Examining Teacher Perspectives on Computational Thinking in K-12 Classrooms

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***Abstract*— This paper examines K-12 teacher perspectives on the promise and challenges of computer science (CS) and computational thinking (CT) education for all students across three states and three school districts—one rural, one suburban, and one urban. Through a series of teacher survey and focus groups, this exploratory research presents the perspectives of K-12 teachers across three distinct vantage points: First, to what degree do these teachers see a clear value as to why CS and CT matter to their students' learning? Second (if the pathway is deemed valuable) who, in their estimates, are the crucial players to help develop a coherent CS/ CT K-12 pathway and what is their capacity? Third, how can such a prospective pathway be practically implemented? These elements of why, who, and how are essential to wider questions around equity of student access to high quality computing, and with this paper, they come from the perspectives of teachers—a group too often left out of early discussions around K-12 curricular design. Discussion section points to how these preliminary surveys and focus groups with teachers offer an early predictor in terms of how each district develops its own K-12 computing pathway, with the expectation that such focus groups offer a powerful research/ evaluation protocol that can be repeated annually among districts to gauge to what extent teachers' hope (and concerns) about comprehensive K-12 computing pathways are warranted.**

Keywords—computational thinking; competency-based education; educational infrastructure

I. Introduction

Recent studies [8, 12, 13] have emphasized how K-12 students are meeting neither college nor workplace expectations in an ever-growing computational world that relies upon the capacity to code and, even more importantly, the capacity to "think creatively and computationally" [3].

By implementing introductory computer science (CS) and computational thinking (CT) as early as elementary school and through secondary education, there is a strong argument that not only can students be better prepared for academic and career success, but also that such early exposure may also encourage more diversity and inclusivity in the CS field, which has long been troubled by a lack of racial, ethnic, and gender diversity [10]. *Crucial however to this call for more rigorous and equitable K-12 technology education are qualified and enthusiastic teachers*. While education policy-makers, pundits, and school administrators are seemingly never short on vernacular about the importance of CS education, this paper examines **teacher perspectives** on the promise and challenges of CS and CT education.

Working with three distinct school districts in the U.S. through a federally-funded research practitioner partnership (RPP) [6], this proposal presents K-12teachers' thoughts on whether they have (i) a clear sense as to **why** CS and CT matters to student learning?, (ii) **who** are the key players to help develop a CS/ CT K-12 pathway in their own schools and district?, and (iii) **how** such a Pathway can be practically implemented in K-12? The Results section is likewise structured around these three research questions.

II. Background

Since Jeannette Wing's [15] influential article on computational thinking (CT) as a K-12 educational imperative, a total of forty (40) states have enacted—or are in the process of enacting—computer science (CS) standards and frameworks for their K-12 schools [5, 7]. What was once consider an erudite (even arcane) technical skill a decade ago is now promoted as a fundamental 21st century literacy for all children, with steep implications in terms of equity of access and quality instruction [4]. A recent Google report [2] however points to a series of systemic obstacles for future growth. Perhaps most prominent of these obstacles—and one directly mentioned by all interviewees in the Google report—is scaling effective teacher professional development. The national teacher shortage [9] has only exacerbated the lack of qualified teachers in CS and CT. Remarkably, despite the tremendous economic need and states' growing efforts, still less than two-thirds of K-12 schools offer any computer science (CS) based curricula [9, 7].

There has been considerable rhetoric around generating a national "pipeline" of teachers for K-12 CS and CT education (and STEM, in general), but too little in terms of what teachers, themselves, see as a reasonable groundwork for such a pathway. Returning to the research questions above, this proposal represents a modest—yet important—early step to include a wider range of voices in this key conversation.

METHODS

A. Participants

A total of thirty (30) K-12 instructors and three (3) administrators participated in this study as part of the CT Pathways Research Practitioner Partnership (RPP, see Acknowledgement below). Participating teachers ranged from kindergarten through high school and came from range of geographies: A small, rural school district in Alabama (approx. 7,300 students); a mid-sized, urban school district in Iowa (approx. 14,000 students); and a large but decidedly suburban school district in Illinois (approx. 28,000 students). Gender, grade level, and geographic breakdown of these participants are listed in **Table # 1**.

