Reimagining Professional Development for K-8 CS Teachers: Evaluating a Virtual, Diffuse Model

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ABSTRACT

There is a need for more K-12 computer science (CS) teachers. The need to scale teacher professional development (PD) points the CS education community towards virtual learning, and prior work shows that in-person PD with a diffuse schedule is more successful than condensed schedules. There is currently little research about virtual K-12 CS PD with a diffuse schedule. The pandemic served as a forced opportunity to explore the design and implementation of a diffuse-scheduled virtual PD for two small, equally-sized cohorts of middle school (grades 5-8) teachers; one from a metropolitan school district and another from across the United States.

Our findings reveal several important post-pandemic design implications for future CS PD programs. First, the teachers' CS knowledge and attitudes significantly increased in both cohorts. Second, there were no significant differences in attitudes or achievement between the cohorts. Third, the teachers in the virtual PD showed as good changes or better in attitude than those in a prior in-person PD. Finally, both cohorts were largely positive about the change from a few intensive PD days to a few hours a week for several weeks, even as they joined from vacations.

CCS CONCEPTS

• **Social and professional topics → K-12 education**; **Computing education**.

KEYWORDS

computer science education, professional development, K-8

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1 INTRODUCTION

A central focus of the computer science (CS) education community over the last decade has been to broaden participation in computing and bring CS to learners of all ages. To accomplish this goal, more K-12 CS teachers are needed. Yet, as of 2020, only 20 states had state-approved pre-service teacher preparation programs at institutions of higher education [7]. This shortage, coupled with the many teachers that currently have little or no preparation to teach CS, has resulted in in-service teacher professional development (PD) serving as a major mechanism for preparing teachers to teach CS [2]. Effective CS PD should be long-term, discipline-specific, and classroom-relevant [2]. However, the majority of K-12 CS PD programs merely span a week or less [17].

In the summer of 2020, in the midst of the COVID-19 pandemic, we were forced to shift our annual summer CS PD to a virtual setting. This situation was unique for two reasons. First, teachers who normally would have chosen to attend physical, in-person PD would be forced to take virtual PD. Second, pandemic restrictions both placed extra burdens of childcare onto teachers during the summer and often disrupted teachers' prior summer plans. Given these factors, instead of just replicating our in-person PD in a virtual space, we took this opportunity to rethink the structure of our PD, seeking to take advantage of the new participation structures and instructional opportunities afforded by this situation.

Towards this end, we created a diffuse-schedule PD model. To do this, we expanded our PD to last 8 weeks with teachers only needing to attend synchronous sessions 1.5 hours a week. The remainder of the activities were completed asynchronously and were estimated to take 2 to 3 hours a week. This resulted in a 28-36 hour virtual CS PD program for middle grade (5-8) teachers. We chose an extended schedule because of the lack of vacations and few hours per week because of extra at-home responsibilities. Having shorter, synchronous PD sessions spread out over a longer period of time provided attendees additional time between sessions to work on assignments and reflect on the material being taught. The activities, described in Section 3, were designed to balance providing flexibility with providing the benefits of in-person learning. Our goal was to increase teachers' CS pedagogical content knowledge, and confidence in, and attitudes towards teaching CS.

Given the PD was now fully virtual, participants were no longer geographically constrained. This allowed us to recruit two cohorts of teachers - a local cohort from a single large school district who normally would have attended the PD in-person and a national cohort of teachers spread across the United States. Having these two cohorts provided an opportunity to investigate if and how teachers attending a virtual PD with teachers from the same (local) or different (national) district and geographical location impacted their experience. Additionally, having run this PD in the past, we have the data to compare the diffuse virtual PD to the in-person, condensed PD run in 2018. To better understand the effectiveness of the virtual, diffuse-schedule PD model for preparing middle school CS teachers, we investigate the following research questions:

- *RQ1 - Cohort: Do the teachers' CS attitudes and knowledge differ based on being in a local or national cohort?*
- *RQ2 - Outcomes: Is a virtual diffuse-schedule CS PD effective for improving teachers' CS learning and attitudes?*
- *RQ3 - Perceptions: What were teachers' perceptions of a diffuse and virtual CS professional development?*

