Institute or if they could be involved without attending the Institute. Three potential participants expressed concern that the cost of hiring a babysitter for their children was too much in comparison to the stipend ($250) they would receive for attending the Institute. Eleven potential participants indicated that they would not be able to attend all four days and thus could not participate. Other potential participants indicated that they had decided not to participate for other reasons such as a mismatch to their instructional goals or personal reasons. At the end of May, we had 41 confirmed participants, but an additional 13 teachers indicated that they would not be able to participate in the Summer Institute, citing the following reasons: 1) unable to attend all four days of the Institute (7 teachers), 2) commitment to another PD opportunity (2 teachers), 3) other personal obligations (4 teachers). An additional 10 teachers did not respond to the final confirmation, which left us with an anticipated 18 participants in the

Summer Institute. Seven of these participants did not show up to the Summer Institute, which resulted in 11 teachers attending the Institute. When we contacted the seven participants to ask why they did not attend, only one responded and cited personal reasons. This analysis indicated that requiring participation in a face-to-face Summer Institute inhibited teachers' participation, particularly since 81% of teachers who were initially interested were not able to participate in any part of our model because they could not attend the Summer Institute. Because the Summer Institute was clearly a factor inhibiting participation, we determined that it was important to modify this component of our model.

Modification 2:

To consider alternatives to the Summer Institute, we analyzed focus group and interview data from our teachers and reviewed the literature for examples of other approaches to providing learning opportunities where teachers can engage in deep, sustained learning. Focus group and interview data indicated that teachers preferred opportunities to learn online or during already scheduled PD days during the academic year. Accordingly, we decided that we would not hold any face-to-face PD sessions during the summer of the subsequent year. As an alternative, we chose to make the content of the Summer Institute available entirely online, with no face-to-face options. Instead, a set of online modules were made available for four weeks during the summer, and teachers could complete the work at their own pace during that four-week period.

Enhancing Factor: Content and Flexibility of the Professional Development Model

The enhancing feature that emerged from analysis was teachers' perceptions about the usefulness of the PD content. This feature is important to note as, during Years 1 and 2, the CS standards for the state had not yet been mandated. Instead, teachers were compelled by the quality of the content and the direct usefulness of PD that supported them in integrating CT and coding into their existing instruction. Particularly, teachers appreciated how our approach to designing instruction and integrating CS with other content was systematic and easy to understand and implement. For example, teachers discussed the usefulness of our planning approach during interviews, stating ideas such as "The model you guys created was easy to look at. It made sequential sense. You start here and you work your way around. I like how you guys put the content first, not the tool" (Bob, teacher participant).

In regards to our planning approach, another participant stated, “I think having that design thinking of here’s where you start, work your way around and reflect on this whole process of integrating these technologies is very important” (Sandra, teacher participant).

Finally, analysis indicated that teachers valued online or hybridized ongoing support. The PD model in this study was developed to support teachers in integrating CS into their instruction and thus a essential component of the model was that of continuous support. Using online and hybrid models of support allowed for both asynchronous and synchronous interactions with teachers that provided them flexibility alongside real-time interactions.

Final Model

After making the aforementioned modifications to our model of PD, the final model contained the elements shown in Figure 2.

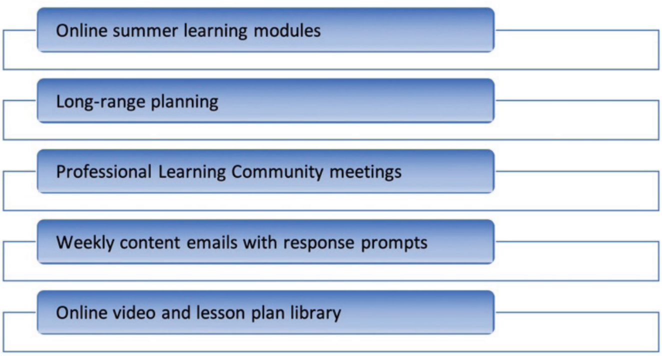

Figure 2. Final model of professional development.

In what ways does participation in the ICS Model of Professional Development influence teachers’ instruction and perceptions about teaching computer science to students with disabilities?