TABLE I. TEACHER PARTICIPANTS FROM K-12 PROGRAMS

Region	**# of Participants**	**Grade Levels/ Subjects Taught**
Iowa (urban city; 14,000 students)	6 male instructors 6 female instructors 1 male administrator	5 elementary school teachers 3 middle school teachers (1 Science, 1 Math, 2 STEAM/Project Lead the Way [PLTW]) 4 high school teachers (1 Special Education, 2 Math, 1 Math/ CS, 1 CS/ PLTW)
Alabama (rural; 7,300 students)	1 male instructor 9 female instructors 1 female administrator	4 elementary school teachers 3 middle school teachers (1 Life Science, 2 STEAM/Project Lead the Way) 3 high school teachers (2 Science, 1 CS)
Illinois (suburban; 28,000 students)	3 male instructors 5 female instructors 1 male administrator	4 elementary school teachers 3 middle school teachers (Instructional Tech Support) 1 high school teacher (Business)

Each of the three districts (via their technology directors and superintendents) expressed a commitment to more equitable access to computing coursework for their students. Each district's commitment is listed here (as detailed at the outset of the research):

- **Iowa District:** "It is our desire to reach the specific population of Black and Latinx students in an effort to broaden their participation in computing…. These students face many barriers. Over 75% of our Black and Latinx students quality for Free/Reduced Lunch; and 25% and 45% of our Black and Latinx students, respectively, are English Language Learners. At the secondary level only 60% of Black students and 68% of Latinx students are proficient in math compared to 91% of our White students."
- **Alabama District:** "Our focus is on two specific populations, students from low socio-economic households and female students.
    - Of the high school students currently enrolled in a computer science or engineering course, 16% of our more affluent students are enrolled, while only 4% of our students in poverty are enrolled.
    - Of the high school students currently enrolled in a computer science or engineering course, only 30% of the students are female."
- **Illinois District:** "Providing computational thinking to these schools will help mitigate persistent barriers and support the students along this pathway. As a district, we're confident we can bridge the opportunity gap by providing all students with an effective, sequenced education in computational thinking and computer science."

B. Data Colletion & Analysis

In Winter 2018, each school district was asked to complete the Strategic CSforALL Resource & Implementation Planning Tool (SCRIPT) [14] to be used as a guide for the planning and/or expansion of each district's Computer Science (CS) and Computational Thinking (CT) program in their K-12 education setting. In March 2019, the research team conducted four teacher focus groups across K-12 grade levels in order to gain insight into the perspectives of CS and CT across these grade levels. The discussions were centered on (i) Why CS & CT?; (ii) Who are the key players in developing a CS/ CT K-12 Pathway?; and (iii) How such a Pathway can be practically implemented?

While these three components represented the central elements of the focus groups, these discussions were loosely-structured, with the intention to provoke free responses and wider discussion from participants. All four focus groups were recorded, and subsequently transcribed and analyzed using Dedoose Software. Utterances were divided into primary, secondary, and tertiary codes. Refer to **Table #2** for coding schema and **Table #3** below for examples.

FIGURE I. CODING SCHEMA

1. **Personal Understanding of the Computational Thinking Pathway**
   a. **Administrative**
      i. What is CT?
      ii. Why is CT important?
      iii. How does CT get implemented into the classroom?

   b. **Teachers**
      i. What is CT?
      ii. Why is CT important?
      iii. How does CT get implemented into the classroom?

2. **Perceived Stakeholder "Buy In" / "Pushback"**
   a. Parents
   b. Students
   c. Teachers

3. **Operationalizing Next Steps**

While the table above provides the basic schema, below are examples of utterances from participating teachers and how they were coded under the initial "primary" with a "secondary" sub-code offering more specific categorization.

