Finding Balance: The Tradeoffs in Ambition and Specificity When Creating an Inclusive Computing Pathway

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ABSTRACT

Over the last three years, we have worked in a research practice partnership (RPP) between a research non-profit and three school districts to establish system-wide K-12 pathways that support equitable participation in computational thinking (CT) that is consistent across classrooms, cumulative from year to year, and competency-based. Reflecting on the work done over the last three years, we have identified tensions related to ambition and specificity within our RPP and the development, implementation, and spread of inclusive computing pathways. Ambitions can waver between grandiose upheaval in curriculum and classes and the identification of CT solely in what is already happening. While it is relatively easy to adopt and spread programs that propose modest change, these programs are not necessarily worth an investment nor do they produce CT skills in alignment with the district's overall vision. Similarly, the specificity in which computational thinking is operationalized can teeter between prescriptive lesson plans and broadly-stated curricular standards. Vague initiatives are difficult to implement, but teachers are also resistant to overly prescriptive programs. In this paper, we explore these tensions balancing ambition and specificity using examples from our partner districts. Drawing on our experiences co-designing the inclusive computing pathways as well as interviews with and open-ended questionnaire responses from our district partners, we discuss implications related to these issues and the ongoing tensions around ambition and specificity that need to be considered and overcome in order to meet the national call to develop more inclusive computing pathways for schools and districts.

CCS CONCEPTS

• Social and professional topics ~ Professional topics ~ Computing education ~ Computational thinking • Social and professional topics ~ Professional topics ~ Computing education ~ K-12 education • Social and professional topics ~ Professional topics ~ Computing education ~ Computing education programs ~ Computer science education

KEYWORDS

Computational thinking, computing pathway, ambition, specificity, computer science education

1 Introduction

Over the last decade, computer science (CS) and computational thinking (CT) education has increased its presence within schools internationally. As both CS and CT have become requirements within school systems globally (e.g., New Zealand [3], England [4], Israel [1], United States [8]), CT has been identified as a means to integrate computing into disciplinary subjects to both provide a greater number of students with computing skills as well as to enhance disciplinary learning [13,14,19,30]. As careers increasingly include elements of computing and motivations for CT integration expand to focus on how students can use computing to express their creativity, advocate for a more just and equitable world, and develop a more innovative society [25,27], CT is becoming increasingly important in education. As such, CT curriculum and initiatives exist that provide learning opportunities for youth both in formal and informal learning environments.

Despite the increasing prevalence of CS and CT opportunities for students, inequities remain around who participates in these opportunities and their experiences. Physical, social, and psychological barriers exclude Black, Indigenous, and Latinx students, students who identify as a women or non-binary, and students with disabilities from computing opportunities [17,18,28]. In our work, we are focused on decreasing these barriers and creating equitable and inclusive computing opportunities for students across the K-12 spectrum. In a research practice partnership (RPP) [7] between three school districts and a research non-profit, we have worked to develop inclusive computing pathways that will provide all students within the school districts, particularly those excluded from computing, with opportunities to learn CT and CS. Looking at the inequities in who participates in elective high school CS offerings, our districts have come to the conclusion that their existing patchwork of opportunities to learn computing is at fault and instead a cumulative, consistent, and competency-based pathway is necessary to provide computing opportunities for students from kindergarten through 12th grade (the span of compulsory education in the United States).

As our RPP concludes its third year of working together, in this paper we look back at the individual processes the districts went through as well as trends across the districts to provide insights for new districts seeking to design, develop, and implement an inclusive computing pathway. Across our three partner districts, researchers and district leaders observed tensions related to how ambitions and specific a pathway needs to be to be successful given unique characteristics of the districts. Given the importance of providing comprehensive and inclusive computing pathways for all students K-12, in this paper we examine the tensions felt by the districts relating to ambition and specificity. We present data from the district leaders regarding how these tensions were felt within their district and strategies they used to overcome the tensions. We aim to answer the research questions:

1. How do school districts experience and alleviate tensions related to the ambitiousness of a novel inclusive computing pathway?
2. How do school districts experience and alleviate tensions related to the specificity of a novel inclusive computing pathway?

This paper contributes to the growing knowledge of how districts can develop an inclusive computing pathway and aims to support researchers and practitioners working in partnership to anticipate, plan for, and overcome the tensions they experience related to ambition and specificity.

In section 2 we review prior literature on CT in K-12 spaces, tensions when scaling educational programs, and measuring scale up. Through this literature, we define specificity and ambition. Next, in section 3, we detail our methods for completing this work including providing descriptions of each of our partner districts. In section 4, we present the findings of our work using illustrative cases from our partner districts to highlight facets of the tensions of specificity and ambition. Finally, in section 5, we discuss these findings and implications for work broadly within CS and CT education and the creation of inclusive computing pathways.

2 Literature Review

This work is grounded in literature regarding the integration of CT within K-12 education and evaluation literature on tensions in scaling educational programs and measuring scale up. In the following section we provide a brief review of these literatures as they relate to the present work and define the concepts of ambition and specificity.