One way that teachers indicated the extent to which they integrated CS into their instruction was by responding to a weekly checklist in which they indicated what CS activities, if any, they included in their instruction that week. Additionally, teachers indicated if and how they used UDL principles in the design of their CS instruction. One goal of our study was to increase the frequency with which teachers integrated CS into their instruction since

0% of participants had previously integrated CS. Analyses indicated that, on average, teachers included CS in their instruction 15 times throughout the academic year. This was a substantial increase since none of the teachers had previously included CS in their instruction. We also wanted to ensure that teachers made CS appropriate and accessible for students with high-incidence disabilities by using UDL principles to design their CS instruction. Daily diary results indicate that teachers used UDL principles to design their CS instruction 63.64% of the time, an increase from 0% since none of the teachers had previously used UDL principles in the design of their instruction, though many of them indicated that they generally differentiate instruction for students.

Participants also described the ways that UDL principles influenced the design of their instruction. These responses were categorized according to which principle they applied to their instruction. Analysis indicates that teachers applied each of the UDL principles about equally, applying Multiple Means of Representation 37% of the time, Multiple Means of Engagement 32% of the time, and Multiple Means of Action and Expression 31% of the time.

Additionally, we hoped that participation in the Inclusive CS Model of PD would improve teachers' perceptions about their readiness to provide CS instruction to students with disabilities and about the benefits of providing CS instruction to students with disabilities. Table 5 below shows teachers' responses about their perceptions before and after participating in the Inclusive CS Model of PD.

Table 5

Comparisons of Teachers' Perceptions About Teaching CS to Students with Disabilities

	Strongly disagree (%)		Somewhat disagree (%)		Neither agree nor disagree (%)		Somewhat agree (%)		Strongly Agree (%)	
	Pre-PD	Post-PD	Pre-PD	Post-PD	Pre-PD	Post-PD	Pre-PD	Post-PD	Pre-PD	Post-PD
I feel prepared to teach CT to students with disabilities (SWD).	12.5	0.0	12.5	12.5	25.0	0.0	37.5	62.5	12.5	25.0

	Strongly disagree (%)		Somewhat disagree (%)		Neither agree nor disagree (%)		Somewhat agree (%)		Strongly Agree (%)	
I feel prepared to teach coding skills to SWD.	12.5	0.0	0.0	12.5	25.0	12.5	50.0	50.0	12.5	25.0
SWD should participate in CT lessons.	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	75.0	100.0
SWD should participate in lessons that integrate coding.	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	75.0	100.0
SWD can learn CT.	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	75.0	100.0
SWD can learn to code.	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	75.0	100.0
SWD can benefit from CT.	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	75.0	100.0
SWD can benefit from learning to code.	0.0	0.0	0.0	0.0	0.0	0.0	25.0	12.5	75.0	87.5

NOTE: n=8, participants who were not in a traditional teaching role were not included in analysis

As can be seen in Table 5, teachers' perceptions of their preparedness to teach CS to students with disabilities improved, as well as their perceptions of students' abilities to learn CS and the benefit of CS to students with disabilities.

As another way to understand teachers' perceptions about teaching CS to students with disabilities we interviewed teachers (*n*=10) at the end of the academic year after participating in the PD. Our analysis revealed three themes, which we present subsequently.

Theme 1: Ability to apply new information to classroom instruction

Teachers in this study had no previous experience integrating CS or UDL into their instruction, though many teachers had previously heard of

UDL principles. None of the teachers reported that they intentionally applied UDL to their instructional design, though many indicated that they did things that were in alignment with UDL without intentionally thinking about designing instruction with UDL principles. Over half of the teacher participants (*n*= 6) indicated satisfaction with how they were able to apply what they already knew about UDL and CS, as well as the new information they learned. Representative of this idea, Becky stated:

> As a fairly new educator, UDL is kind of woven in your training. But being able to use it more cognitively, and not just haphazardly…was new. I will definitely use those things… It was probably a 200% increase in how I implemented [CS and UDL].

Further analysis of the interview indicated that the sample lessons designed with UDL that teachers received were key to helping teachers apply UDL.

Relatedly, although it was a challenge for some interested teachers to attend the Summer Institute and the Institute prevented some teachers from participating, every teacher who did participate in the Summer Institute (*n*=10) indicated in their exit interviews that the Summer Institute was the most valuable part of the PD. The primary reasons they indicated that the Summer Institute was useful were: (1) they were able to see CS lessons modeled for them and able to see how these lessons could be designed with UDL; (2) they were able to collaborate with other teachers; (3) it was a concentrated period of time that was not interrupted by other school obligations. Collectively teachers indicated that the Summer Institute was a valuable part of helping them apply what they learned, and four of the teachers specifically mentioned UDL in their interviews. Hearing from teachers that the Summer Institute was the most valuable aspect of the PD provides new considerations about the role of the Summer Institute even though it was mandatory attendance at the Institute that prevented many teachers from participating in the PD.