TABLE II. CODING SCHEMA W/ SAMPLE PARTICPANT UTTERANCES

Example Utterance from Teacher Participant	Primary Code(s) of this Utterance	Secondary Codes of this Utterance
"I think when you're thinking about PD going forward, the how is really important but not as important as the why for teachers."	Teachers'/Administrators' Personal Understanding of the Computational Thinking Pathway	Teachers • Why is CT important? • How does CT get implemented into the classroom?
"That was kind of my question too is as I'm looking at this, especially the high school and what are some of the, the ways that students are going to demonstrate their knowledge here besides coding, Arduino, robotics, those kinds of things. What other things can they do to show mastery of this? You know what schools are successful in this right now and how are they showing it?"	Teachers'/Administrators' Personal Understanding of the Computational Thinking Pathway	Teachers • How does CT get implemented into the classroom?
"(T)o me that the more it can be integrated in multiple disciplines, the more sustainability you have in this district and I've seen it for 22 years, you know, as I love it, I love the idea."	Teachers'/Administrators' Personal Understanding of the Computational Thinking Pathway Perceived Stakeholder "Buy In" / "Pushback" Operationalizing Next Steps	Teachers • How does CT get implemented into the classroom?

III. RESULTS

A. WHY is Teaching CS & CT Considered Important?

Teachers from all three districts provided substantial reasons as to "Why?" for CS and CT programs within their schools. The top reasons, outlined in Table 4 below, include: (1) **Promotes skills needed for future academic and career success** (including critical thinking, critical writing, problem solving, and relatable career connections); (2) **Increases student productivity, interest, motivation, & engagement**; and (3) **Promotes equity/inclusivity/dissolution of stereotypes**.

TABLE III. WHY IS INSTRUCTIONAL CT IMPORTANT?: TOP REASONS GIVEN BY PARTICIPANTS

	% of participants in **Alabama**	% of participants in **Iowa**	% of participants in **Illinois**	% of participants in **Overall**
Promotes skills needed for future academic and career success *(including critical thinking, critical writing, problem solving, and relatable career connections)*	***4/11*** *of respondents*	***5 /13*** *of respondents*	***8/9*** *of respondents*	***17/33 = 52%***
Increases student productivity, interest, motivation, & engagement	***4/11*** *of respondents*	***0/ 13*** *of respondents*	***3/9*** *of respondents*	***7/33= 21%***
Promotes equity/inclusivity/dissolution of stereotypes	***3/11*** *of respondents*	***1/13*** *of respondents*	***6/9*** *of respondents*	***10/33= 30%***

Teachers from all 3 school districts spoke to CT as having the ability to promote future academic and economic success for their students. This point was illustrated by a middle school STE(A)M instructor:

Because so many jobs of the future are still not even invented yet. We need to train her children, teach them how to think outside of the walls of the school and think further ahead so that they can be the problem solvers and things that they haven't even seen yet but they will face in their future."

Teachers also focused on the soft skills students would be able to develop, including productivity, creativity, collaboration, and perseverance. The push for **earlier exposure to computing** was reiterated during all four focus groups as well, with one middle school instructor noting,

I think if the ultimate goal was to get them (the students) into computer classes in high school, then I think the effort should be put into elementary school. And the PD needs to be there...you know, we need to teach kids how to think, teach them not just to go through a textbook and do problems whether it's science or math.

An elementary teacher emphasized starting early is important:

(S)o kids have just an idea of what could be out there for them. And so, it's not something you're just thrown into at the end of high school….

The question of **equity** figured most prominently during the Illinois focus group discussion. One middle school technology teacher, who has used Scratch with her students, particularly addressed the equity issue, indicating the earlier children had an opportunity to code, the better:

I know this is a really important… I've had as many as 28 kids in the classroom and one girl and zero African Americans. And I'm like, 'But it's so much fun and it's middle school!' But it's still too late. So, I know it's important that we're pushing this down and showing kids even younger than middle school that this is cool because we teach it in sixth and seventh grade it's required and I've got my girls shutting down."

It is worth pointing out here though that, as noted in the Methods section, equity was an expressed focal point for all three district's from administrator's perspectives; Illinois teachers' discussion of issues around equity in computing and CS education does not necessarily mean this element of equity was less of an issue within the other two districts, but rather less a talking point during the loosely-structured focus groups.

