The Virtual Pivot: Transitioning Computational Thinking PD for Middle and High School Content Area Teachers

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ABSTRACT

In 2018 and 2019, Infusing Computing offered face-to-face summer PD workshops to support middle and high school teachers in integrating computational thinking into their classrooms through week-long summer PD workshops and academic-year support. Due to COVID-19, 151 teachers attended the Summer 2020 PD workshops in a week-long virtual conference format. In this paper, we describe Virtual Pivot: Infusing Computing, which employed emerging technology tools, pre-PD training, synchronous and asynchronous sessions, Snap! pair programming, live support, and live networking. Drawing on findings from participant interviews and post-PD surveys, we argue that three categories of changes (digital tools, formats, and supports for teacher engagement and collaboration) were effective in increasing participants' self-efficacy in teaching CT, supporting collaboration, and enabling participants to design CT-infused content-area lessons. We conclude by discussing how elements of this virtual PD can be replicated to increase teacher and student access to CT practices in middle and high school classrooms.

CCS CONCEPTS

• Social and professional topics→ Computational thinking • K-12 education

KEYWORDS

Computational Thinking, Teacher Professional Development, Online Learning, Virtual Spaces, Disciplinary Teaching

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1 Introduction

Even before the COVID-19 pandemic, numerous questions have arisen regarding the most effective outcomes, formats, and functions of teacher professional development (PD). Studies of teacher professional development have demonstrated mixed results [15], with one large-scale study showing little change in teacher practice or student outcomes despite a large financial investment [31]. Recent research highlights the need for more rigorous studies to investigate effective PD models, formats, and goals [6, 7, 19]. Given the need to develop a robust STEM workforce [25] and to give students opportunities to understand how computers work and how to "harness their computing power" ([29] p. 143), there is also growing interest in teacher PD that supports teachers in making connections between computational thinking and disciplinary content.

In order to broaden participation in computer science in P-12 schools, researchers have proposed working with content area teachers to integrate computational thinking (CT) into disciplinary teaching and learning [27, 34]. There are additional barriers to designing and implementing teacher PD to support teachers in these CT infusion efforts, including the fact that CT is often initially understood by content area teachers as the basic use of computers or technology in the classroom [35]. In order for teachers to understand CT and the implications for classroom instruction, teachers need clear definitions of CT [18], as well as explicit, ongoing training and support [6]. A growing body of research on teacher PD in CT shows that as practicing teachers engage in active learning about CT, they can come to view it as a problem-solving process with implications for content area classrooms [13, 23, 34, 35].

To date, there has been little research on computational thinking PD in an entirely virtual format [36]. Due to the COVID-19 pandemic and a growing need to build virtual teacher communities across time and space, this is a critical area for research and practice. The broader literature base on online PD for teachers suggests that effective design requires rethinking outcomes, tools, and formats [16, 22, 36]. For example, instead of outcomes focused solely on teachers' skills, knowledge, or beliefs, teachers have reported a different desired outcomes for online PD, including changes in their identities, approaches to learning, classroom culture, and relationships with colleagues [36]. Also, designing virtual PD experiences requires careful consideration of tools and explicit training for participants. Finally, moving to virtual PD formats requires intentional design for active participation, collaboration, and engagement [24].

In order to address the need for effective online PD models that actively engage content area teachers in integrating computational thinking, this paper details an online PD model, Infusing Computing: Virtual Pivot, for middle and high school content area teachers. The first two iterations of Infusing Computing were offered in face-to-face format in 2018 and 2019, but we shifted to a week-long virtual conference PD in Summer 2020 due to the COVID-19 pandemic. Section 2 provides background on Infusing Computing. In Section 3, we detail three categories of support (digital tools, collaboration, and engagement) for Virtual Pivot participants to build self-efficacy and skills for integrating CT. In Section 4, drawing on analyses of participant surveys and interviews, we examine teachers' PD experiences and describe how they have used or plan to use Virtual Pivot elements in their own online, hybrid, and face-to-face teaching. Finally, in Section 5, we conclude with implications for designing CT PD, as well as general implications for creating effective virtual professional learning experiences.