2.1 Integrating Computational Thinking

Adding opportunities for all students to learn computer science to the K-12 curriculum is not easy because requirements already fill the curriculum [12]. Further, many of these requirements have mandated accountability via statewide assessments, and thus it is not an option to reduce the time dedicated to the existing core subjects to make room to add a new core subject. Consequently, computer science is often first added to the curriculum as an elective, summer, or afterschool activity [e.g., 15,29,32]. Unfortunately, confining CS to electives or extracurriculars tends to maintain inequities; this strategy does not broaden participation [8].

As an alternative, researchers have called for *integration* of computational thinking into existing core curriculum [13]. For example, projects have developed materials that integrate computational thinking with coursework in science [30], English [5,20], and more [16]. Through such integration, students are not only exposed to computing, they also learn to use CT skills and practices to enhance their disciplinary learning [13,19,30]. The term “computational thinking” encompasses competencies with topics such as algorithms, data, and simulations, as well as practices like debugging and abstraction. [2,10,31]. Integrating CT into compulsory education has been proposed as a viable strategy to broaden participation in computing, particularly for students who experience marginalization and are disproportionately enrolled in elective coursework [31].

In practice, many school districts provide all three possibilities: elective courses (e.g., AP Computer Science), extracurricular activities (such as robotics clubs), and integration of CT into existing curricular requirements. Through a combination of these three opportunities to learn computing, districts focus on creating a pathway for students to learn CT beginning in early elementary school and continuing through high school [22]. These pathways aim to not only provide computing experiences for all students, but to do so in ways that are purposefully equitable and inclusive and that work to counter the effect of exclusion in computing spaces.

2.2 Tensions in Scaling Educational Programs

The goal of increasing CT integration to reach all students implies scaling up. Scaling up has long been a topic in educational research and evaluation, and much is known about the challenges that arise as educational institutions take programs that were initially developed and tested at small scale and now will be implemented in many more districts, schools, and classrooms [9]. Evaluators have observed that scaling a program involves going from an *intended* curriculum (what the program developers plan and envision) to an *enacted* curriculum (what teachers and students do) [21]. Gaps between an intended and enacted curriculum can arise at scale for many reasons, two of which have been found to be important in program evaluation [23] are applied in the analysis that follows.

Ambition refers to distance between existing classroom practice and what a new curricular program asks teachers and students to do. When the distance is large, fewer teachers and students can easily enact the new program. They may stop using materials or enact them for a short time or in shallow ways. Conversely, when the distance is small (for example, using new worksheets to replace existing worksheets in a math course), a curricular change can be easier to scale with fidelity to intentions. Ambition is a tension in designing and implementing curricular change. Too much ambition will be unrealizable, too little is not worth doing.

Specificity refers to a continuum from highly prescribed teaching and learning activities to merely suggestive teaching and learning activities. When a new curricular program is at least somewhat ambitious, teachers and students will not know what to do. On one extreme, materials may tell them exactly what to do in a step-by-step fashion. On the other extreme, materials may give broad guidance that requires much local elaboration by teachers and students into activities they can do. Highly scripted materials are hard to adapt to local needs and may undermine teacher expertise. Yet if the expectations of what teachers and students can elaborate on their own are too high, they might not be able to figure out what to do or may elaborate in ways that result in enactment that drifts far from intended learning goals. Thus, both ambition and specificity are tensions that must be resolved as local school participants figure out how to go from an intended to an enacted curriculum.

2.3 Measuring Scale Up

The easy definition of scale up as achieving a large number of users for a new curricular program may be easy to measure in terms of exposure and access, but it can also fail to measure what is important in terms of continued engagement and changes in actual practice. Educational researchers today define scale up in terms of depth, spread, shift of ownership, sustainability and evolution [6,11]. *Depth* means that curricular enactment provides opportunities for students to progress to advanced proficiency in the intended curriculum, in contrast to experiencing a watered-down, light coverage only. *Spread* incorporates equity by considering which populations a new curriculum program reaches and for whom it provides intended growth in competencies. *Shift of ownership* considers the extent of the transition from the original provider to local schools, teachers, parents, and students, and to what degree such parties continue a program because they adopt it as their own desired approach rather than based on top-down compliance measures. Though *sustainability* and *evolution* are likewise key elements, this research herein will not use these additional two elements because the timescale is too short for sustainability and evolution of programs to come into play.

3 Methods

We worked in an RPP [7] between an educational research non-profit (Digital Promise) and three school districts (Indian Prairie School District (Illinois), Iowa City Community School District (Iowa), Talladega County Schools (Alabama)) to develop inclusive computing pathways in each of the three districts as part of a three-year project. While the three districts and research team co-designed a general structure for the pathway development process together, each district adapted the structures to fit the unique attributes and specific ambitions of their schools and communities. Each district identified a district lead for the work. In the following section we first introduce each of the school districts. Then, we detail data collection and analysis used within the present work.