B. WHO are the key players to help develop a CS/ CT K-12 Pathway?

The stakeholders whom participants talked about included students, parents, teachers, and school administration. Here, conversations revolved around who are the optimal teachers to recruit and where there may be pushback from instructors. The top reasons provided by participants for potential stakeholder pushback are listed in Table 5 below:

TABLE IV: TOP REASONS PROVIDED BY PARTICIPANTS FOR STAKEHOLDE PUSHBACK POTENTIAL

	% of participants in **Alabama**	% of participant s in **Iowa**	% of participants in **Illinois**	% of participa nts in **Overall**
Teachers don't understand why this is important or how to measure it	***4/11*** *of respondents*	***2 /13*** *of respondents*	***1/9*** *of respondents*	**7/33= 21%**
Teacher workload/lack of time	***6/11*** *of respondents*	***8 /13*** *of respondents*	***2/9*** *of respondents*	**16/33= 48%**
Lack of resources	***0/ 11*** *of respondents*	***3 /13*** *of respondents*	***0/9*** *of respondents*	**3/33= 9%**
High performing students (OR parents of these students) in higher grades *(anxiety related to leaving forms of instruction with which they are already familiar)*	***5/ 11*** *of respondents*	***1 /13*** *of respondents*	***0/9*** *of respondents*	**6/33= 18%**
Fear of Accountability	***4/ 11*** *of respondents*	***1 /13*** *of respondents*	***1/9*** *of respondents*	**6/33= 18%**

In terms of how teachers perceived "buy-in" into a district-wide pathway, instructors from all 3 districts touched upon the same challenge of **time** (time for instructional PD, time to implement, and time to reflect). The question of time was a three-fold concern, with some instructors quickly pointing for the time to prepare lessons via professional development as well as preparatory time during the day. But the question of finding time during the school day was a deeper concern for many instructors, especially on the elementary school levels where teachers are often expected to be offering a wide range of subjects (and activities) in a single classroom. A female kindergarten teacher's concerns were echoed by several teachers throughout the districts:

> *It's really hard for me to think about these big (questions) ... giving them time to do these big things and to be creative, and I want to do that. That's what I want to do, but what my day actually consists of doesn't match this. Making this adjustment and still giving a reading block the allotted time it's supposed to have...I'm already struggling, I have an open mind. So that worries me about taking that back to kindergarten/first grade teachers.*

This sentiment was seconded by a kindergarten teacher from another district, who stated, *"We probably have less time for science than most other schools, less time for social studies because we have to do extra intervention....We have only so many hours in a day to accomplish a lot."*

This question of **time** is compounded by a wider question of how to **assess**, as a high school physical & environmental science instructor remarked: *"Where's your pushback gonna come? Well, aside from (teachers saying) "this is another thing that I have to do", the second one I feel like is going to be "How do I know when they've got it?"*

Interestingly, resources were not consider to be a major barrier by two of the districts (AL & IL) and only minimally so in Iowa, pointing to the long-held adage (and demonstrated research [Penuel]) that districts do not necessarily lack tools nor curricula but rather the time for teachers to learn about such tools and curricula in meaningful professional development and the time to enact such PD during an already-crowded school day.

C. HOW can a CT Pathway be implemented in K-12?

The question of how to enact comprehensive K-12 pathways was perhaps the most discussed question within teacher focus groups across all three districts. As evident in Table 6 below, it was also the question that saw the most consensus across all three districts.

As indicated in Table 6, what participants across districts felt is needed in order to successfully implement a comprehensive K-12 Pathway included: (1) Time (planning time for implementation, designated planning time while implementing, and time to educate parents/train teachers); (2) CT curricular/assessment tools across grade levels (how to implement in different subjects, cross curricular opportunities, and student performance metrics); (3) Resources (support staff; mentors; coaches; tech support; examples; and vocabulary to match/reflect grade level understanding, current standards (CSTA, NVSS, Alabama state standards, etc.), & most recent initiatives (PBL,etc.); and (4) Teacher training (developing metrics for teacher/curriculum success, helping teachers understand why this is important, showing teachers that they are already doing most of this already, observing other classes in which this is implemented, coaching, & allowing teachers to hands-on train).

TABLE III. WHAT DO TEACHERS/SCHOOLS/STUDENTS NEED IN ORDER TO SUCCESSFULLY IMPLEMENT PATHWAY?