2 PRIOR WORK

2.1 Theoretical Framework - Effective PD

We frame our work using Desimone's conceptual framework of effective PD [9, 10], which has been shown to be successful across multiple subjects and age groups [11, 21]. According to Desimone, effective PD includes the following factors: (a) *Content focus* - Emphasizing content and how students learn content; (b) *Active learning* - Providing opportunities for teachers to be involved in activities during PD rather than listening passively; (c) *Coherence* - Aligning PD content to other PD opportunities, teachers' knowledge and beliefs, and school, district, and state policies; (d) *Duration* - PD should include 20 hours or more of contact and last over at least a semester of time; and (e) *Collective participation* - Teachers should work together in a learning community with other teachers from the same grade, subject, or school [9, 10].

Diffuse schedule PDs that involve shorter sessions taking place over an extended period of time have shown to be more effective than condensed PDs [9, 10, 17]. PD opportunities rarely achieve the duration recommended by the literature. This is consistent with Menekse's finding that CS PD often lasted a week or less [17]. We investigate the outcomes of redesigning an existing K-8 CS PD to increase the span of time in which teachers learn the content.

2.2 Effective CS PD

Menekse concluded that effective PD for CS educators also requires similar factors: duration, active learning, pedagogical content knowledge focus, collaboration with local district or school administration, and support for classroom implementation [17]. Menekse did not include any factors that map to Desimone's *collective participation*. Additionally, *support for classroom implementation*, which is not a factor in Desimone's framework, is important for having teachers try new teaching practices [17].

Researchers in CS education have begun to design PD programs that adhere to effective PD factors [12, 19, 26]. For example, *SPARCS* PD [26, 30] was designed to teach middle school teachers computational thinking (CT) and programming (content focus). The teachers spent a minimum of 100 hours completing the activities in SPARCS (duration) learning CS content through Problem Based Learning (active learning). A second example can be seen with the *Exploring Computer Science PD model* [12], which had teachers engage in group lesson planning (active learning). The leaders modeled lessons and teachers learned from a student perspective (content focus), and collaboratively solved problems (collective participation). During the *Disciplinary Commons for Computing Education (DCCE)* [19] PD, teachers (9-12 grade) gathered eight times throughout the school year (duration) to learn CS concepts (content focus) and form a community (collective participation). Finally, the *Beauty and Joy of Computing PD program* [4, 18] for 9-12 grade teachers was designed with active learning, coherence, and a focus on content knowledge. Our virtual, diffuse PD also aligns with factors of effective PD and we investigate how we can redesign an effective in-person PD to an effective virtual PD with deliberate changes.

2.3 Online and Hybrid CS PD

Studies investigating or comparing online, hybrid, and in-person PD programs for K-12 grade teachers revealed promising results in terms of teacher knowledge, teaching attitude, and teaching confidence [5, 28]. Studies revealed the importance of addressing teachers' needs, modeling teaching, and encouraging collaboration to build a community [24]. Participants found value in collaborating with other teachers [25] and they found that being able to connect with teachers from other cities and states helped them feel less isolated [14]. Researchers also found that their online PD allowed participants access to the PD that normally would not be possible for them [13]. In an investigation of effective online PD for teachers that taught grades 6-12, researchers found that the teacher reflections often expressed positive and neutral sentiment throughout the weeks of the PD [26]. Additionally, when researchers compared student survey results from teachers who participated in online PD to those of students of teachers who participated in face-to-face PD, they found no differences [32].

Since the start of the COVID-19 pandemic, researchers have adapted their in-person PD for K-12 grade teachers to online PD [1, 15, 31]. Some found similar results to previous online PD where the teachers' teaching self-efficacy increased. Additionally, they found that their online PD model was successful in supporting teachers in completing coding activities collaboratively and in designing CT-infused lessons [15]. Others identified key takeaways from their experience: (a) Elementary teachers may struggle with using and adopting new technology and need support during the PD; (b) to keep teachers active in a online environment, it is useful to infuse shared physical activities, and include collaborative and individual activities; and (c) CT is a tool that can be used to design an effective and engaging online PD [31]. Amiel and Blitz developed a flexible 3-day PD where teachers could sign up for specific sessions they were interested in attending [1]. They found that many of the teachers were satisfied with the PD and felt confident after completing the PD. These recent works reveal the potential of adapting in-person PD to online PD and highlight challenges that should be addressed and design factors to consider when developing PD. Our PD was designed with the benefits of online and in-person PD and learning in mind. To our knowledge, we are the first to investigate how the switch from a condensed, in-person PD to a diffuse, virtual PD affected teachers during the pandemic.