In addition to the Summer Institute, nearly all teachers (*n*=8) mentioned that the ongoing PLC meetings were an important component of the PD model that worked well to supplement the Summer Institute. As a representative sample, Lynn explained the benefit of participating in a PLC and how they supplemented her learning from the Summer Institute:

> It really was a community thing and you could bounce ideas off each other…And, the institute was needed in order to go into it. I mean, I knew what a computer was. In the early 2000s I had done like a web design class, but that was like ridiculous. So that's like the only knowledge I had of it. And, you know, the institute laid out what it needed to be. And the why, of course... I definitely needed the Institute and PLC to do all that.

This excerpt reveals both the importance of the initial Summer Institute and the importance of the ongoing discussion with other teachers beyond the Institute. It also reveals how the Institute helped teachers consider why it is important to emphasize the inclusion of students with disabilities in CS instruction. The Summer Institute provided teachers with the foundational information that was necessary to start and the PLCs helped them sustain their participation.

Theme 2: Surprise at how students with disabilities were able to participate

The second theme that emerged relates to teachers' surprise at the extent to which students were able to participate in CS activities. Nearly all participants (*n*=8*)* commented during their exit interviews on their surprise or satisfaction at how students become engaged in CS activities. For example, Carly stated that her students with disabilities were "…actually more engaged in the computer science activities than in the regular core content and some of the symptoms of their disabilities actually waned." She went on to describe a student of hers who is twice exceptional and on the autism spectrum, stating:

> He thinks like a computer...You look at some of his writing journals and it's written in code, which doesn't necessarily get him great grades in English because we're looking for specific English standards. When you redirected that energy into a computer science activity, it's…his special treat and he's paying attention.

As another example, Alexandra commented on how her perception of what students with disabilities could do shifted when she applied UDL to her instruction. She explained that she had hesitations about introducing the content to students with disabilities, but ultimately, those were the students who were most engaged. In regards to her students with disabilities, she stated "They are the ones I was worried about. And now I don't know why...I was shocked that they actually got it as well as they did." Alexandra went on to explain that, out of the four or five students who have been posting their work related to coding, three of the students had IEPs (individualized education plans) related to a learning disability.

Additionally, several teachers indicated their surprise at how beneficial it was to design their instruction with UDL principles. Illustrating this idea, Alice stated:

> They [students with disabilities] were right there with everybody else. I think it was because there were multiple means of engagement [a UDL principle]. They gravitated towards using Scratch to code story sequencing and even story elements because it wasn't

> just okay, now write this out. They were manipulating things…and engaging with the stories.

As a whole, teachers indicated that when they designed their lessons with UDL principles they were pleased with how it enabled all students to participate. Yet, teachers were not always successful at integrating CS and designing lessons with UDL in mind. This reality relates to the third theme of our analysis.

Theme 3: "It was a little bit too much on my brain."

Although teachers reported many success stories with integrating CS and UDL into their instruction, teachers also indicated that learning to apply their new learning on both of these topics was challenging. When Carly was asked about how successful she felt at implementing CS lessons and whether she preferred to have fully developed lessons provided to her or to design her own CS lessons she stated:

> I valued the autonomy, but at the end of the day, it was a little bit too much on my brain to figure it out on my own. The suggestions were hard as a novice. The CS was new and the UDL was new. It was a lot to do them both.

In a similar fashion, several other participants (*n*=4) commented on the idea that it was difficult, and perhaps unrealistic, to design every lesson with UDL. For example, Alice described how she often integrated UDL principles on the spot when the opportunity arose rather than planning her instruction that way from the outset. She stated:

> In an ideal world, sure, yeah, I'm coming up with these amazing lessons like that with every shot. I mean, but let's be realistic, I mean honestly. Do we really have the time to be able to do that? For every single lesson we do on a daily basis? No.

Throughout the interviews, several teachers discussed their enthusiasm for learning the new content but indicated the difficulty they had in designing instruction that included two new concepts for them. Even so, equally as many teachers (*n*=5) indicated that they were pleased at how they were able to apply what they learned from the PD and that learning about UDL in relation to CS helped them better understand it.

