Project, District and Teacher Levels: Insights from Professional Learning in a CS RPP Collaboration

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ABSTRACT

This paper presents an experience report from an NSF-funded researcher-practitioner partnership (RPP) project. Based on a collaboration among two public research universities and three urban school districts in the Northeast USA, the goal of the project is to establish an institutionalized middle school computer science curriculum in the districts. The CS curriculum incorporates digital literacy skills as an integral aspect of learning computer science, and is based on students developing mobile apps that provide social and community good. Here, we share our professional learning process during the project's first year, which had been developed iteratively and dynamically adjusted to a remote format in response to exigencies of Spring 2020. The paper includes analysis of three data sets from teacher-participants: (1) their questions about the nature of the project, which we categorized into three levels: project, district and teacher levels. These questions bridge the visions and knowledge among different groups of the project partners; (2) analysis of semi-structured interview conversations with more than half of the teacher-participants; and (3) teacher survey responses. Our findings include two recommendations: that RPP projects elicit teacher questions to illuminate the three levels identified, and use strategies that engage teachers in designing a professional learning process for teaching computer science.

CCS CONCEPTS

•Social and professional topics~Computing education~K-12 education

KEYWORDS

Middle School, Teachers, Computer Science, Digital Literacy, CS RPP, Community, Confidence

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1 INTRODUCTION

Since the 1980s, the researcher-practitioner partnership (RPP) has been an established practice for education research and innovation (e.g., [3]). In the RPP model, researchers and state or local education agencies partner to "identify an education issue or problem of high priority for the education agency that has important implications for improving student education outcomes" [1]. RPP collaborations are long term relationships, focusing on "problems of the practice," and providing "mutualism" which builds trust [2]. In the United States, the National Science Foundation began supporting computer science (CS) education research projects based on the RPP model as part of its CSforAll program [8].

The paper is an experience report from the first year of CS Pathways RPP, a project funded under the NSF CSforAll:RPP program. The funding supports a collaboration among the University of Massachusetts Lowell, the University at Albany, and three urban school districts in MA (Lowell and Methuen) and NY (Schenectady). The partners are establishing a lasting middle school CS curriculum that is based on students developing mobile apps for community and social good. The work is based on prior NSF-supported work that developed an 18-hour middle school CS curriculum [6, 7].

Table 1 summarizes the student demographics of the three partner school districts. All districts have substantial populations of students who are underrepresented in STEM fields, including computer science. Of particular note, Lowell's population includes a large number of students who are the children of Southeast Asian refugees, Methuen includes a substantial Hispanic population, and Schenectady is one of the most economically disadvantaged cities in the USA. All partner schools are located in urban areas, and are nearby to one of the two partner universities. The project principal investigators had prior collaborations with their nearby district partners and used these as the foundation for the current project.

Table 1: District Demographics. Data for MA from 2017–18 and for NY from 2016–17.

	Lowell, MA	Methuen, MA	Schenectady, NY
total enrollment	14,436	6,935	9,251
gr 6–8 enrollment	3,350	1,719	2,068
# middle schools	9	4	3
Black %	7.9	1.2	31.7
Asian %	28.9	3.8	17.2
Hispanic %	31.9	39.4	20.5
White %	27.4	50.5	24.2
economically disadvantaged %	55.9	34.8	83.9

This paper focuses on an iteratively developed professional learning experience engaged in by the project team—university faculty, staff, and students, and school district teachers and administrative leaders. Five major themes emerged from teacher interviews and surveys: building teacher confidence, changing perceptions on CS and CS education, exploring identity as a CS educator, building a professional learning community, and teacher challenges and needed support. Additionally, teacher questions revealed the need for the project to distinguish among project, district, and teacher level implementation goals. Recognizing these levels was a key insight in the present work, and provides a framework that may be used by other RPPs.

2 PROFESSIONAL LEARNING

Here, we present the structure of the professional learning (PL) experience we shared with our teachers, how we modified the design in response to the needs to be remote in Spring 2020 owing to the COVID-19 pandemic, and how teacher questions about the nature of the project led to insights to the RPP structure.

2.1. PL Overview

Content. The goal of the professional learning plan was to engage the district teachers with (1) learning what is computer science and digital literacy (CS/DL), (2) why it matters for students to learn CS/DL, (3) how this teaching may be integrated into each school's existing curriculum structures, and (4) how CS/DL can be taught in a way that engages all students and is culturally responsive.

