Paper Title A Virtual Professional Development Program for Computational Thinking During COVID-19

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A Virtual Professional Development Program for Computational Thinking During COVID-19

Abstract: The need to expand computer science learning for all students has led to an increase in publicly and privately funded professional development (PD) opportunities for teachers. Our research team has been involved in the design of equity-focused PD opportunities for teachers in computing since 2012 by building partnerships with K-12 systems. The COVID-19 pandemic necessitated changes in our approach and a shift to a virtual PD institute. In this work, we describe our transition to a virtual PD institute, including the topics and design principles guiding the institute. We also examine how the virtual PD influenced teacher outcomes. Findings suggest an increase in teachers' knowledge and self-efficacy while highlighting the affordances of virtual platforms most valued by teachers.

Introduction and Purpose

Across the U.S., efforts are underway to expand K-12 student participation in computer science (CS). Although progress has been made, data suggests that opportunity gaps exist in relation to female and minoritized student participation in computing (Code.org, 2020). At the same time, global events such as the COVID-19 pandemic have further highlighted the critical role of CS in analyzing complex data through graphs, charts, and computer models used to explain the pandemic itself, the economy, and the well-being of citizens (Lee & Campbell, 2020). Further, with existing inequalities exacerbated during the pandemic, understanding of how to use principles from CS to make sense of complex societal problems and understand the impact on one's communities has made computing more personally relevant to students (Lee & Campbell, 2020). In turn, these opportunities require that teachers are well prepared to engage *all* students with CS principles in ways that help them address pressing societal problems.

As the need to engage all students in computing is gaining increased attention, professional development (PD) efforts that prepare teachers to deliver CS instruction using culturally responsive pedagogies (CRP) is key. CRP models aid teachers in producing a rich learning environment and culturally appropriate content as a response to their students' community and culture (Mejias et al., 2018; Warren, 2017). With support from the National Science Foundation, our research team has been involved in the design of equity-focused PD opportunities for teachers in computing since 2012 by building partnerships with K-12 systems. Our PD incorporates a three-tiered approach, which includes: (a) an annual week-long summer institute, (b) a college field-experience course in which undergraduate students with background in CS assist teachers in developing and implementing CS lessons back in their classrooms, and (c) sustainable partnerships with local public and private schools. The COVID-19 pandemic has necessitated changes in our approach and a shift to a virtual PD program. In this work, we describe our transition from the face-to-face week-long institute to a virtual institute delivered over multiple sessions in the fall of 2020. We describe the topics and design principles guiding the institute and investigate the following questions:

1. How did participation in the virtual PD institute influence teachers' knowledge, skills, confidence, and preparation to teach computing in culturally relevant ways?
2. What elements of the virtual PD institute were most valued by participating teachers?
3. How did participating teachers apply CS content and pedagogy learned during the virtual PD institute in their classrooms?

Theoretical Framework and Program Description

PD that affects teachers' practice and student outcomes contains certain key elements, including extended duration, a dual focus on content and pedagogy, coherence, active learning, collective participation, and follow-up support (Desimone, 2009; Supovitz & Turner, 2000). Although the majority of PD research has been conducted for core subjects such as mathematics, language arts, and science, the more limited body of research regarding CS specific PD points to these components being instrumental in supporting CS teachers as well (e.g., Menekse, 2015; Milliken et al., 2019).

Due to the COVID-19 pandemic, the medium for PD required substantial alterations, with many PD programs shifting from face-to-face to virtual delivery. Unlike face-to-face PD, virtual PD can be offered both synchronously or asynchronously depending on the digital tools being used. However, these approaches are substantially different and require different elements to ensure their success (Treacy et al., 2002). Research into synchronous virtual delivery methods offer promising results with teachers in multiple PD sessions showing that outcomes in pedagogical beliefs, instructional practices, and student outcomes were not statistically different when compared to face-to-face PD delivery (Russel et al., 2009). Moreover, some features associated with online face-to-face delivery methods, such as chat, offer additional affordances that may support teachers' learning (Chen et al., 2009). This is consistent with the literature on PD, which states that the delivery method is less important than the PD content for altering teachers' beliefs and practices (e.g., Darling-Hammond et al., 2017; Desimone et al., 2002). In this work, we describe how we transitioned our face-to-face PD institute to online delivery (see Table 1) and examine how this shift impacted teachers' learning and practice.