3 PD DESIGN

In this section we detail the design of our 2018 in-person and 2020 virtual PD, planned with our local district partners. The PD is intended to prepare teachers to teach Scratch Encore using Scratch. *Our PD has two major design goals: learning and community.* To simultaneously build content knowledge, develop Scratch programming skills, and introduce Scratch Encore, we have teachers experience the challenges students may face by having the teachers act as learners. In addition, we introduce the pedagogical approaches used in the lessons, automated assessment tool, available teacher supports, and common student challenges. We also provide opportunities for teachers to interact with each other in order to build relationships and community.

In-Person PD (2018). In the summer and fall of 2018, we offered two rounds of in-person PD, each lasted two days and covered seven modules of Scratch Encore. Modules 1-4 were introduced on the day 1 and the remainder of the modules are covered on day 2 of the PD. In order to facilitate teacher interactions, the teachers sat at tables in groups of 4-8 and collaborated throughout the PD.

Virtual PD (2020). Developing or transitioning an in-person to virtual PD by simply digitizing the materials is not enough to ensure that the PD is effective [23]. Effective PD includes five factors [10]: coherence, active learning, content focus, collective participation, and duration. For Summer 2020, the research team and district leaders reimagined and adapted our PD structure and activities for a virtual PD for Scratch Encore that satisfied the goals (learning and community), followed best practices for effective PD, and worked within the unique constraints of the pandemic (e.g., less vacation travel, potentially greater childcare burdens).

Consistent with our RPP, we maintained *coherence* by co-planning all PD activities for all offerings with district partners, which helped align the PD with other initiatives the district was working on. We addressed the need for a flexible schedule by moving from the condensed to a diffuse schedule (*duration*) which resulted in an 8-week PD that combined synchronous and asynchronous activities. We met synchronously for 2-3 hours per week; each week began with a 30-minute full-group introduction to that week's material and one pedagogical concept. Teachers then asynchronously completed 1-2 hours of work: a short learn-by-example task, then an open-ended project. The switch to a diffuse schedule allowed time for *active learning*, where teachers completed both, rather than only one, of the activities from each module and gave teachers more *content focus* by providing more time to process the content in all seven modules.

Our other goal, building community, depended on maintaining opportunities for teachers for *collective participation.* In our traditional PD structure, teachers typically work together and converse with the teachers seated at tables near them. Online, this same conversation is not naturally possible, so we sought to mimic the collaboration that happens organically in person by using collaborative coding sessions (CCSs) that were designed to give teachers work time for their assignments as well as the opportunity to ask questions to and collaborate with peers and facilitators. CCSs were held towards the end of each week for 1 hour. This gave teachers time between the introductory lesson to process the content and work on their activities before attending the CCSs with questions.

4 METHODS

4.1 Recruitment and Participants

In this section, we detail the recruitment of participants in our IRB-approved study. In summer and fall of 2018 we recruited 9 and 22 teachers, respectively from a single, metropolitan school district. In summer 2020 we recruited two cohorts of teachers. The first was recruited through the school district office. Their CCSs were facilitated by district lead teachers. The second cohort consisted of teachers from across the US that had been recruited via an email sent to everyone that had registered to use Scratch Encore (human subjects requirements limited participation to US teachers). We chose middle grade public school teachers who were teaching technology or science and had not taught Scratch Encore before. Their CCSs were facilitated by researchers who were former teachers. The two cohorts participated in the same activities, but in separate synchronous sessions. Of our 42 participants (22 local, 19 national), 25 were female, 14 were male, 1 was non-binary/third gender and 1 preferred not to state. 29 participants were white, 6 were Black or African American, 2 were Hispanic or Latino(a), 2 were Asian, and 2 preferred not to state.