Structure. The project's original PL plan included 52 hours in the first year, shared between in-person meetings and homework activities. The three districts would each receive a parallel schedule, with one PI organizing the meetings with their two local districts and the other PI working with their one local district. Each site would have four joint meetings on Saturdays, and other six separate monthly after-school meetings. Then in March 2020, the project moved to virtual meetings along with the rest of the world. We established a schedule of one whole-project PL meeting every two weeks.

The project included 19 middle school teachers, four district leads (two in one district), and one devoted school principal. This pivot allowed us to accomplish something wonderful: have the three districts meet jointly. This facilitated teachers and district leads to learn from each other's joint challenges and differences.

Approach. The full project team comprises the PIs, graduate students, staff members, the project evaluator, and district leads. This team worked closely to plan PL experiences for the teachers which dynamically responded to needs as they emerged. As the four content goals noted are all interrelated, the work of the PL experience wove continuously back and forth among them. Sessions included discovering priorities using the SCRIPT Visions Toolkit [9], learning experiences building mobile apps, and conversations about teachers' own learning challenges.

2.2 PL Adjustments

The original project plan called for teachers to deliver initial in-school instruction to students in the latter half of the spring semester. The in-person school year was called off shortly after going remote. It then became evident that remote learning was going to be essential on an extended basis—that teachers might need to deliver instruction remotely in the upcoming fall.

This led to a re-evaluation of project technology, which had been based on the use of MIT App Inventor. This system is technically complex in how the browser-based software pairs with tablets and phones, and only works with the Android platform. Once we began working remotely, we recognized the need for a solution that could more easily be used at home. We introduced alternative technology which addresses these technical challenges—Code.org's App Lab.

2.3 Soliciting PL Questions

Midway through the professional learning process, we asked teachers to ask us questions they had about the project. We scaffolded this by asking them to review the 18-hour project curriculum that had been created by teachers in the prior project, think about what they needed to implement this curriculum into their own classroom, and state three questions this generated. This approach was inspired by the Question Formulation Technique, where learners are encouraged to ask questions about the topic they are investigating and allow each question to prompt the next one [4].

We had expected that teachers would produce questions that were quite local to their own teaching, and specifically about the computer science curriculum. In reviewing teachers' questions, we recognized that they covered an entire gamut of possible inquiry about the project scope and intentions. We invested in the richness of the questions by organizing them into three levels—project level, district level, and teacher level (Table 2).

Table 2. Three Levels of Teacher Questions (Examples)

Project Level	Is it okay if some students do not participate in this project? Is the overall goal of this project to have students make their own unique, community focused apps? If student collaboration is allowed, at what level?
District Level	Are we to reach all students in the same grade level? In which subjects? Will high school be prepared for an influx of students interested in CS?
Teacher Level	Is there a database/information center/FAQ area for students to easily access examples, questions, troubleshooting, etc.? Are there models/examples to look at to get a better idea of how I could make the lessons in this project fit into my already very full curriculum?

Project level refers to foundational assumptions about project implementation. In our case, the project is intended to bring computer science and digital literacy to *every student* in each of the three partner school districts. This came up as a question, and it was one that we thought we had answered.

District level refers to decisions that may be made at a district level, and can be different among the partner districts. An example is "Are we to reach all students in the same grade level?"—the answer is yes for each district, and each district is free to choose different target grades.

Teacher level refers to choices that can be made individually by teachers. These were mostly requests for resources which could be shared among teachers.

As teachers genuinely asked things they needed to know to accomplish their work, their questions spanned the whole project. With the framing of the three levels, teachers' questions revealed their understandings about the overall structure of the RPP collaboration—what they knew and what they wanted to know. This revealed information that we had not yet successfully communicated, and allowed us to bring topics back to the district leads for conversation.

3 METHODS

As part of a Design-Based Implementation Research (DBIR) process [5], data was collected at multiple points and reviewed by the RPP team to inform project planning and implementation. Teacher data included pre- and post-surveys, meeting notes, teacher products from homework, and end-of-year interviews. In this paper, we report results from the teacher interviews supplemented with the pre- and post- teacher survey data, focusing on teachers' PL experience.