	% of participants in **Alabama**	% of participants in **Iowa**	% of participants in **Illinois**	% of participants in **Overall**
Time (including planning time for implementation, designated planning time while implementing, and time to educate parents and train teachers)	***7/11*** *of respondents*	***8 /13*** *of respondents*	***4/9*** *of respondents*	**19/33= 58%**
CT curricular and assessment tools across grade levels (including how to implement in different subjects, cross curricular opportunities, and student performance metrics)	***8/11*** *of respondents*	***7 /13*** *of respondents*	***9/9*** *of respondents*	**24/33= 73%**
Resources (includes support staff; mentors; coaches; tech support; examples; and vocabulary to match/reflect grade level understanding, current standards (CSTA, NVSS, Alabama state standards, etc.), & most recent initiatives (PBL, etc.).	***6/11*** *of respondents*	***10 /13*** *of respondents*	***7/9*** *of respondents*	**23/33= 70%**
Teacher training (includes developing metrics for teacher/curriculum success, helping teachers understand why this is important, showing teachers that they are already doing most of this already, observing other classes in which this is implemented, coaching, & allowing teachers to hands-on train)	***5/11*** *of respondents*	***4 /13*** *of respondents*	***5/9*** *of respondents*	**14/33= 42%**

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Across all four focus groups, 14 teachers (47%) and all 3 administrators indicated they are already applying aspects of this pathway in their classrooms in the form of computer/tech classes, music, robotics, design tasks, engineering design, data collection, data analysis, coding, creating, communicating digitally, and/or Scratch. This stated, teachers in IOWA definitely saw the need to integrate CS and CT across not only multiple grade levels but also across multiple subjects. *"To me,"* remarked one middle school teacher, *"the more it can be integrated in multiple disciplines-the more sustainability you have in this district...and giving people time to see the connections across the curriculum. That's how this initiative will be sustained."*

Still, this aspect of implementation is seemingly downright scary for several teachers from all districts as they struggle with the vocabulary and deciding how it will fit into the curriculum: *"I just immediately get a little overwhelmed with all the vocab and my brain just goes like "computer science" and I forget about how I'm applying it to my subject."* One teacher on the elementary level also pointed out the need for a common vocabulary as being essential to the question of "How?" to get more teachers and students on board with the initiative: *"If we're gonna start down here,"* she remarked about offering introductory CS and CT on the lower grade levels, *"and we wanna get kids up here, we need to identify common themes and a vocabulary that follows them through the grade levels."*

IV. Discussion

By looking at teachers' perspectives, we are able to discover some of the challenges and opportunities that present themselves when trying to implement computational thinking into K-12 curriculum. This may also reveal the practices and strategies teachers feel confident about utilizing within their classrooms. This data indicated challenges that were both extrinsic (resources, time, training, workload, etc.) and intrinsic (fear, uncertainty, anxiety felt by high performing students, etc.), while also revealing that these teachers would like to promote strategies that are multidisciplinary, cross curricular, and contextual-all of which supports earlier research on best strategies for implementing CT within the school system [3]

Of course, these initial focus group with instructors represent an early stage within this three-year research program. Currently (Fall 2019) we are entering the classroom "Pilot" stage of the research, in which a select group of instructors begin to offer preliminary computing coursework within their classroom over the 2019-20 academic year. On the elementary level, this coursework is largely to be integrated into existing coursework (largely math and science units); on the high school level, coursework across all three districts is strictly "stand-alone" and makes use of existing curricula (i.e., Exploring Computer Science and Computer Science Principles). On the middle school level, the three districts are taking different approaches, with Iowa and Illinois offering stand-alone coursework via existing programs such as Project Lead the Way (PLTW) and Code.org, while Alabama intends to integrate into science coursework via computational modeling and Next Generation Science Standards (NGSS). The intention is to repeat these teacher focus groups over the Winter of 2019-20 to investigate to what degree participating instructors' own hope s and concerns were warranted and to what degree there may be other considerations not initially considered from their perspectives. Here, we expect to collect more empirical data from teachers in terms of the **Why?, Who?** and **How?** of K-12 CS and CT education. These three questions, of course, are certainly not static in nature, but may very well represent a series of shifting points among educators based on effective professional development or the lack thereof.

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