DISCUSSION

Design based implementation research offers a unique opportunity to consider not only the outcome of a research study, in this case a refined PD model, but the processes and decisions involved in refinement. In this study, inhibiting and enhancing factors provided important insight into the intricate process of collaboratively refining a PD model for CS and CT in K-5 inclusive classrooms.

First, we consider the somewhat unforeseen realities of the division demands on teacher time in this project. Although project leaders met with division directors as part of our research-practitioner partnership prior to the start of the project to better understand the context of the school division as well as expectations for teachers regarding PD, direct interactions with teachers painted a slightly different picture. Indeed, while data in Phase 1, which was collected at the end of Year 1, allowed for reconsideration of Challenge Saturdays, analysis during this phase also suggested that teachers were willing to complete, and fully supported, online modules during the academic year to support their learning about CS integration. It was not until teachers were firmly situated in the academic year in Year 2 that analysis indicated that the modules were not feasible. This scenario raises the complex issue of planning PD for teachers that is situative (Kopcha, 2012), and aligns both with what teachers perceive to be useful and supportive with what works within the specific context of the academic year in which they are teaching. In a school division, such as the one in which this project was situated, where accreditation of schools is often in flux and learning priorities and objectives are somewhat of a moving target, it may be most useful to develop PD that can be augmented or refined during the academic year to meet teachers' needs. This need not affect the content of the PD, but it may be useful to have multiple methods by which to support teachers and structure content to increase teacher participation and learning.

The results of this study also provide new insights about teachers' beliefs about students with disabilities and CS. Although teachers' questionnaire responses indicated that a majority of teachers believed that students with disabilities could learn CS, the post-PD interviews reveal that many teachers were doubtful about whether students with disabilities could participate and were surprised when these students were able to participate successfully. Some studies have found that teachers' stated beliefs sometimes contradict their practice (e.g. Bryan & Recesso, 2006). There appears to be some element of this contradiction for these teachers in regards to teaching CS to students with disabilities. The majority of teachers in the current study indicated that they "strongly agree" that students with disabilities can benefit from and learn CT and coding. Yet, they were surprised when students succeeded during CS instruction. This mismatch indicates a need to further probe and promote teachers' beliefs about the benefit of CS for students with disabilities and their abilities to engage in CS. On a positive note, by the end of the study, 100% of teachers believed that students with disabilities could learn CT and coding. The researchers consider this to be a great success of the PD model, as it seems to indicate that teachers' beliefs about the students with disabilities can be changed with education, modeling and experience. As many researchers have found, negative beliefs or uncertainty about content or a pedagogical approach can cause cultural incompatibility (e.g. Ertmer, 1999) and prevent teachers from applying or integrating new content. Conversely, positive beliefs can mobilize teachers to overcome barriers to implementation and persist in difficult circumstances (Ertmer, 1999). Thus, a positive shift in teachers' beliefs about teaching CS to students with disabilities is a valuable outcome of this study on the ICS Model of PD.

Another important finding of this study relates to the challenge of learning to apply two or more new concepts simultaneously. In this case, the CS concepts were new for most teachers, designing CS lessons was new for all teachers, and applying UDL to CS instructional design was new for all teachers. Our findings indicate that it may be more useful to introduce these new ideas separately and using a gradual release of responsibility approach (Pearson & Gallagher, 1983). For example, since some of the teachers were already familiar with UDL, even though they weren't applying it, it may have been beneficial to teach, model, and practice designing instruction with UDL until mastery was reached before asking teachers to apply it to new CS concepts. Further, results seem to indicate that, after introducing CS concepts, teachers would most benefit from being provided with lesson plans that they can implement exactly as they are rather than being given sample lessons that they are free to modify. Although teachers liked having options to modify lessons, they also indicated that it would have helpful to not have that option in the beginning. Thus, it may be useful to design CS PD so that teachers begin by implementing a ready-made set of lessons designed with UDL principles and then gradually move toward designing their own lessons. Further, the ready-made UDL-designed CS lessons should have all materials and options already developed and provided since teachers indicated that there were challenged to always provide UDL options in every lesson due to time constraints.