4.2 Data Collection

In 2018, we collected general information about their teaching background. Surveys for attitudes towards CS and teaching CS were given before (pre-survey) and after the PD (post-survey). In 2020, assessments for CS content knowledge were given before (pre-assessment) and after the PD (post-assessment). Surveys for attitudes towards CS and teaching CS were also given before and after the PD, as well as on a weekly basis.

After the 2020 PD, teachers participated in focus group interviews. Questions included "What went well with the professional development?", "What supports helped you as both a learner and a teacher?" and "What challenges were associated with the professional development?" The 9 focus groups (45-60 minutes), run by researchers who administered the PD, were separated by cohorts (5 local groups and 4 national) and had 3-5 teachers in each. The focus groups were video and audio recorded and transcribed.

4.3 Data Analysis

This study uses a QUAN + QUAL convergent mixed methods design [8] to examine teacher experiences during the PD and outcomes. Both quantitative and qualitative data were collected and analyzed concurrently, giving the two data streams equal importance within the work. We compared the results to highlight similarities and differences between the data streams. In the following section we describe the analysis methods for each data type.

4.3.1 Qualitative. Two researchers individually open coded three transcripts [29] and reached saturation. We developed a code book from the codes that emerged during the open coding phase. The codes relevant to this work cover teacher comments about the PD modality (virtual vs. in person and synchronous/asynchronous activities), how they learned over time, their increase in CS knowledge, and the time commitment of the PD. Afterwards, we individually coded three transcripts to calculate inter-rater reliability. The kappa values ranged from .53 to .60, showing moderate reliability [16]. We met and came to an agreement on their differences. The remainder of the transcripts were coded individually and we met to resolve our differences and reached complete agreement.

4.3.2 Quantitative. Quantitative data were analyzed to better understand changes in participant knowledge of CS, perceptions of CS, and attitudes towards teaching CS.

Participants' knowledge of CS was measured using the CS content pre- and post-assessments. The assessment had 41 questions and the questions were mostly multiple choice with a few short answer questions. Questions were graded as either right or wrong, and total assessment scores for each teacher were calculated and compared. We examined not only the group as a whole, but also the two local and national cohorts as separate groups. To determine whether the pre- and post- assessment scores differed between the two cohorts, we conducted a Mann-Whitney U test. For within-subject analyses (e.g. comparing pre and post scores for the same participants), we conducted a two-sided t-test.

The attitudes data was drawn from the pre- and post-surveys. The 2018 PD used the validated Teachers' Attitudes Toward Computers Questionnaire [6]. Five relevant factors from the survey (enthusiasm, anxiety, semantic perception, absorption, and significance) were included in our pre- and post- survey. The semantic perception questions asked the teachers to rate how they felt about CS ranging from positive to negative adjectives (e.g. pleasant to unpleasant). In addition to these five factors, Enthusiasm for Teaching Computer Science was added specifically pertaining to teaching CS. In total, the final survey consisted of 33 Likert-scale questions.

In 2020, the validated attitude questionnaire was used with the questions being modified to ask about "computer science" rather than "computers" as the original questionnaire was written. To determine whether the pre- and post- survey answers differed between the local and national cohorts, we conducted a Mann-Whitney U test. Then we conducted a Wilcoxon Signed Rank test to compare pre- and post- survey results. We also compared the pre- and post-survey results between the 2018 and 2020 teachers.

5 RESULTS

We begin by comparing the local and national cohorts and presenting results on the overall effectiveness of the PD. We then review our findings about how the teachers perceived the diffuse schedule and virtual modality of our PD.

5.1 RQ1: Within vs. Across District Cohorts

The structure of our virtual PD allowed for two distinct cohorts: a local cohort drawn from a single, large, metropolitan school district and a national cohort. Our hypothesis was that teachers drawn from the same school district, even though they never met in-person and may be physically scattered over a great distance, might have attributes that led to greater learning and attitudinal gains. We have three lines of reasoning that lead to this hypothesis. First, teachers may feel more accountable because district leaders were involved in the PD. Second, teachers might share an identity and sense of community with other teachers in the cohort due to being in the same district and teaching similar students. Third, they might be more engaged because the teachers they meet would be potential local collaborators in the future. To investigate whether there were differences, we compared the scores of the pre- and post-CS assessments and pre- and post- attitudes surveys by cohort.