2 Background: Infusing Computing

Infusing Computing is a three-year, NSF-funded project designed to support content area teachers in infusing computational thinking into their disciplinary teaching. From 2017-2019, more than 250 teachers participated in intensive, week-long summer PD workshops held in the Southeastern United States [1, 2]. In-person workshops were designed according to the 3C (Code, Connect, Create) model [3]. Code sessions, led by teacher facilitators and research team members, helped participants develop! coding skills in Snap! [12], a programming language based on Scratch [20]. Connect sessions targeted knowledge of CT concepts. To guide teachers' understandings of CT, we developed the PRADA model [1], which is a mnemonic device that reorders and refines elements (pattern recognition, abstraction, decomposition, and algorithms) of computational thinking [12] for adaptation to different disciplines [1, 2]. Create sessions tasked participants with applying their developing understandings of CT to create a lesson and Snap! Prototype.

All elements of the 3C model were designed to scaffold participants towards increasingly complex understandings of CT. Follow-up activities and supports for the academic year included monthly webinars, technical support, an ongoing podcast series, and virtual networking experiences. In accord with recommendations [8] for effective PD, Infusing Computing is content-focused (CT infusion into disciplinary teaching), utilizes active learning, supports professional collaboration, provides expert coaching, offers opportunities for reflection, and is of sufficient duration.

Initially, the Summer 2020 *Infusing Computing* workshops were scheduled for a face-to-face format. Planned adaptations based on data analyses from Year 2 (Y1) and Year 2 (Y2) included additional support for classroom implementation and the curation of a lesson library. In March 2020, due to the ever-increasing impact of the COVID-19 pandemic, the research team decided to move the PD to a virtual format. In the next section, we detail the digital platforms for the PD, adapatations of digital tools, the supports provided, and the overall structure of the fully online PD.

3 Virtual Pivot

In order to ground the redesign of Infusing Computing in both the literature and the project-specific context, the research team analyzed previous research on online teacher learning, as well as implementation data from Y1 and Y2 of the project. These analyses pointed to the need for explicit supports for teacher collaboration and engagement, as well as an increase in asynchronous work time and a decrease in synchronous session time. Table 1 provides an overview of changes made to the PD for Virtual Pivot. 151 teachers, including 23 teachers returning from Y1 and/or Y2 of the project, attended four days of Virtual Pivot PD in Summer 2020. In the next sections, we describe three categories of support (digital tools, formats, and supports for engagement and collaboration) that increased teacher self-efficacy in teaching computational thinking and enabled participants to design CT-infused content area lessons.

3.1 Tools Support

Hopin (www.hopin.to), a virtual conferencing platform, offered participants a visceral conference experience as they moved among a Stage, Sessions (smaller group sessions in breakout rooms), Networking, and an Expo Center that hosted open-all-day Help Desks. In a post-PD interview, one participant praised the "variety of ways to interact" that Hopin affords. She describes one particularly lively Connect session: "...people jumping in and talking and we felt we all had a lot to say. And so, we started utilizing the chat. That was fun because you could see people as they're frantically typing. And then the networking feature is just a cool feature of Hopin…you get to randomly meet people that you wouldn't otherwise!"

Research on virtual teacher PD suggests that convenient access to materials is essential for success [22]. Thus, in addition to Hopin, we utilized Canvas (www.canvas.instructure.com) to house all PD materials, tasks, submissions, badges, and discussion boards. To give participants a clear organizational structure, we designed Canvas modules for each day, with individual pages for 3C Code, Connect, and Create sessions. This module structure provided consistency that participants appreciated, especially in light of the unstructured nature of pandemic pedagogy.

Table 1. Change in PD format (modified from [3]).