-- Table 1 --

Methods

Data were collected using both quantitative and qualitative procedures. To answer the first question, participants completed electronic pre- and post-surveys, administered through Qualtrics. The pre- and post-surveys were designed to gauge participants' level of knowledge, skills, and confidence in teaching CS before and after the institute. Thirteen questions related to teaching CS appeared on both the pre- and post-survey and were measured on a five-point Likert scale. There were substantially more responses to the pre-survey (n=16) than to the post survey responses (n=8). Therefore, t-tests were not completed. Mean values and standard deviations for each item on the pre- and post-administration of the surveys were calculated.

To answer the second question, the post-survey asked participants about their perceptions of the institute's overall quality using several open-ended questions. We also administered exit tickets at the end of each synchronous PD session, through which the participants were able to express what they valued most. Responses to both the post-survey and the exit tickets were coded for themes using open coding.

To answer the third question, teacher interviews were conducted in the spring of the same year. In April 2021, all participants who had attended at least two PD sessions from the fall 2020 PD were invited to participate in an interview. A total of 15 participants were invited and eight agreed to be interviewed (53.3% participation rate). Interviews were conducted via Zoom in April and May 2021 and recorded for transcription. Data were analyzed in Dedoose using a mixture of *a priori* codes based on previous work and emergent codes. Table 2 provides participant demographics.

-- Table 2 --

Results

Teacher Knowledge, Skills, Confidence, and Preparation

After participating in the PD institute, participants generally rated themselves higher in knowledge and skills (see Table 3). Looking at individual change, five of the eight respondents rated themselves higher after the institute and three rated themselves the same. The three participants who felt they were "below average" before the PD all claimed to be "average" or "above average" after it. On the other hand, the two individuals who were "above average" before the PD remained in that category afterwards.

-- Table 3 --

Post-survey responses indicated higher levels of confidence than pre-survey responses in each area (see Table 4). Of the seven dimensions, participants felt most confident about teaching skills related to the CS principle of Creativity and least confident about teaching skills related to Algorithms both before and after the institute. The CS dimensions that showed the largest growth between pre- and post-surveys were Abstraction and Impacts of CS.

-- Table 4 --

There was no change in participants' rating of their knowledge about CS-related career opportunities (see Table 5). Ratings related to integrating CS career opportunities into coursework and generating student enthusiasm about CS-related occupations were lower on the post-survey compared to the pre-survey.

-- Table 5 --

Table 6 presents teacher' sense of preparation to teach CS before and after the PD institute. Of these ten items, seven had higher mean ratings on the post-survey compared to the pre-survey. Two items were unchanged and one item had a lower mean rating on the post-survey. While changes were fairly small, the most growth was evident in preparation to provide enrichment opportunities for gifted students and to teach CS to English language learners (ELLs). Teachers generally reported little preparation for teaching students with learning or physical disabilities (average rating < 3.0).

-- Table 6 --

Valuable Elements of Virtual PD

Participants' ratings of the overall institute quality are shown in Table 7. Everyone who completed a post-survey rated the institute "average" or better, and two participants called the institute "excellent." Further, participants rated every aspect of the PD as either neutral or positive. Out of 18 statements, 17 had average ratings of at least a 4, meaning an overall level of agreement. The highest-rated items pertained to relevance and learning.

-- Tables 7 & 8 --

When asked to identify the most valued aspects of the PD on the post-survey, six common themes emerged (see Table 9). Many of these ideas recurred in the interviews and the exit tickets. Specifically, participants emphasized the importance of (a) professional collaboration and networking; (b) exchanging curriculum ideas, tools, and resources; and (c) the advantages of online delivery. As one teacher explained, the PD can help break down the isolation often experienced by CS educators:

> I love being able to communicate with other educators that are in the same computer science field because often you are kind of alone when you're in these schools. You know, [if you teach] math, you can talk to all the other teachers that are teaching math . . . but technology [cannot do that].