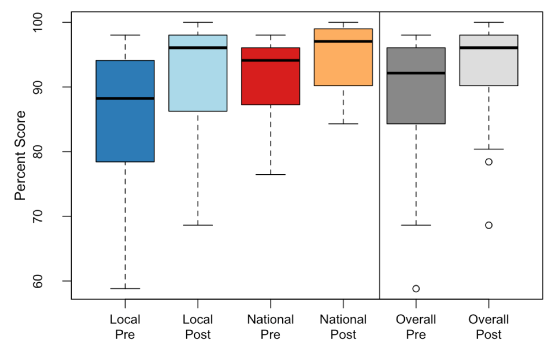

Figure 1: The scores of participants in both cohorts and overall, in knowledge pre- and post- assessments

Finding 1: There were no statistically significant differences in pre- and post- attitudes or knowledge between the local and national cohorts.

Figure 1 displays the pre- and post- CS assessment scores of the participants, both separated by cohort and combined. Despite a visual difference in the graph between the pre- assessment scores of the cohorts, there was **no statistically-significant difference between the groups' knowledge** for either the pre- (W=120.5, p=0.15, r=0.241) or post-assessment (W=145, p=0.48, r=0.117).

Figure 2 displays the CS attitude scores of the cohorts. We combined Likert scores to form composite attitudinal scores for each factor. Differences in values between the survey factors is partially due to the fact that each survey factor has a different range of values on their Likert scale, shown by the black line. Enthusiasm, Anxiety, Absorption, Significance, and Teaching CS Enthusiasm are measured on a 1 to 5 scale, and Semantic Perception is measured on a 1 to 7 scale. A higher Likert rating indicates a more positive attitude, including the Anxiety factor. There were **no significant differences between the groups' CS attitude for any factors** in either the pre- or post-survey.

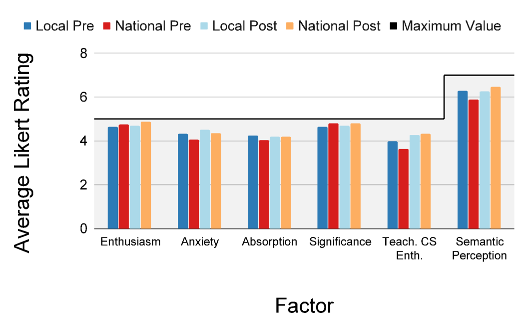

Figure 2: Average Likert rating per survey factor of participants in both cohorts in attitudes pre- and post- survey.

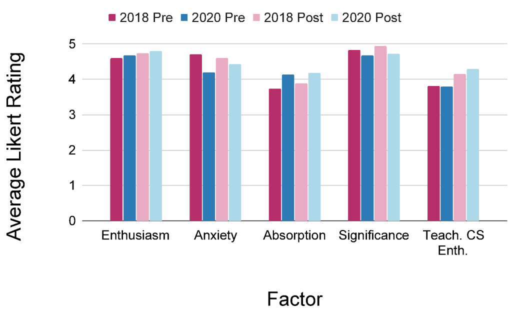

Figure 3: Average Likert rating per survey factor of 2018 and 2020 participants in attitudes pre- and post- survey

	Pre		Post	
	2018	2020	2018	2020
Enthusiasm	4.60	4.68	4.73	4.79
Anxiety	**4.71***	**4.19***	4.59	4.42
Absorption	3.73	4.14	3.88	4.18
Significance	4.82	4.67	4.93	4.72
Teach. Enthu.	3.80	3.79	4.14	4.29

Table 1: Average rating per factor between the groups. Bolded with a * indicates statistically significant differences when adjusted using the Bonferroni Correction.

5.2 RQ2: Outcomes of a Diffuse, Virtual PD

We next investigate the second research question, which asks if the diffuse PD was successful. To answer this question, we look both at the pre/post differences of the virtual, diffuse PD run in 2020 and also by comparing the 2020 virtual, diffuse PD with the condensed, in-person version of the PD conducted two years prior.

Finding 2: There was a statistically significant improvement in both learning and attitudes in 2020.