Face to Face Components (2018-2019 PD)	**Virtual Pivot with Tools used (2020 PD)**
Pre-PD Work *Snap! Homework:* Sent one week prior to PD for participants to create accounts and get acclimated with the interface.	**Virtual Pre-PD Sessions** *Facilitator Trainings:* Ensured facilitators could use tools to facilitate sessions and that they had consistent understandings of CT elements *Tech-Check (synchronous and asynchronous):* Ensured participant access to virtual PD tools through a scavenger hunt *Swag Box Mailing:* Provided materials for icebreaker activities, branded masks and headphones, loaner laptops, and wifi hotspots as needed *Snap! Homework:* Sent after tech check for participants to create accounts and get acclimated with the interface
Face-to-Face Opening Session *Time:* 1 hour *Content*: Project and CT Introduction *# of participants*: ~180 teachers *Location*: Auditorium	**Virtual Opening Session** *Time:* 30 minutes (Day 1) *Content*: Algorithms and Sandcastles (demo with kinetic sand mailed before PD) *# of participants*: ~180 teachers *Location:* Hopin Stage with breakout sessions *Supports:* Hopin chat and Help Desk
Face-to-Face CODE *Time*: 3 sessions of 60/105/105 minutes *Facilitators*: CS teacher-leaders *Content*: Introduction to programming *Breakout*: Pairs work in Rooms by experience level (beginner, intermediate, Netsblox, Python) *# of participants*: 20-30 per room *Alternative Code Session*: PRADA with Python (offered in 2019) *Location*: Classrooms on site	**Virtual CODE** *Time*: 3 sessions of 60/90/90 minutes *Content:*10 minutes: Introduction to Snap! and expected work; 50-80 minutes: Driver-navigator pair programming with tutorial instructions *Facilitators*: CS teacher-leaders and HS interns *Supports:* Augmented Snap! environment, Hopin Code Help Desk, office hours *# of participants*: 2 per room (facilitators float) *Alternative Code Session*: PRADA with Python *Location*: Hopin Sessions
Face-to-Face CONNECT *Time*: 75 minutes/day *Content*: Explore CT strategies through a disciplinary lens *Breakout*: by Content area *Facilitators*: Disciplinary teacher-leaders *Number of participants*: 20-30 per room *Location*: Classrooms on site	**Virtual CONNECT** *Time*: 60 minutes/day *Content:* 10 minutes: Introduction of PRADA; 30-45 minutes: Independent work in small discipline-based groups via breakout rooms; 15 minutes: Reflection *Facilitators*: Disciplinary teacher-leaders and returning teachers *Supports:* Canvas, Hopin chat, and Help Desk *# of participants*: 12 or fewer per room *Location*: Hopin Sessions
Face-to-Face CREATE *Time*: 120 minutes/day *Facilitators*: CS and disciplinary teacher-leaders *Content*: Develop lessons and programs that infuse CT with content area standards *Number of Participants*: 20-30 per room *Location:* Classrooms on site	**Virtual CREATE** *Time*: 120 minutes/day, plus virtual office hour sessions *Facilitators*: Both CS and disciplinary teacher-leaders float among breakout rooms *Content:* 10 minutes: Sharing pre-designed scaffolds and models; 90-120 minutes: Work Time; 15 minutes: Reflection *# of Participants*: 3-4 per room Supports: Hopin Help Desks, HS interns, 1-1 Hopin Video Chats *Location:* Hopin Sessions
Virtual One-on-One Zoom Sessions Facilitators: Additional High School (HS) student interns available via Zoom for technical support and Snap! content development	**Virtual One-on-One Hopin Video Sessions** Facilitators: High School (HS) student interns available through the Hopin Code Help Desk for technical support and Snap*!* Content development

Conversations with Y1 and Y2 Infusing Computing participants and a review of literature on online PD [16, 36] also indicated a need to give participants practice with the selected tools prior to the PD. Initial facilitator training included a discussion of the PD goals, platforms, tools, and supports available for both participants and facilitators. During practice sessions, facilitators worked together to navigate tools for PD content and organization. Code facilitators also practiced serving as both driver and navigator for Code sessions in order to be able to assist participants. HS interns practiced making integrated lesson plans in Snap!, using pair programming online, and learned about computational thinking and inclusive pedagogy. For participants, we held 10 "Tech Checks" in Hopin. During these sessions, participants tested their video and audio connections, logged into Canvas and Hopin, and previewed the use of Hopin and Canvas in the PD.