3.1 Partnering School Districts

The three partnering school districts were selected to purposefully represent a diversity of contexts. All three districts had some computing offerings within their schools before working in the RPP, but these opportunities often varied by school or grade level and data from the districts demonstrated inequities in offerings and course registration across student demographics. Prior to beginning the work, each district identified an equity goal, typically a population or set of schools within the district who were excluded from or did not offer computing courses, on which they focused throughout the work. Details about each district and their equity goals are provided below.

3.1.1 Indian Prairie School District

Indian Prairie School District (IPSD) is a suburban district located outside of Chicago in Illinois. IPSD has a student enrollment of around 28,000 students across 31 schools (21 elementary, 7 middle, 3 high). Within IPSD, about 12% of students identify as Latinx and 9% of students identify as Black. Seventeen percent of students have been identified by the district as low-income. IPSD set the equity goal of focusing on a cluster of five Title I elementary schools within the district and increasing computing opportunities within these schools. This goal sought to ensure that computing was occurring in all parts of the district rather than only in specific schools. Prior to developing their inclusive computing pathway, IPSD offered robotics K-12 and had specific computing-integrated technology courses for middle school students (grades 6-8) and CS courses offered at the high school level (grades 9-12). Additionally, the elementary school and middle schools had makerspaces, often within their library media centers.

3.1.2 Iowa City Community School District

Iowa City Community School District (ICCSD) is an urban school district located in Iowa City, Iowa. The district serves around 14,500 students across 28 schools (21 elementary, 3 junior high, 4 high school). Across the district, 12% of students identify as Latinx, 19% identify as Black, and 37% have been identified as low income. ICCSD identify the equity goal of focusing on improving access to computing for their Black and Latinx students, including students who have been designated as English language learners. Prior to building their inclusive computing pathway, ICCSD offered robotics clubs at the elementary, middle, and high school levels and CS courses for high school students.

3.1.1 Talladega County Schools

Talladega County Schools (TCS) is a rural school district in Talladega County, Alabama. The district enrolls 7,500 students and has 17 schools (7 elementary, 3 junior high, 7 high school). Two percent of TCS students identify as Latinx, 33% identify as Black, and 71% have been identified as low income. TCS set an equity goal of increasing computing offerings for students from low socio-economic households as well as students who identify as girls. The district is a leader in STEAM (science, technology, engineering, art, and math) education and prior to implementing their inclusive computing pathway, TCS had CS and CT materials available to teachers such as robotics and maker kits and materials for using Scratch and simulations, but these materials were not used consistently.

3.2 Data Collection

Two data sources are reported upon within the present work: (1) an open-ended questionnaire and (2) follow-up interviews with district leaders. These data were collected at the close of the three-year project. While other data were collected during the project (i.e., exit tickets, field notes, focus groups, lesson plans), this paper reports upon the opportunity for district leads to reflect individually and together on the inclusive computing pathway development process and the tensions within ambition and specificity.

he three district leads were asked to complete a questionnaire about ambition and specificity within their district pathway and their development process they used to develop that pathway. The questionnaire included nine questions, four about ambition and five about specificity. The questions were purposefully open-ended and were given in a questionnaire format to provide the district leaders the time to think through their responses rather than answering immediately. Questions included "We are interested in 'ambitiousness' of a CT Pathway as a tension. Describe how your district experienced the tension of being 'too ambitious' (asking teachers to change too much) and 'not ambitious enough' (allowing teachers to avoid change)" and "What characteristics of your district play a role in how specific your CT pathway and the related changes could be?"

After completing the questionnaire, the district leaders participated in interviews with the research team to learn more about their answers and ask follow-up questions. The semi-structured interview protocol was developed based on responses to the initial questionnaire. One or two districts participated in each interview and interviews lasted 30 minutes. The interviews were audio recorded and transcribed.

3.3 Data Analysis

Once all of the districts had completed the questionnaire, one researcher read through all responses and inductively open coded the responses using descriptive coding [24]. These codes were discussed with the entire research team and were used to develop a set of inductive codes (Table 1). Then, two researchers separately coded all questionnaire responses using the codes. Following coding, the two researchers met and discussed any coding discrepancies to reach 100% agreement on the coding.

This coding was used to develop the follow-up and clarifying questions used during the interviews. Following the interview, the interview transcripts were coded using the same inductive codes by the same two researchers. The researchers again met to discuss any differences in their coding and discussed the coding to reach 100% agreement.