The overall results depicted in Figure 1 show a statistically significant improvement in CS content knowledge in teachers who participated in the diffuse PD (t=2.385, p=0.02, d=0.62) with the average pre-assessment score being 88.5 and the average post-assessment score being 93.27. The standard deviation for the pre- and post-assessment scores are, 9.56 and 7.5, respectively. Across all participants there was an increase in score between the pre- and post-knowledge assessment. Participants scored on average 4.3% higher on the post-assessment than on the pre-assessment. This increase is despite a possible ceiling effect, since the starting average was already above 88%, indicating that many of our teachers began with a strong set of knowledge about CS and Scratch programming.

Figure 3 displays the average Likert rating for the pre- and post-surveys of the 2018 PD and the combined cohorts of the 2020 PD. Looking just at the 2020 results, we see that there was a significant increase in positive attitudes between the pre- and post- attitudes survey (V=115, p=0.005, r=0.372).

Finding 3: The virtual format was as or more effective than the in-person model with respect to attitudinal outcomes.

Figure 3 displays the attitude scores for each factor with each cohort. Table 1 shows that there was *a statistically significant difference in the CS anxiety between the 2018 and 2020 groups in the pre-survey* (W = 439.5, p-value = 0.002166, r=0.427) but not the post-survey (W = 356, p-value = 0.1639, r=0.194). The 2020 had a larger reduction in CS anxiety; they started at a higher CS anxiety level but ended at a similar point to 2018.

5.3 RQ3: Teacher Perceptions of a Diffuse, Virtual PD

In this subsection, we expand on the quantitative results of the attitudinal Likert questions to present an analysis of teachers' perceptions of the diffuse, virtual PD design. Our focus group interview protocol asked participants to share their perceptions about the diffuse nature of the PD sessions and the infrequent meetings over a longer period of time than is typical of teacher summer PD.

Finding 4: Teachers had a positive view of the PD length.

An overwhelming majority of the teachers indicated that they had positive views of the PD length (36 out of 42 teachers). Teachers cited the spacing of the sessions, the virtual format, and commuting difficulties as contributing to these views. They felt that the spacing of the introduction and collaborative sessions allowed them time to work on their projects, explore and digest the content, refresh their knowledge and understanding, think about their problems, and ask for help when needed. As one teacher said, the extended length *"gave me more time to process and assimilate the information and get a clearer understanding"*. As the PD progressed, teachers reported developing routines that fit the diffuse structure: *"I was able to work on it Tuesday, Wednesday, so that way Thursday if I had any questions...I was able to kind of come prepared with that."* Five of the above teachers, however, also expressed that the duration of the PD was too long: *"I mean this was a long PD."* and *"I could even have done like longer sessions ... in between a 2 full days versus the eight weeks."* This indicates that although the teachers found the diffuse schedule to be beneficial, they also found the full 8 weeks to be a large time commitment.

Finding 5: Teachers liked the blend of synchronous and asynchronous work.

Teachers mentioned the blend of synchronous and asynchronous work when we asked about the unique aspects of our PD compared to other virtual PD programs. Nine teachers highlighted positive interactivity and the blend of synchronous and asynchronous components as unique compared to other virtual PD programs. One teacher stated: "*I took one other virtual PD this summer and it was asynchronous so it was all just...do it at your own pace and there really wasn't any real human interaction. So I liked that there's real human interaction, so that was unique.*"

6 DISCUSSION

Our goal for this work was to understand the experiences of teachers going through a diffuse, virtual PD. In redesigning the PD, we created a longer PD (in terms of calendar days but not in terms of in-person content hours), resulting in a diffuse structure that provided significant flexibility to attendees. The PD also blended synchronous and asynchronous learning opportunities to maximize the benefits of working virtually. In this section, we review our findings and evaluate the effectiveness of the PD and discuss implications of this work and limitations of the study.

6.1 Local vs. National Cohort Similarities

Research has shown evidence of the importance of having a collective community for effective PD [3, 20, 23]. Our hypothesis was that a cohort of teachers from a single school district would see greater benefits compared to a cohort of teachers from different districts. This is because teachers from the same school district may know each other, follow similar norms, and understand the needs of students in the district better. However, no differences appeared in the data. There could several reasons for the lack of difference.