Using Hopin as the virtual venue and Canvas as an anchor platform for PD materials access was a critical element of the Virtual Pivot PD design. Analysis of interviews with Y1 and Y2 participants indicated that they and many of their colleagues had difficulties in navigating multiple platforms in previous PD experiences and during the initial stages of COVID-19 virtual teaching. While we considered using additional platforms, such as Slack, to increase communication among participants, we ultimately decided to streamline the number of platforms used to facilitate easy access to PD sessions and materials. Members of the research team and teacher facilitators did use other platforms, including Slack and Zoom, for backchannel discussions. This allowed the team to respond immediately to participant requests for assistance and to distribute team members and resources where they were most needed.

3.2 Formats for Virtual Pivot Sessions

While researchers argue synchronous videoconferencing can serve as a powerful means for supporting the development of community in teacher PD [21, 22], other studies [13, 28] indicate that the addition of asynchronous PD components can facilitate teacher reflection and allow more connections to classroom practice. In accord with this research, Virtual Pivot was designed to provide participants with a purposeful balance of synchronous and asynchronous learning opportunities.

Each day began with a whole-group session held on the Hopin Stage. On the first day, participants completed a virtual sandcastle building activity designed to introduce them to CT concepts. Prior to the PD, kinetic sand and a picture book (*How to Code a Sandcastle* by Josh Funk) had been mailed to all participants as part of an Infusing Computing swag box. Facilitators modeled the activity on the Hopin stage, and then participants were sent to smaller sessions to explore connections between CT concepts (e.g., debugging, abstraction, and algorithm) and their own attempts to build a sandcastle. Participants also reflected on how the sandcastle activity might be used in a classroom environment to introduce CT to students. Subsequent introductory sessions were designed to provide an overview of daily PD activities and goals, to address participant feedback from daily surveys, to highlight key CT concepts, and to celebrate participant accomplishments and collaborations.

Code sessions offered synchronous engagement for participants to collaborate on self-paced, pair-programming [5] activities in Snap! that highlighted basic programming concepts and their connections to CT elements. The instruction slides for the coding activities contained objectives of the activity, step-by-step instructions, solution code, and the CT elements involved in the coding activity. Code sessions began on the Hopin Stage, where a research team member introduced the daily programming activity and answered participant questions. Participants then moved into Hopin Sessions to work on the pair programming activity. The facilitators and high school interns intermittently joined the breakout sessions to ensure all participants received abundant support [4]. During Summer 2019, we divided participants among 8 rooms (10 total facilitators + 20 HS interns). During Virtual Pivot, participants transitioned to a room with their partner after receiving instructions, monitored by one of the 56 facilitators/interns.

Connect sessions offered both synchronous and asynchronous learning experiences. Participants were grouped by grade level (middle or high school) and content area in breakout rooms of no more than 14 participants. Each room had two facilitators--a teacher-leader (Y1 and Y2 Infusing Computing participants) and a room facilitator to manage technical issues. At the start of each session, facilitators introduced CT concepts and guided participants to connect the concepts to their disciplinary teaching. Participants then engaged in standards mapping activities designed to explicitly connect content area standards and lessons to CT. Once participants felt comfortable in their understanding of CT concepts, they could apply for Canvas badges in each of the four PRADA areas--pattern recognition, abstraction, decomposition, and algorithm. During Summer 2019, we divided participants among 8 rooms (16 facilitators). During Virtual Pivot, participants started in one of 14 different pre-assigned rooms based on their content area (28 facilitators).

Create sessions were held in the afternoon and also offered both synchronous and asynchronous engagement. At the beginning of each session, participants discussed goals for their lessons and shared ideas and resources. Participants were assigned to Create "homerooms" with no more than 6 participants. Each homeroom was assigned a high school intern to provide coding assistance and facilitators circulated among Create rooms. Additional assistance was available in targeted Hopin sessions. During Summer 2019, we divided participants among 8 rooms (16 facilitators). During Virtual Pivot, participants started in one of 35 different pre-assigned rooms.