Code	Code Definition	Example
Ambition		
Speed	This code describes the speed at which the CT initiative took place. This includes discussion of the initiative moving slowly or quickly, opinions about the speed of the initiative, and the overall timeline for the initiative. This also includes discussion of specific phases of the initiative if it relates to timing.	"Again, this takes time, but allows teachers to onboard when ready and with support at the building level."
Scale	This code describes the overall scale of the initiative including how many teachers or schools are involved. This includes descriptions of how the initiative was rolled out if they relate to the specific teachers or buildings involved, the use of small groups, and the requirements on individual teachers.	"We decided early on to frame our CT Pathways work as a district-wide initiative."
Scope	This code describes the types of changes that were necessary to implement the CT Pathway. This includes discussion on introducing novel elements to the curriculum/school system, discussion of foundations on which the CT initiative is built and ways those foundations have been utilized, and the specific changes made to enact the CT Pathway.	"We've really tackled this by trying to provide the best of both worlds. On one hand, highly-specified curriculum (PLTW), while on the other, an opt-in (so far) model that provides teachers with the skills and resources necessary to incorporate CT into their existing curriculum."
Specificity		
Competencies	This code includes the use of definitions, specific competencies, and describing a shared vision in order to clarify/specify what computational thinking is. This includes description of instructional strategies for integrating competencies and using these competencies within the classroom and in teacher professional development. It also includes creating shared understanding through the use of competencies, visioning, and definitions and discussion of creating, editing, or using the district competency map.	"…spend time in the beginning describing both the "why" of the work and develop a common vocabulary for our work."
Curriculum	This code includes all discussion of curriculum, teaching materials, lessons, and resources. This includes discussion of specific curriculum used, assessments, and reasons for choosing those curricula. This also includes discussion of integration of computational thinking within disciplinary subjects and the level of innovation within these integrations.	"We need to be able to ensure that all students, in all schools, have access to high-quality curriculum that addresses CT competencies and the CSTA standards."
Collaborative Professional Development	This code includes all mentions of professional development, teacher support, and professional learning related to the inclusive computing pathway.	"Our best learning has happened when we provide opportunities for our staff to experience CT in action in relation to their curriculum and instruction."
Choice	This code includes discussion of teachers having autonomy and making decisions related to the enactment of the inclusive computing pathway.	"This ensured that teachers had choices and options to use when planning."

Table 1: Analysis codes, definitions, and examples

4 Findings

We examined the facets of the tensions of ambition and specificity faced by our district partners when developing and implementing inclusive computing pathways. We found that ambition needed balancing in three areas: speed, scale, and scope. Likewise, we found four areas where districts needed to balance specificity: competencies, curriculum, collaborative professional development, and choice. Answering our research questions, we define each of these seven areas and provide an example of how the area manifested in one of our partner districts. The examples describe both how the district experienced the tension and their actions toward alleviating it. In some cases, we compare and contrast district experiences across the designated area; however, in what follows, for the sake of space, these illustrations are usually singular examples and highlight the tension in one particular district, even though similar tensions may have existed in the other two districts as well.

4.1 Ambition: Speed

District leaders discussed needing to find a balance with the speed of their pathway rollout. All three districts began with three- to five-year timelines for the rollout of the new initiative and aligned these timelines to the speed at which past initiatives had been implemented. This included a year for research and development, one or more years for piloting, and a final stage of scaling and growth within the district. Yet, these timelines shifted depending on the needs of the district and external factors. One external factor that greatly affected the speed at which districts could rollout their timelines was the COVID-19 pandemic, which began in the middle of the second year of the project.

In Iowa City, district leaders needed to balance the speed at which teachers who were part of the early initiative and pilot wanted to move with how fast something could be implemented across the district. When the project began, the district expected the project "to be a multi-year project and more than the three years" of the grant. The district planned to spend the first year defining and refining the pathway, the second year testing and piloting the pathway, and the third year scaling up, although not to the full scale of the district. In total, the district leadership planned a five-year timeline where by the end of the fifth year the entire district was using the pathway. According to the district leader, the slower timeline in the first years where only certain schools or teachers were targeted was "obviously non-ideal in terms of meeting the demands of the more ambitious faculty who would like to see us scale this initiative more rapidly, but is a necessary approach at this time." As a medium sized school district (and a large school district for their state), it was important for Iowa City to have a gradual rollout that allowed them to show success as a proof of concept when growing and making larger-scale changes than just implementing in a few schools, as they did in the pilot. The slower speed of their initiative along with the longer five-year timeframe allowed opportunities for early adoption and successes before larger spread.

4.2 Ambition: Scale

The ambitiousness of district scaling varied across our three partner districts. For each, the rate at which they could increase the number of teachers or schools involved in the initiative varied. This rate of scaling was influenced by both the size of the district and existing systems in place to roll out initiatives.

From early in the pathway development process, Talladega decided "to frame our CT Pathways work as a district-wide initiative." After three years, all 17 schools in Talladega are involved in the pathway work, reaching 7,000 students. Teachers "are able to collaborate with teachers from other schools" and the project has been successful because of "teacher leaders because they do have to have the buy in and when they are excited about something it kind of spreads in their building." According to the district leads, the inclusive computing pathways initiative was successful because "all 17 schools had been involved in PBL [project-based learning] and STEAM, we just keep them all involved in the computational thinking as well." One reason this large-scale effort was important to the district was ensuring equity for all students. They wanted "to make sure that, that no matter where they [students] go to school or what grade band they were going to get exposed to this [CT]." Leveraging their small size and these existing structures, Talladega was able to reach a large scale in a short period of time—within eight months.