All the 19 project teachers completed the pre-survey during the first PL meeting and filled out the post-survey at the last school year meeting. These surveys collected teacher demographic information and confidence levels related to the project curriculum. The post-teacher survey also included five open-ended questions asking about their learning experiences. Example questions include: "*What did you learn from the CS Pathways project this past year?*" and *"What questions or concerns do you still have?"*

The project researchers invited all the teacher-participants for a semi-structured interview. The primary aim of this interview was to further understand teachers' PL experiences, their learning needs for next year, and how to build a strong PL community and support their implementation of the CS curriculum. Sample interview questions include: "*What has been your experience with the project?*" and "*How do you feel about teaching computer science?*"

10 of the 19 teachers participated in the interviews, including two science teachers, two math teachers, and six technology teachers, with teachers distributed across the three school districts. Each interview was conducted through a Zoom meeting and lasted around 30–45 minutes. The interviews were recorded and then transcribed in verbatim. The transcriptions were analyzed by three project researchers. The results were synthesized into themes and further triangulated with results from the teacher surveys.

4 TEACHER PROFESSIONAL LEARNING EXPERIENCES

Overall, most of the project teachers reported positive learning experiences in the past year. Teachers valued the joint online PL meetings, for convenient and efficient continued learning during the pandemic. Five major themes emerged from the interviews and surveys related to teacher learning experience and project impact: building teacher confidence, changing perceptions on CS and CS education, exploring identity as a CS educator, building a professional learning community, and teacher challenges and needed support.

4.1 Building Teacher Confidence

The pre- and post-surveys included 15 questions (on the scale of 1=Not at all, 5=Very) asking teachers to rate how confident they were in the following three aspects: app usage (**F1–F2**), app creation (**F3–F9**), and teaching DL (**F10–F15**). A paired t-test was performed on the responses from each question and an overall combined metric. The combined results from the pre-survey (M =3.52, SD =1.45) and post-survey (M = 4.16, SD = 0.999) indicate that there is a significant increase in teachers' confidence after participating in the project PL ($t(18) = -5.94$, $p < .001$). The SD in post-survey is relatively small, indicating the gap across teachers decreases. Figure 1 includes synopsis of these 15 questions.

We also compared the mean of each question's responses. There were seven items relating to teachers' confidence in their own skills in app creation (**F3–F9**). Five of these showed statistically significant increase, indicating a successful process during the PL: **F3** (Pre: M = 2.79, SD=1.47; Post: M =3.95, SD =1.03, $t(18) = -2.39$, $p = .028$); **F6** (Pre: M = 3, SD= 1.56; Post: M = 4.47, SD = 0.84, $t(18) = -3.15$, $p = .006$); **F7** (Pre: M = 2.95, SD=1.51; Post: M = 4.42, SD =0.90, $t(18) = -3.20$, $p = .005$); **F8** (Pre: M = 2.95, SD= 1.61;

Post: M = 4.42, SD = 0.90, $t(18) = -3.00$, p = 0.008); **F9** (Pre: M = 2.89, SD= 1.63; Post: M = 4.11, SD = 1.20, $t(18) = -2.27$, p = .036).

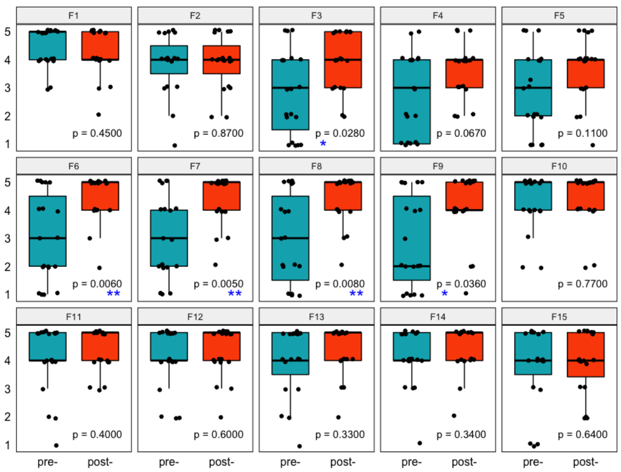

Figure 1: Teacher Confidence (Pre- and Post- Survey)
*$p < .05$. **$p < .01$. N = 19. **Responses**: 1- Not at all, 5-Very. **F1**: Use apps; **F2**: Use apps to solve a community problem; ***F3**: Create apps; **F4**: Create apps for a community problem; **F5**: Create apps relevant and exciting to students; ****F6**: Create apps with an image; ****F7**: Create apps with multiple images; ****F8**: Create apps with sound; ***F9**:Create apps with multiple screens; **F10**: Teach DL skills as part of a CS curriculum; **F11**:Teach-file naming conventions for apps; **F12**:Teach-resize images; **F13**:Teach-edit/select audio files; **F14**: Manage student collaboration; **F15**: Integrate app development into existing curriculum.