The Summer Institute and professional learning communities provide another point of discussion for this study. Although many teachers were unable to participate in the PD because they were unable to attend the Summer Institute, the teachers who did attend the Institute indicated that it was the most valuable part of the PD. Teachers indicated that the Summer Institute was an appropriate intensity and duration for helping them understand the new concepts of CS and applying UDL to CS instruction. Similarly, the time that teachers spent with their PLC members helped them sustain their participation and gain new insights and ideas about how to apply their new knowledge. Thus, despite the barriers that a week-long institute may present, it can be valuable to provide teachers with PD of this intensity and duration away from the normal school year when learning new concepts and content such as teaching CS to students with high-incidence disabilities. Also, as others have found with PD (e.g. Lawless & Pellegrino 2007; Mouza, 2009) it is important for teachers to continue their growth and application within a community such as the PLCs in this study. This seems particularly important when teachers are learning multiple new concepts. As was seen in the current study, although teachers understood the CS concepts and the UDL principles, it was challenging for them to apply them simultaneously. They needed support from their PLCs in addition to model lesson plans. Even with these supports, teaching CS with the added challenge of applying UDL principles was difficult for teachers.

LIMITATIONS

Due to the intensive, design-based nature of this study, it was conducted with a small number of teachers. Thus, it is unclear how the professional development model and instructional materials will work in different settings and with larger groups of teachers. Even so, design-based implementation research enables researchers to carefully and thoughtfully design and refine interventions to meet valued pedagogical goals. Thus, we believe the ICS model of PD is likely to maximize participation and influence teachers' instruction and perceptions about teaching computer science to students with disabilities in other settings.

CONCLUSION

The initial year-long cycle of PD designed to improve the ways in which elementary educators are able to meet the needs of all learners, including those with high-incidence disabilities, in the areas of CT and coding provided implications for others participating in this work, as well as suggestions for future studies. Future implementations of the PD should provide participants with increased scaffolds for implementation by creating a few sets of introductory, grade-specific literacy lesson plans to implement in their classrooms that have already been infused with CT/CS and UDL strategies. The thought is that as teachers facilitate these lessons it will help reduce the teachers' cognitive load and provide initial support to help build teachers' self-efficacy and confidence for integrating future, similar lessons in their classes. Additionally, ways to provide PD with the same intensity and duration of the Summer Institute, but without requiring teachers to attend a week-long training in the summer, should be explored. The researchers of the current study plan to offer the same content in a fully online format that can be completed independently, but research is needed to determine the effectiveness of that approach and others like it.

References

Baker, S., Gersten, R., & Graham, S. (2003). Teaching expressive writing to students with learning disabilities: Research-based applications and examples. *Journal of Learning Disabilities, 36*, 109–123. https://doi.org/10.1177/002221940303600204

Barana, A., Fioravera, M., & Marchisio, M. (2017). Developing problem solving competences through the resolution of contextualized problems with an advanced computing environment, *Proceedings of the 3rd International Conference on Higher Education Advances*, 1015–1023. Editorial Universitat Politècnica de València.

Bryan, L. A., & Recesso, A. (2006). Promoting reflection with a web-based video analysis tool. *Journal of Computing in Teacher Education, 23*(1), 33–39.

Cobb, P., Jackson, K., & Dunlap, C. (2015). Design research: An analysis and critique. In L. English, & D. Kirshner (Eds.), *Handbook of international research in mathematics education* (3rd ed.) Routledge.

Cobb, P., McClain, K., & Gravemeijer, K. (2003). Learning about statistical covariation. *Cognition and Instruction*, *21*(1), 1–78. https://doi.org/10.1207/S1532690XCI2101_1

Code.org. (2019). *33 states expand access to K-12 computer science in 2019.* https://codeorg.medium.com/32-states-expand-access-to-k-12-computer-science-education-in-2019-7d2357fe6f3d

Code.org. (2018, August 27). *Girls and minorities break records in computer science as fastest growing group!* Medium. https://medium.com/@codeorg/girls-and-minorities-break-records-in-computer-science-as-fastest-growing-groups-39d23425810e

Edyburn, D. L. (2013). Critical issues in advancing the special education technology evidence base. *Exceptional Children, 80*(1), 7–24. https://doi.org/10.1177/001440291308000107

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47–68.