One explanation is that the school district for the local cohort was too large geographically to produce a cohesive sense of community among the teachers. None of the teachers in the local cohort taught at the same school and might not have known each other. Additionally, with such a large school district, the norms and needs of one school may not be as similar to the norms and needs of other schools as we thought they would be.

A second possible explanation is that this PD was the first opportunity for a national cohort to participate in Scratch Encore PD, but it was the third opportunity for the local cohort, which may place them in different places in Rogers' Diffusion of Innovation theory [27]. The national cohort self-selected based on learning about the curriculum from national forums and then being contacted about the opportunity by our team, which means they might be innovators or early adopters [22]. The teachers from the local cohort, on the other hand, were strongly encouraged by the district, which might have resulted in a group skewed towards early majority. So the personal initiative shown by the national cohort teachers may have balanced out the identity advantages of the local cohort.

6.2 Outcomes of an Effective PD

Virtual PD has shown promising results [5, 28] in the past and allows us to reach more teachers around the country and across the world. Recent work has shown the community that an emergency switch from in-person to virtual PD can still result in positive outcomes for the teachers [1, 15, 31].

Desimone asserts that effective PD should result in the increase of the teachers' knowledge and skills of the subject, changes in their beliefs and attitudes, or both [9]. Our analysis revealed that diffuse structure of the PD for Scratch Encore was effective in increasing teachers' CS knowledge, CS attitude and confidence, and teaching CS attitude and confidence. We also found that the teachers who went through the diffuse, virtual PD in 2020 experienced similar or better positive effects in CS attitude as the teachers in the in-person PD in 2018. We believe that the positive outcomes of our PD can partially be explained by the combination of the diffuse format and teachers increased comfort with virtual instruction.

In offering a diffuse, virtual PD, we found the blend of synchronous and asynchronous time spread across many weeks allowed local and national teachers to participate in the PD due to the flexibility of the schedule. This is attractive to teachers in the summer, especially once the pandemic is resolved. One teacher in this PD even attended a PD session while on vacation.

From our focus group interviews, we also discovered that the virtual aspect removed the barrier of commuting for many teachers, even some teachers in the local cohort who would have only needed to commute within the (large metropolitan) city in which they live. Five teachers discussed commuting as a barrier to attending in-person PD (*"I would never have come out to [the city] this summer... it just wouldn't have been in the cards for me."*). The virtual and thereby geographically neutral format was important in allowing equal access to CS PD and will lead to more well-trained K-12 CS teachers. While many parts of our lives will return to "normal" once the pandemic is over, the knowledge we gain from learning and teaching online can be harnessed to improve teachers' PD experiences and to continue to reach a larger number and more diverse group of teachers.

6.3 Limitations

The number of teachers who participated in the PD was relatively small (42), and the participants were self-selected because only teachers who had interest in teaching CS would join the PD. Additionally, as a qualitative study, there is always a potential of researcher bias. However, we worked together to resolve our differences through discussion in order to minimize those biases. Finally, we currently do not have data on how teachers implemented CS in their classrooms and whether the PD program helped them boost their students' learning. This is an area of active research and plan on continuing this research to address these limitations.

7 CONCLUSIONS

With the increase in demand for CS in K-12 schools comes the need for knowledgeable teachers to teach CS content. Research on PD for middle grade (5th-8th) teachers has only emerged recently and there is still much to learn about how to design effective and scalable PD for these teachers. Towards this end, this work reports on the effectiveness of a virtual, diffuse schedule PD program for middle grade teachers. We found that the diffuse, virtual PD was equally effective in terms of knowledge and attitude for both local and national cohorts of teachers. Our analysis found that teachers who participated in virtual, diffuse PD for Scratch Encore had increased CS knowledge and improved CS attitudes. Further, they expressed positive sentiments about the extended and virtual PD and its blending of synchronous and asynchronous instruction. Collectively, this work contributes to the growing body of knowledge on how to design effective PD programs for K-12 CS teachers, and in doing so, seeks to help address the need to scale effective CS PD to help prepare teachers to bring CS into classrooms across the country and around the world.

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