During the PD, teachers also reported gaining insight into new resources and tools, as well as learning "practical tips" for teaching CS. For instance, several teachers expressed interest in learning more about and making use of CS Unplugged activities, including the following teacher who commented on an encryption-based Unplugged activity:

> It was culturally relevant to use barcodes to teach encryption and algorithms, since we all have barcodes somewhere in our kitchen (unless someone only eats local, whole, unpackaged food).

Finally, teachers emphasized the value of breakout rooms, which offered choice, relevance, collaboration:

> Breaking out and getting to choose which group you wanted to go with and see different demonstrations of things on the computer.

-- Table 9 --

Applying CS Content and Pedagogy

Of the eight individuals interviewed, five could describe an activity that they had or would soon implement with their students or a strategy or resource they had discovered. Most frequently, these entailed projects using the Scratch programming language: "[Scratch] was the only thing I actually used in practice. We used Scratch and they had to tell a story about themselves and how the pandemic was affecting them personally." One participant described implementing "the barcode activity for teaching algorithms" and another described learning strategies for successfully implementing Code HS curricula (although they noted this came from informal discussion, not planned agenda items): "There were some other teachers that were using it, and that sharing of 'how did you make this work? How do you work around that?'" At the time of the interview, two participants had not yet been able to implement anything because of the PD timing and the pandemic. Both described planning to use what they had learned about Micro:bits (pocket-size computer) later in 2021. Finally, although it was not an interview question, many participants described how COVID-19 had constrained their classrooms and their prospects for implementation of ideas from the PD.

Significance and Implications

Despite growing attention to PD, we continue to know little about the CS concepts that teachers succeed or struggle with, the pedagogies they engage with, their self-efficacy and confidence, and the manner in which they apply PD learning into their practice (Authors, 2017; Rich et al., in press). Findings from this work indicated that the virtual PD institute achieved several important successes, despite highly demanding circumstances and the complexities of the pandemic. Participant satisfaction remained generally high and all data sources point to the particular value that participants found in the PD community of CS educators. The opportunity to collaborate and share resources and ideas, both officially and unofficially, was also important. Some veterans expressed gratitude that the community was able to reconvene during 2020-21. As one interviewee put it, upon learning that fall PD would be offered, it was a "no brainer" to sign up. There is also evidence of increased confidence and preparation to teach CS as well as application of new learning into practice. Based on this data, we generated a list of four recommendations for practice: (1) diversify and broaden participation, (2) differentiate instruction, (3) increase hands-on activities, and (4) prioritize participant engagement (see Table 10).

-- Table 10 --

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Table 1

Content, Delivery, and Rationale of Transition to Online PD

Face-to-Face Component	Reasoning/Literature Support	Changes for Virtual PD
Opening Session Time: daily 30-minute sessions Content: Introductions and Logistics	Introductions Logistics Overview	**Virtual Opening Session (Synchronous)** Time: 30-minute session Content: Introductions and Logistics
CS Unplugged Group Activities Time: daily 30-minute sessions Content: CS Unplugged activities that connected with the CS Big Idea of the day.	Introducing CT concepts using metaphors to create connections Bell & Vahrenhold, 2018)	**Virtual CS Unplugged** Time: two 30-minute sessions Content: CS Unplugged activities that can be delivered in an online environment: Cryptography and Product Code Magic
Culturally Responsive Pedagogy Time: daily sessions, ranging 30-75 minutes Content: Activities centered on promoting diversity, self-reflection, centering equity, and implementation	Expanding access, interest, and identification in CS Broadening participation in computing (Alvarado et al., 2012; Ladson-Billings, 1995; Pollock, 2008; Scott et al., 2010)	**Culturally Responsive CS Pedagogy** Time: one 45-minute session Content: culturally responsive computing, activities focused on designing supportive learning environments, student-centered instruction, and addressing structural inequities
Programming Time: two 60-minute sessions Content: Introductory and Advanced programming exercises using Scratch	Teachers learning programming skills (e.g., content knowledge) Teachers learn pedagogical approaches to teaching programming, including equity pedagogies (e.g., pair programming; Madkins et al., 2020)	**Programming in Scratch** Time: two 60-minute sessions Content: Beginner, Intermediate, Advanced Sessions facilitated by teacher leaders using breakout rooms in Zoom
Incorporating CS Standards into Core Lessons Time: one standalone session and opportunities for discussion throughout the week Content: Connecting CS to content-area instruction	Providing connections to teaching expectations (e.g., Coherence)	**Examining Standards and Examples of CT** Time: one synchronous 60-minute session and asynchronous independent work on lesson development Content: CS standards developed by CSTA, content area standards, and CS lessons appropriate for different grade levels