For Indian Prairie, reaching the full size of the district means expanding to 31 schools and 28,000 students. According to the district leader, "to get every, every building and every grade level moving in the same direction is sometimes difficult because we have a lot of initiatives." Due to the size of their districts, the "district has a long-standing practice of allowing many instructional shifts to happen organically. The early adopters engage in professional learning and introduce the concepts to students. Through the evolution of the change additional teachers join in the work." By getting a few teachers who "have a natural connection to it, have shown an ambition toward this, who are ready to go and adapt" and then using their success to get a classroom neighbor or grade level colleague involved, Indian Prairie is able to have initiatives "trickle" into buildings and develop a stronghold in the district. Within Indian Prairie, the most effective professional development has been small scale, having teachers participate in several meetings over a period of time. But, this does not allow the district to reach all teachers or buildings quickly. Using professional development, all school buildings within Indian Prairie have been exposed to computational thinking, but not all teachers in those buildings have received the professional development and using the pathway.

4.3 Ambition: Scope

The third area in which districts needed to balance ambition was the scope of the changes they sought to make. The exact scope of the inclusive computing pathway was different for each district, but all three districts worked to build their CT initiative on existing district programs and curricula through strategic alignments. Within the scope of changes, districts considered the degree to which they integrated computational thinking into courses verses the development of new CS or CT specific courses, using a prescribed or flexible curriculum and who developed that curriculum, and how CT was aligned with and expanded existing programs.

Talladega has been able to take on a more ambitious scope because they had an "established framework of teacher leaders who would advocate for positive, innovative change" and they followed a process that had been successful in other initiatives. The teacher leaders included "experts down the hall", school-level technology coaches, and the math and science leadership teams who participated both in the development of the pathway as well as supporting their fellow teachers as the pathway was implemented. According to district leaders, "the key was to connect computational thinking to previous learning." In order to do this, the district focused on first "describing both the 'why' of the wok and develop[ing] a common vocabulary for [the] work" before turning to the competencies and, finally, to integrated CT within the curriculum. This allowed for a strong foundation on which to build out a larger program.

Grade 3: *By the end of Grade 3, what will ALL students **know and be able to do?***				
Relevant Standards (From Alabama DLCS)	**What do the Standards Mean?** (Unpack/Restate in your own words.)	**Key Vocabulary** (Students will KNOW / understand…)	**What Does it Look Like in Class?** (Students will be able to DO…)	**Opportunities to Learn** (Lessons, Resources, etc.)
ABSTRACTION				
DLCS 1. Use numbers or letters to represent information in another form. Examples: Secret codes /encryption, Roman numerals, or abbreviations.	I can use numbers and letters to represent information in another form.	**Encryption –** the process of turning data into a code **Secret Codes –** a secret method of writing **Roman Numerals –** any of the letters representing numbers in the Roman numerical system **Abbreviations –** a shortened form of a word or phrase	**Math** - Explain how equations are balanced. - Use Roman numerals to write numbers differently. - Explain how equivalent decimals and fractions are examples of the same information in different forms. **ELA** - Illustrate or write instructions on breaking secret codes in expository text. **Science/SS** - Create secret messages that may have been sent during different historical events.	Nearpod Lesson: Coding Lessons to strengthen coding skills Khan Academy: Journey into Cryptography Assess the students' understanding of code breaking presented in the ancient cryptography lesson. Purdue.edu: Encryption for kids Introduction to cryptology. Scholastic: Writing Secret Messages Using Ciphers How to use ciphers to create a secret message.

Table 2: Talladega County School District Competency Map for Grade 3, Abstraction

Talladega elected to focus the scope of their inclusive computing pathway on integration within existing curricula across disciplines. Discussing this integration, the district leaders noted, "it was important for us to make sure teachers could see the connection with what they were already doing in their classrooms." Talladega focused on having a group of teachers develop their competency map with connections to standards, objectives, vocabulary, disciplinary subjects, as well as example lessons and resources for each grade level (Table 2). Having a homegrown program developed by Talladega teachers was, according to district leaders, "the reason our initiative was successful…teachers actually did the work of learning and creating." While Talladega's competency map and inclusive computing pathway is very ambitious, this ambition was made possible by their combination of building on past successes, programs with support in schools, and building the new initiative within the district.

4.4 Specificity: Competencies

In order to guide the new CT initiatives, each school developed a competency map. Similar to that of Talladega described above, each competency map identified four to six computational thinking competencies that cumulatively build across grades or grade-bands. Given the varied definitions of computational thinking [26], the identification of competencies was important for each district to develop their own definition that aligns to state or national standards. This gives each district a shared vocabulary and pacing that is specific to their district and needs.