Live help desks were open from 8:00 a.m. to 4:00 p.m. on each day of the PD. The help desks were divided into three categories: General, Code Help, and Canvas Help. Each desk was staffed by at least one team member throughout the PD. We also added additional Code Office Hours via Zoom each evening for 2 hours on days 1-3, and 1 morning hour on days 2-4 to help participants who were unable to complete the code activities or needed extra help with programming for Code or Create.

3.3 Collaboration and Engagement

Research [36] points to the need to prioritize the development of teacher communities in online spaces, as well as affective outcomes, as a key part of the design process for virtual teacher PD. We argue that developing this sense of community was even more essential in light of the COVID-19 pandemic, which led to isolation and disconnection for teachers across the United States and the world [10]. Thus, offering support for teacher collaboration and engagement throughout Virtual Pivot was a critical element of the PD design. We utilized several supports, including badges, networking, collaboration, and pair programming [32], in order to develop a connected community of teacher-learners in the online space.

3.3.1. Badges. Research on digital badging in teacher PD [11] indicates that badges can serve to encourage participants to set their own learning goals, complete learning activities aligned with those goals, and engage in teacher communities. Studies have also demonstrated that as teachers come to learn more about digital badging, they can envision its use in other contexts, including classroom teaching [17]. For Virtual Pivot, we designed a badging system that awarded skill-based badges for Code, Connect, and Create sessions using Badgr (www.badgr.com), an open badging system that is integrated with Canvas. As participants developed skills and completed PD activities, they were able to apply for badges in Canvas. Badges were available within Canvas and could be exported so that participants could display them on social media accounts and within their school communities. The badges and badge leaderboard served as virtual checklist to ensure that participants, many of whom were unfamiliar with Canvas, could independently check their own daily progress in relation to PD goals.

3.3.2. Networking. Previous research on virtual teacher PD also indicates that activities should be purposefully designed to maximize engagement within a digital environment and generate learner collaboration [9]. In addition to synchronous and asynchronous Hopin sessions, we developed several supports to encourage networking and collaborative work. One of the primary reasons for the selection of Hopin as a conferencing platform was the networking feature, which allows participants to easily connect to a randomly selected fellow participant for five-minute sessions (predetermined time). Networking was built directly into the schedule and allowed for participants to interact with colleagues in different content areas, school districts, and states.

3.3.3. Pair Programming. In the Code sessions, participants learned programming through a set of five coding activities. Each activity included 6-7 objectives for participants to complete, and detailed instructions were provided in Canvas (via Google Slides integration) on what they needed to do for each objective. Participants were pre-assigned into pairs of two to practice pair programming, where one participant is first the driver who writes the code, and the other is the navigator who gives coding instructions. The slides included prompts for participants to switch roles after completing every two or three objectives so that both participants could get experience being the driver and the navigator.

To facilitate distributed pair programming online, we added an asynchronous pair programming feature to the Snap! environment to transfer projects from driver to navigator during role switching. The Snap! environment binds the user's Snap! username with their partners' Snap! username for any activities. Role switching is an asynchronous process. When asked to switch roles, the current driver, A, clicks the swap role button to upload their current code to the server automatically. After A's code is uploaded, the current driver, B, clicks the swap role button to load A's code into the environment. Once the code is loaded, A becomes the new navigator, and B becomes the new driver.

4 Results and Impact of Virtual Pivot

In order to investigate the impact of Virtual Pivot, we analyzed post-PD survey responses (n=119) and interviews (n=53) held the week after the PD, as well as artifacts of participant work in the Snap! environment. We also compared participant data from Y1 and Y2 of the project to Virtual Pivot data to examine the efficacy of the virtual model in comparison with the Y1 and Y2 face-to-face iterations of Infusing Computing. Qualitative responses were coded using a grounded theory approach, with participants' responses broken into meaning units [30], so that each unit contained only one unique idea. Then, we analyzed the data in recursive cycles of open and axial coding. Open coding was used to identify emergent categories and themes, while the axial coding process involved organizing data into themes and sub-themes across interview questions in order to identify central phenomena [26]. For this paper, only qualitative data that are triangulated with the quantitative analysis are reported. The following sections detail results in connection with the following areas: participants' self-efficacy in integrating computational thinking into their disciplinary teaching, their ability to develop CT-infused lessons, and the impact on their virtual and hybrid teaching.