Introduction to Various CS Tools Time: two 90-minute sessions Content: Beebots, Micro:bits, Ozobots, MakeyMakey,	Not all teachers have access to the same funding and/or tools. Providing a broad range of examples of tools allows for teachers to have a greater understanding of what is out there and what they might be able to use.	**CS Tools with Online Components** Time: one 2-hour session Content: Micro:bits and Twine facilitated by teacher leaders using breakout rooms in Zoom
Collaborative Lesson Planning Time: one stand-alone session and independent work throughout the week Content: Development of lessons that integrate CS with content-area instruction within one's own context	Connecting CS with existing content-area instruction (Yadav et al., 2016) to demonstrate coherence and engage in active learning	**Offline Lesson Planning (Individually or in Teams)** Time: Independent, asynchronous work following participation in PD Content: Development of lessons that integrate CS with content-area instruction within one's own context

Table 2

PD Participant Demographics

		Number	Percentage
Gender	Female	15	93.75
	Male	1	6.25
Race/Ethnicity	Asian	1	6.25
	Black/African American	5	31.25
	White	9	56.25
	Prefer not to answer	1	6.25
	Hispanic or Latinx	0	0.00
Teaching Experience	0-3 Years	0	0.00
	4-5 Years	1	6.25
	6-10 Years	4	25.00
	11-15 Years	3	18.75
	16+ Years	8	50.00
CS Experience	0 Years	6	37.50
	1 Year	2	12.50
	2-3 Years	4	25.00
	4-5 Years	2	12.50
	6+ Years	2	12.50
Primary Discipline	Computer Science	5	31.25
	Business	3	18.75
	Career/Technical Ed	1	6.25
	Science	1	6.25
	Other	6	37.50

Table 3

Participant Knowledge and Skills Before and After PD Institute

Ratio of Knowledge and Skills	Before Institute		After Institute	
	Number	Percentage	Number	Percentage
Poor	0	0.00	0	0.00
Below Average	3	37.50	0	0.00
Average	3	37.50	3	37.50
Above Average	2	25.00	5	62.50
Excellent	0	0.00	0	0.00
Average	2.88		3.63	
SD	0.84		0.52	

Table 4

Confidence Before and After PD Institute

Items	Pre Mean	Post Mean
I feel confident teaching . . .		
CS Skills Overall	3.69	3.88
CS skills related to . . .		
Creativity	3.69	4.38
Abstraction	2.88	3.63
Data	3.00	3.63
Algorithms	2.75	3.25
Programming	2.94	3.63
The Internet*	3.60	4.13
Impact of CS*	3.38	4.13
	N=16, **N*=15	*N*=8

Table 5

Career Knowledge and Confidence Before and After PD Institute

Statements	Pre Mean	Post Mean
I am knowledgeable about my students' career opportunities related to CS.	3.75	3.75
I am confident that I can integrate career opportunities related to CS in my courses.*	3.94	3.86
I am confident that I will be able to generate student enthusiasm about CS-related occupations.	4.06	3.88
	N=16	*N*=8, **N*=7