Indian Prairie identified six competencies: decomposition, pattern recognition, abstraction, algorithms, working with data, and creating computational artifacts. Since the state of Illinois did not have computer science standards when they created their map, Indian Prairie developed these competencies based on definitions of computational thinking by leading computer science education organizations (e.g., International Society for Technology in Education, Computer Science Teachers Association). In order to ensure that all teachers within their district defined their competencies similarly, IPSD created a definition page at the beginning of their competency map (Table 3). This page not only defines each competency, but also makes connections to other initiatives within the district: World of Work (career connections) and design thinking. The combination of the shared definitions as well as the competency map as a whole "provided defined learning outcomes for all grade levels and subjects that are developed in collaboration with teachers and [the] district curriculum and instruction team." Over the last three years, Indian Prairie has worked to help teacher see how their instructional approaches already had and could be enhanced by CT. According to district leadership, "they [teachers] just needed to highlight when it was happening and the vocabulary." After a few years of learning about and using CT, a visitor to an IPSD classroom would see teachers "highlighting and leveraging these competencies in their classroom." While IPSD has focused on providing examples and strategies for integration for their teachers, competencies have been at the core of their efforts and they have used these competencies to provide specificity for their initiative without removing teacher autonomy.

Computational Thinking- KEY ELEMENT/CONCEPTS

IPSD Adopted Definition: Our goal is to help all learners become computational thinkers who can harness the power of computing to innovate and solve problems. *(Adopted from ISTE Computational Thinking definition)*

Decomposition: Breaking down a complex problem or system into smaller, more manageable parts.

- Career Connection: Project managers often get clients who want them to build very large and complex programs. To understand what a big project will take, these pros need to break it down into many small elements so they can figure out how to approach the project. *(Design Thinking Stage: Look, Listen and Learn; Understand the Problem)*

Pattern Recognition: Looking for similarities among and within problems.

- Career Connection: Professionals look for patterns in their problems and try to solve them based on solutions they've used before for other problems that were similar. *(Design Thinking Stage: Look, Listen and Learn; Understand the Problem)*

Abstraction: Removing details from a solution so that it can work for many problems.

- Career Connection: Creating computer models, professionals determine that some details are just not necessary in creating a visual prediction. *(Design Thinking Stage: Navigate Ideas; Build Prototypes)*

Algorithms: Developing a step-by-step solution to the problem or the rules to follow to solve the problem.

- Career Connection: Behind every computer automation, there is a computer program. Behind every computer program, there is an automation. *(Design Thinking Stage: Navigate Ideas; Build Prototypes; Highlight and Fix)*

Working with Data: Collection, representation, and analysis.

- Career Connection: Computers can be used to collect, store and analyze massive amounts of data quickly and reliably. Computer programs can use data to make decisions or to automate tasks. *(Design Thinking Stage: Look, Listen, and Learn; Understand the Process/Problem; Build Prototypes)*

Creating Computational Artifacts: Embraces both creative expression and the exploration of ideas to create prototypes.

- Career Connection: Professionals create artifacts that are personally relevant or beneficial to their community and beyond. Computational artifacts can be created by combining and modifying existing artifacts or by developing new artifacts. Examples of computational artifacts include programs, simulations, visualizations, digital animations, robotic systems, and apps. *(Design Thinking Stage: Navigate Ideas; Build Prototypes; Highlight and Fix)*

Table 3: Indian Prairie School Competency Map front page

4.5 Specificity: Curriculum

All three partner districts provided curricular supports to their teachers, particularly to teachers who were new to incorporating CT in their classrooms. Yet, this looked very different in each district based on the needs, norms, and affordances of the districts. Below we present the curriculum solution of each district partner to demonstrate the variety of curriculum specificity provided within their CT initiatives. For all three districts, embedding within existing curriculum features was important for specificity and districts had to help teachers balance between simply identifying that CT exists in lessons they already do and enhancing disciplinary learning by adding and highlighting computational thinking.

In Indian Prairie, the district has focused significantly on the competencies, as described above, particularly in the lower grades where the district does not have designated technology or computer science courses. As such, they have developed examples and strategies for integration to provide to teachers rather than a set curriculum they need to follow. According to district leaders, "it is difficult to provide a prescribed scope and sequence for computational thinking because we wanted to embed the competencies into all instructional areas." Yet, the district leaders have noted that examples only go so far. Although they "developed example lesson plans for teachers at the K-5 grade level…the difficult part with this approach is that unless you are teaching the specific grade level and subject you cannot utilize the lesson with students." While the teachers asked for these examples, "they were not used as much as we [district leaders] hoped." Instead, the district is shifting to highlighting integration strategies (e.g., creating a story timeline, data-driven science experiments, creating infographics) that can be used within any context and they continue to balance curricular specificity.

In Iowa City, the district elected to use a pre-packaged curriculum as a feature supporting teachers and creating clear expectations. The district has adopted Project Lead the Way (PLTW) classes both for technology and science courses. The courses integrate CT and provide teachers with a prescribed curriculum and professional development. This approach has not been without pushback. According to district leadership, "we've had some pushback from our science program coordinator about a perception that our approach of tying CT instruction into science curriculum is limiting science curriculum." Despite this pushback, overall, the district leader feels that the "PLTW programming has been well-received" and while, PLTW "offers a great deal more specificity than most curriculum in the district," this specificity has led to success because it can be implemented with fidelity and provides support for teachers who are not familiar with CT. Although the prescribed curriculum has been successful to date, the district continues to "engage in active evaluation of whether PLTW continues to be our best option going forward." The specificity of the curriculum, particularly with such a defined curricular solution, is an ongoing tension that was not, and cannot be expected to be, balanced within the three initial years of the project. It will continue to be an ongoing balance.