4.1 Self-Efficacy in Integrating CT

A comparison of post-PD survey responses from three years of Infusing Computing data indicates that Virtual Pivot successfully increased participants' self-efficacy in integrating computational thinking into their disciplinary teaching. Participants reported being more likely to incorporate CT activities into their classrooms, that they can more effectively design CT activities, and that they were better prepared to engage students with CT for the purposes of problem-solving. In all post-PD survey items related to self-efficacy, Virtual Pivot participants' scores were the highest across all years of Infusing Computing (see Table 2).

Table 2. Participant self-efficacy in integrating CT

Survey Questions (5-point Likert items)	Y1 Mean (n=111)	Y2 Mean (n=115)	Virtual Pivot Mean (n=119)
I am more likely to incorporate CT activities in my classroom.	4.56	4.57	4.65
I can more effectively design CT activities.	4.42	4.47	4.52
I can better engage students in making sense of CT and designing solutions to problems.	4.43	4.50	4.58

4.2 Ability to Collaboratively Code

To investigate participants' ability to code collaboratively online, we compared the completion rates and time required for common Code activities between 2019 and 2020. Overall, we found similar completion rates for the Code activities, with 85.1% of the participants completing the Day 3 activity, compared to 90% in 2019. However, participants took more time to complete Code activities during Virtual Pivot, with more time needed for log-ins and transitions. Switching roles took around 1 minute per swap. When programming, participants performed programming actions less frequently and spent more time in between consecutive actions. This may indicate that communicating code changes may be more difficult online than in-person since the navigator can only describe code changes verbally online instead of pointing at the driver's screen. Seven-point Likert survey items showed an increase in the perceived benefit of collaborative coding, with the average response to "I feel I benefited from collaborative coding" increasing from Day 1 (M=5.4, SD=1.55, n=141) to Day 2 (M=5.68, SD= 1.43, n=130), and "I feel I contributed to someone else's coding" from Day 1 (M=5.02, SD=1.76, n=136) to Day 2 (M=5.44, SD=1.43, n=126). Our results suggest that Virtual Pivot promoted Code activity completion and successful collaborations, but that there is a need to provide additional time for collaborative coding in a virtual environment in order to facilitate transitions.

4.3 Ability to Design CT-Infused Lessons

In Create sessions, participants were asked to design a CT-infused lesson individually, with other content area participants, or as part of an interdisciplinary team. As Matt, a middle school social studies teacher, said, "The Infusing Computing program has just done a great job, not only providing that exposure but making sure that those learning tasks and assignments are meaningful and quality and good. I think one of the goals that we're achieving here is that we're able to provide a solid thought process that is helping students and to be honest teachers as well."

Participants also indicated that despite inexperience and uncertainty in relation to their future teaching environments and formats (hybrid, virtual, face-to-face), they felt that they would be able to make the adjustments necessary to implement their CT-infused lessons. As Ethan, a middle school teacher, said, "You know kindergarteners figured out letters. I mean, that's where some of us are with coding, but that's okay. And, you know, we're just going to have to really meet kids where they are. I'll be honest--I think some of our projects that we do, we're going to kind of have to scaffold a little more and provide a little bit more support."

4.4 Impacts on Future Teaching

In order to examine the impact of Virtual Pivot on participants' plans for future virtual, hybrid, and face-to-face teaching, we analyzed quantitative survey results and qualitative interview responses. See Table 3 for an overview of post-PD survey responses related to general teaching strategies and impacts. The research team also identified three overarching themes in relation to the impact of Virtual Pivot on virtual and hybrid teaching: use of learning management systems, virtual opportunities for integrating CT, and badging as a form of motivation.