Table 6

Preparation for Different Aspects of CS Instruction Before and After PD Institute

Items	Pre Mean	Post Mean
Plan differentiated instruction for your students.	2.69	2.88
Teach the relevance of computing in their daily lives.*	3.00	3.25
Encourage students' interest in computing.	2.88	3.25
Provide enrichment opportunities for gifted students.	2.63	3.13
Teach computing to . . .		
Students who have learning disabilities.	2.50	2.50
Students with physical disabilities.	2.44	2.50
English-language learners.	1.94	2.38
Girls.	3.13	3.13
Students of racial or ethnic minorities.	3.06	3.00
Students from low socioeconomic backgrounds.	3.00	3.13
	N=16, **N*=15	*N*=8

Table 7

Overall Quality of PD Institute

Please give an overall rating for the quality of this institute.	**Number**	**Percentage**
Poor	0	0.00
Below Average	0	0.00
Average	11	12.50
Above Average	5	62.50
Excellent	2	25.00

N=8

Table 8

PD Institute (Workshop) Feedback

Statement:	Mean	SD
I can use this training to positively impact the achievement of my students.	4.75	0.46
The intent of the workshop is relevant to my professional responsibilities.	4.38	0.52
The facilitators helped me understand how to implement my learning.	4.25	0.46
This workshop will extend my knowledge, skills, and performances.	4.63	0.52
This workshop was tailored to meet my needs as a learner.	4.50	0.54
The facilities were appropriate for the activities.	4.25	0.71
The facilities were conducive to learning.	4.25	0.71
The workshop was supported by effective/appropriate use of technology.	4.50	0.54
New practices were modeled and thoroughly explained.	4.13	0.64
Sufficient time was provided for guided practice and tasks.	3.88	0.84
The facilitators were knowledgeable and helpful.	4.50	0.54
The facilitators were well prepared.	4.13	0.64
The instructional techniques used facilitated my learning.	4.63	0.52
The materials used were accessible and enhanced my learning.	4.50	0.53
The workshop's activities were carefully planned and organized.	4.25	0.71
The workshop's goals and objectives were clearly specified.	4.38	0.74
The workshop included a variety of learning activities relevant to the topic.	4.63	0.52
Time was used efficiently and effectively.	4.50	0.54

N=8

Table 9

Most Valued Aspects of the PD Institute

Post-Survey Theme	Number	Percent
Peer support/network	5	71.4
Learning new resources or tools	2	28.6
Facilitators	2	28.6
Computer Science content	2	28.6
Breakout rooms	1	14.3
Chance to model lessons	1	14.3

N=7. Some responses mentioned more than one theme.

Table 10

Recommendations for PD Practice

Recommendation	Explanation
1. Diversify and Broaden Participation	Diversify and broaden participation, including increasing the representation of middle school teachers and those from [the southern] counties. The virtual format may facilitate reaching a wider geographic catchment.
2. Differentiate Instruction to Meet Teacher Needs	Differentiate and provide options as much as possible, and be transparent when it is not. Participants generally want to see PD tracks, breakout rooms, and curriculum resources that closely match their teaching context and level of experience. Given that this is not possible in *all* cases, helping participants identify the "translations" or adaptations necessary is recommended. If participants are welcome to return to the PD for multiple years, plan agendas to ensure that everyone can discover something new. Also, explore online and asynchronous ways to support those who need more practice or review.
3. Increase Hands-On Activities and Concrete Examples	Incorporate a wider variety of activities and examples, even in online PD. With more experience coordinating online sessions, the PD may be able to offer more hands-on or interactive activities this summer. Seek to have educators build and do during the PD. Additionally, consider bringing in new speakers or examples virtually. Participants expressed an interest in hearing from industry professionals and in seeing concrete applications of CRP in CS.
4. Prioritize Participant Engagement	Support engagement and focus in online PD. During the summer, it will likely be easier to capture participants' attention. A greater variety of activities and examples can help capture participants' attention. To the extent possible, facilitate breakout sessions to support equitable participation and nurture engagement.