Evers, A. T., van der Heijden, B. I. J. M., Kreijns, K., & Vermeulen, M. (2016). Job demands, job resources, and flexible competence: The mediating role of teachers' professional development at work. *Journal of Career Development*, *43*(3), 227–243. https://doi.org/10.1177/0894845315597473

Fanscali, C., Tigani, L., Isaza, P. T., & Cole, R. (2018). A landscape study of computer science education in NYC: Early findings and implications for policy and practice. *Proceedings of the 49th ACM Technical Symposium on Computer Science Education*, 44–49. Association for Computing Machinery. https://doi.org/10.1145/3159450.3159467

Graham, S., Collins, A. A., & Rigby-Wills, H. (2017). Writing characteristics of students withlearning disabilities and typically achieving peers: A meta-analysis. *Exceptional Children, 83*(2), 199–218. https://doi.org/10.1177/0014402916664070

Graham, S., Hebert, M., & Harris, K. R. (2011). Throw 'em out or make 'em better? State and district high-stakes writing assessments. *Focus on Exceptional Children, 44*, 1–13.

Gregg, N., & Mather, N. (2002). School is fun at recess: Informal analyses of written language for students with learning disabilities. *Journal of Learning Disabilities, 35*, 7–22. https://doi.org/10.1177/002221940203500102

Hestness, E., Jass Ketelhut, D., McGinnis, J. R., & Plane, J. (2018). Professional knowledge building within an elementary teacher professional development experience on computational thinking in science education. *Journal of Technology and Teacher Education, 26*(3), 411–435. Waynesville, NC USA: Society for Information Technology & Teacher Education.

Hutchison, A. (2020). Computer science for all is a right, not an option. In *Proceedings of the 2019 Connected Learning Summit*. Carnegie Mellon University Press.

Hutchison, A., Nadolny, L., & Estapa, A. (2016). Using coding apps to support literacy instruction and develop coding literacy. *Reading Teacher, 69*(5), 493–503. https://doi.org/10.1002/trtr1440

Hutchison, A., & Woodward, L. (2018). Examining the technology integration planning cycle model of professional development to support teachers' instructional practices. *Teachers College Record, 120*(10), 1–44.

Kopcha, T. J. (2012). Teachers' perceptions of the barriers to technology integration and practices with technology under situated professional development. *Computers & Education, 59*(4), 1109–1121. https://doi.org/10.1016/j.compedu.2012.05.014

Lawless, K. A., & Pellegrino, J.W. (2007) Professional development in integrating technology into teaching and learning: Knowns, unknowns, and ways to pursue better questions and answers. *Review of Educational Research, 77*(4), 575–614. https://doi.org/10.3102/0034654307309921

Pearson, P. D., & Gallagher, G. (1983). The gradual release of responsibility model of instruction. *Contemporary Educational Psychology, 8*, 112–123.

Penuel, W. R., Fishman, B., Cheng, B. H., & Sabelli, N. (2011). Organizing research and development at the intersection of learning, implementation, and design. *Educational Researcher, 40*(7), 331–337. https://doi.org/10.3102/0013189X11421826

Pfeiffer, W. M. (2019, November 1). *There are 700,000 open tech jobs in the US. Here is how companies can fill them.* CNBC. https://www.cnbc.com/2019/06/18/there-are-70000-open-tech-jobs-here-is-how-firms-are-hiring-for-them.html

Rao, K., & Meo, G. (2016). Using universal design for learning to design standards-based lessons. *SAGE Open, 6*(4), 1–12. https://doi.org/2158244016680688

Rose, D. H., Meyer, A., & Hitchcock, C. (2005). *The universally designed classroom: Accessible curriculum and digital technologies*. Harvard Education Press.

Reinking, D., & Bradley, B. A. (2007). *On formative and design experiments: Approaches to language and literacy research*. Teachers College Press.

Rich, P. J., Jones, B., Belikov, O., Yoshikawa, E., & Perkins, M. (2017). Computing and engineering in elementary school: The effect of year-long training on elementary teacher self-efficacy and beliefs about teaching computing and engineering. *International Journal of Computer Science Education in Schools*, *1*(1), 1–20. https://doi.org/10.21585/ijcses.v1i1.6

Scratchjr.org. (2015). *What is ScratchJr.?* http://www.scratchjr.org/about.html.

Thomas, D. R. (2006). A general inductive approach for analyzing qualitative evaluation data. *American Journal of Evaluation, 27*(2), 237–246. https://doi.org/10.1177/1098214005283748

Vee, A. (2017). *Coding literacy.* The MIT Press.

Wille, S., Century, J., & Pike, M. (2017). Exploratory research to expand opportunities in computer science for students with learning differences. *Computing in Science & Engineering, 19*(3), 40–50. https://ieeexplore.ieee.org/document/7914581