Table 3. Impacts on future virtual and hybrid teaching

Survey Questions (5-point Likert Items)	Mean Rating (n=119)	Standard Deviation
The format of the PD was conducive to learning.	4.66	0.60
This professional development session will extend my knowledge, skills, and performances.	4.71	0.56
I can use this training to positively impact the achievement of my students.	4.66	0.60

In interviews, several participants noted that their PD experiences impacted plans for organizing classroom learning management systems and using synchronous videoconferencing strategies. As Rick, a returning middle school social studies teacher, said, "We've always had Canvas, but they've always given the choice whether or not to use Google Classroom or Canvas…You all did a great job at it and it's really made us more excited about learning Canvas than we were a month ago." Other participants referenced "stealing" ideas for classroom use; as Marta, a high school math teacher, said, "Last year I kind of forced everybody to be in the room at the same time. And somebody would share their screen and we'd see what's on their screen. I really liked having the breakout rooms. That was awesome. I'm totally stealing that."

Participants also noted that the web-based format of Snap! would allow for adaptation to rapidly changing teaching contexts. As Dawn, a returning participant and high school ELA teacher, said, "We all understand that virtual learning isn't going anywhere, even if this virtual learning disappears and we are all back in brick and mortar buildings. There is really a great tool for us to use at our literal fingertips." Dawn also said that Virtual Pivot helped her envision CT integration for virtual and hybrid teaching: "I think the thing that I'm most excited about is that I actually have a project that is very, very accessible to kids that I know I don't have to wait to use. So, right now the momentum is going, right?"

Several participants also indicated that they planned to use digital badging systems with their own students. As Rick said, "We actually stole the badge idea for badges in our Canvas...I was skeptical, but those badges were just the best motivation to get us through. It was great motivation. I really liked it." Similarly, another participant noted: "People went nuts over these badges, especially the people in my group. I called them "badgers" because they kept on bugging [the research team] for their badges. Grown adults get excited about badges! Can you imagine what happens with high school and middle school kids?"

5 Conclusion

The COVID-19 pandemic has led to an immediate need for virtual PD models and formats that can engage teachers in rich learning around disciplinary teaching and learning in hybrid and virtual formats [10]. Further, due to the growing demand to increase access to computational thinking in K-12 classrooms [14], more research is needed on effective supports and for teachers to learn to integrate CT into existing disciplinary standards and curricula. Virtual Pivot illustrates the possibilities for virtual computational thinking PD experiences that are intentionally designed to support teachers through orchestrated digital formats, virtual tools and supports, and planned teacher engagements and collaborations.

The potential for failure in Virtual Pivot was high and presented numerous challenges for both facilitators and participants, who were tasked with learning computational thinking and coding, determining how CT can be used to support disciplinary teaching, and collaborating with new tools. These challenges raised the bar for our team, requiring us to carefully plan each moment of each day, identify the outcomes of each session, and orchestrate the experience to constantly orient the activities to our desired outcomes. Our participants rose to new expectations, as evidenced by their collective support for each other in group discussions and chats, their dedication to collaborating during Code and Create sessions, and their efforts to complete the badges we created.

Overall, our analysis of teacher surveys and interviews demonstrates that Virtual Pivot was successful in increasing participants' self-efficacy in teaching computational thinking, supporting development of collaborative coding ability, enabling participants to design CT-infused content-area lessons, and offering strategies for virtual, hybrid, and face-to-face classroom teaching. Shifting to a virtual format did require a number of adaptations and compromises, including an increase in the number of facilitators, providing more extensive pre-workshop training for both facilitators and participants, and a careful consideration of virtual tools to maximize affordances while also streamlining the experience for participants. Based on the success of the virtual format and the fact that participants reported greater engagement and higher self-efficacy, we plan to continue development of virtual PD experiences, even when F2F options are viable. It is our hope that elements of Virtual Pivot can be adapted by other researchers and educators who aim to design comprehensive virtual PD experiences for teachers to support computational thinking integration into disciplinary teaching and learning.

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