Talladega created their own specified curriculum because they felt that using a pre-packaged solution would cause more specificity tension due to the norms and needs of the district. According to the district leader, the "goal with our CT Pathways was to embed those opportunities in every class, no matter the content area." Creating their own curriculum not only allowed Talladega to meet their goal, but specificity "wasn't an issue for [them] since [they] didn't buy a prepackaged solution." Beginning with their middle school science teachers, Talladega brought together their teachers "to work together to plan lessons, teach lessons, [and] reflect on them together." It was "so successful that we see the value in doing that with other groups as well." Their final curriculum map (Table 2) uses detailed lessons and resources along with a grade-by-grade map to provide teachers with structure and support regarding what they need to do to integrate CT within their classroom.

4.4 Specificity: Collaborative Professional Development

Professional learning opportunities played an important role in balancing ambition and specificity and the successful spread of the district CT initiatives. All three districts began with small, collaborative groups who helped to build the competency maps, examples, and other resources to support the CT initiative. Often, these groups were also pilot teachers. In this way, the inclusive computing pathway planning time was also collaborative professional development that allowed teachers to discuss and learn from one another. According to the district leader of Indian Prairie, these small, collaborative groups were the most effective professional learning opportunities for teachers. How these small, collaborative groups grew into larger district professional development initiatives differed depending on the district, and in some cases is still something that is being balanced, particularly due to the disruption in implementation caused by the COVID-19 pandemic. This growth included utilizing building teacher leaders to educate each other, on-demand professional development as requested by building administrators, teachers attending curriculum professional learning sessions, and a combination of these (and other) options.

In Iowa City, where expansion of the inclusive computing pathway has been slower, the district has "had to mete out training opportunities, and target specific groups for training and program expansion." They have done this through the use of PLTW and having teachers attend the PLTW trainings each summer as well as developing their own district "professional learning-focused approach to integrate computational thinking into [their] existing curriculum." This is viewed as a complementary approach. According to the district leader, by utilizing the established and highly specified PLTW training, the district can "be pretty confident, because we are providing them [teachers] with all the specific materials, that what they teach will be exactly what they're supposed to teach." This is especially supportive for teachers who might not have a strong background or inclination toward science, the main subject in which the district is integrating CT, or CT itself. Yet, the district leaders do not want to limit teachers. As such, they are providing district professional development over the summer and the district is working to launch a micro-credential program using the credentials available through Digital Promise. The district will "incentivize teachers to earn, in this case CT focused micro-credentials, which are geared largely towards adapting their existing curriculum." In this way, teachers will be able to integrate not only in science using the PLTW content, but also in other subjects using lessons they develop on their own.

4.4 Specificity: Choice

The level of choice teachers had about how they taught CT and what lessons they used varied by district and even within districts. Districts needed to balance the amount of choice provided to teachers with the complexity and novelty of CT concepts. This balance meant providing teachers materials that were specific enough that they could accurately and confidently write and implement lessons focused on CT, but not so specific that teachers lost their autonomy and felt their expertise was in jeopardy.

The tension of specificity with regards to teacher choice was especially salient in Indian Prairie where there is "a long-standing practice of allowing many instructional shifts to happen organically" and "teachers have the autonomy to adjust as needed to meet the needs of students in their classrooms." Because of this, Indian Prairie has adopted a less specific inclusive computing pathway than the other districts and is relying on examples and suggested implementation strategies rather than a scripted or district-wide curriculum. In this way, they "trust the professional in the room to provide student learning experiences that will benefit the students in front of them." While this is not without its own challenges related to other areas of the tension of specificity, this teacher choice centered approach fits with both the norms and needs of Indian Prairie and is aimed at promoting teacher buy-in, rather than leading to push-back against new ways of doing things along with the new content.

5 Discussion

The tensions of ambition and specificity will come up in the development of any new innovation, including the development of an inclusive computing pathway. Being intentional about choices as they relate to ambition and specificity can help districts make computing initiatives more relevant to their schools and communities and, ultimately, more successful. In this paper, we aimed to examine how our partner school districts experience and alleviate tensions related to ambitiousness and specificity when implementing a novel inclusive computing pathway. We found that districts needed to balance the tensions of ambition with regards to speed, scale, and scope and the tensions of specificity with regards to competencies, curriculum, collaborative professional development, and choice. Districts learned that in order to balance these tensions, they needed to make trade-offs. For example, specificity in curriculum supports can provide greater speed in terms of more immediate classroom implementation, but can hinder having an ambitious scope across disciplines and these supports can take a narrower view of the competencies. Each of the districts balanced ambition and specificity in unique ways, demonstrating that there is no one way to successfully scale an initiative and the importance of customizing scaling to the needs and norms of a district. Yet, certain strategies were especially successful across the districts despite their differences in size and location. For example, grounding the inclusive computing pathways in existing initiatives to strategically align to what was happening not only created opportunities for scaling and a clearer scope of where to implement CT, but also provided springboards on which teachers and district personnel could build successfully. Additionally, the use of teacher leaders as experts within and across schools provided opportunities for collaboration that led to not only professional learning for the collaborating teachers, but also to successful identification of competencies and development of curricula that allowed the districts to implement their inclusive computing pathways.

The three areas of ambition which require consideration (speed, scale, and scope) aligned with previously identified dimensions of scaling [6,11], particularly those visible and present within the shorter timeframe in which this work has been executed. Coburn [6] identified the dimensions of *depth*, *spread*, and *shift in reform ownership*. Within the present work and the defined areas of ambition, depth relates to the scope of the work. Work that has a narrow scope and does not ambitiously make change likely also has a shallow depth, leading to change in only "surface structures or procedures" rather than "alter[ing] teachers' beliefs, norms of social interaction, and pedagogical principles" (p. 4) as is the goal according to Coburn [6]. Additionally, spread relates to the scale and speed at which an initiative is implemented. The present work highlights Coburn's definition of spread focused on not only having a greater number of schools or classroom involved, but also spreading norms and pedagogical principles. Using the careful tactics of scale and speed employed by each of our partner districts, spread includes not only having more students gain exposure to CT, but also ensuring that they receive equitable and rich learning experiences. While not described in this paper, we have also explored the shift of reform ownership within the districts. As initiatives spread, sharing leadership has emerged as a key aspect of this shift (see [22] for further details).

Despite the identification of inductive categories and distinct trends when balancing specificity and ambition, we identified significant overlap between these two tensions. While balancing ambition requires attention to speed, scale, and scope, a major part of scope is thinking about elements of specificity. In order to decide on the scope of changes to be made and how ambitious those changes can be, district leaders need to consider the curriculum, professional learning, and understandings that teachers currently have and will need. The tensions related to specificity are actually embedded within the tension of ambition and are, at least in part, the building blocks of scope. That is, the specificity of an initiative is tied to the level of ambitiousness and part of negotiating the level of ambition within an initiative is defining the specificity within it. This is not to say that specificity cannot be considered on its own or that elements of specificity and finding balance within specificity does not also require taking into consideration the ambitiousness of the initiative. When balancing competencies, curriculum, collaborative professional development, and choice as part of the specificity of the initiative, the scale and speed of the rollout must also be considered. Different levels of specificity can be reached at different speeds and scales. As such, districts must consider not only how ambitious their inclusive computing pathway or other initiative is, but also how specific it will be and the balance not only within ambition and within specificity, but between the two concepts as well. Although a challenge that arises could pertain only to ambition or specificity, it is likely that challenge will interplay with both tensions and a balance will be required across the two concepts.

When implementing a new district initiative, these data suggest a small beginning that builds upon current district initiatives and work will help to balance ambition and specificity from the start. Yet, it is important to keep these facets of scaling under consideration from the beginning of the development process. A limitation of the current work is the current three-year timeline does not allow for the elements of sustainability and evolution to be thoroughly examined. Going forward, there is a need to examine how ownership connects to sustainability and have our district leads make predictions about what they see as the potential evolution of their current inclusive computing pathways. Additionally, future work should continue to follow scaling within these districts to examine the sustainability and evolution of their inclusive computing pathways and how the tensions of ambition and sustainability continue to play a role in the pathway development.

As demonstrated by the district cases on curriculum, ambition and specificity will require continuous balancing as both the initiative progresses and new considerations arise. While there is no "sweet spot" that is perfect for every district, each district can find their spot through consideration of the factors that will influence each tension and ways to alleviate them. While this work centers around the development of inclusive computing pathways within an RPP that includes three districts, these tensions are likely to exist no matter the subject of the initiative that is being developed, implemented and scaled. This is supported by the alignment between our findings and past work on scaling. Ambition and specificity will be ever-present tensions within any implementation, consideration of the areas that require balancing and planning as well as purposeful examination of the district will support successful scaling of new initiatives within districts and beyond.

6 Conclusion

When working in an RPP to improve CS in K-12, there are many things on which to focus. Here we have found it useful to examine higher level tensions that permeate all the work. While making choices about curriculum and professional learning, district leaders and researchers are not only making those choices, but also asking, "how specific should we be?" and "how ambitious can we be?" By paying attention to, and being intentional about these two essential dimensions, RPPs can make their work more coherent and promote greater success from the beginning of their work. The tensions of ambition and specificity will continue to exist, considering the speed, scale, and scope will help to balance ambition. Further considering the competencies, curriculum, cooperative professional development, and choice will help in this balancing and provide the correct level of specificity for a district.

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