However, the scores of the three items on using (**F2)** and creating (**F4**) apps to solve a community problem and creating apps relevant & exciting to students (**F5**) were not significantly improved. This result suggests more introduction on apps for community good and apps relevant to students is needed in future PL meetings. Meanwhile, none of the questions regarding teaching of digital literacy showed a significant improvement. Part of the reason is that the pre-survey scores were already high, indicating teachers were already proficient in these skills and had little room to grow throughout the PL.

In the interviews, teachers further shared their thoughts in terms of how the PL influenced their ability or confidence of teaching the CS/DL curriculum. Most teachers felt teaching the project curriculum was feasible, because (1) the PL increased their CS skills and knowledge; (2) non-technology teachers saw the possibility of integrating the CS/DL content into the content areas they were teaching; (3) teachers were empowered with new pedagogies to engage their students; (4) teachers felt they had built connections with project researchers, district leads, and other teachers. They were motivated by other teachers in terms of teaching CS/DL. For example, one teacher reported that she became more confident in terms of integrating the CS curriculum into her science class:

> Teacher B: "For me, to have a little more depth of understanding, has moved it from the bonus zone to something more like, [CS] is another scientific career, another scientific pathway we could try. I have a deeper understanding and deeper commitment to it… It has changed my outlook on my feasibility of implementing the curriculum as far as skills and knowledge."

Another teacher, an experienced technology teacher, reported being more comfortable with implementing the curriculum, with new CS pedagogies learned from the project:

> Teacher C: "It takes [my teaching] to the next level. I've taught coding for six years, but I've never taught pair-programming. That's what I'm really excited to bring to the classroom… I feel like it kind of gave me pause to think that even kids as young as sixth graders are capable of doing this if we give them the tools."

On the other hand, a few teachers were less comfortable with implementing the curriculum. In the post-survey, most teachers expressed they had either already started (3 teachers), or had some specific ideas to implement the whole curriculum or pilot part of it (11 teachers). Four teachers expressed they were not sure how they would implement the curriculum, either due to the uncertainty related to distance learning and school scheduling in Fall 2020, or the need for more time to learn and prepare. Two of these four teachers further explained in the interviews that they did not feel ready to teach the curriculum all by themselves and wished to have more time to consolidate what they had learned from the PL.

4.2 Changing Perceptions on CS and CS Education

Teachers also reported how the project impacted their perceptions on CS and CS education. Through their first year of PL, teachers were able to (1) see the value of CS for all students, with a broader view of CS, (2) learn how CS can be introduced in a more encouraging and fun way; (3) understand it's ok to not know everything when teaching CS.

CS is broad and valuable for all students. Teachers reported their views on CS changed over the past year. CS was perceived as a broader and inclusive field. Most teachers realized CS is not only programming, but also about problem-solving and computational thinking. For example, Teacher A mentioned that her image of CS was changed from stereotypes to broader images, seeing CS as a big field that "every student should be exposed to and needs to do."

Another impact of the PL is that all the teachers were able to see values in teaching CS. Two teachers explicitly said that CS/DL should be part of school curriculum and be taught "on a regular basis". Two teachers highlighted that CS should also be promoted for girls. Another teacher emphasized the significance of CS to culturally diverse students:

> Teacher E: "I've been convinced that it is a big field and it's up and coming… I want my students, especially in the diverse district that I'm in with mostly black and brown population, to be able to have those opportunities to go into computer science."

CS can be introduced in a fun way for middle schoolers. A few teachers changed their perceptions of CS, seeing it as "a more teachable subject." They had thought that CS only focused on coding, and was complicated and inaccessible for their students. After the PL, they felt that CS could be fun for students at younger ages, and be appropriate for middle school students:

> Teacher A: "Now, it is completely not the way I perceived it, which was sitting there typing code… and there's no way I can bring this to my students. They just don't have the background knowledge. But then seeing how we were doing it here, I'm like, this is fun, they could have a really good time with this… There are ways they could do it and enjoy it."

Being a CS teacher: it's okay to not know everything. A few teachers reported they learned from the PL that teachers could make mistakes in coding and learn with their students along the way. Three teachers provided similar comments with:

> Teacher K: "[It] showed me that it is okay to not know everything about coding and apps. A lot of CS is trial and error; if it does not work, go back and try again."

4.3 Exploring Identity as a CS Educator

Teachers reported different feelings and ideas about their roles in terms of implementing the project CS/DL curriculum at their own schools.

Content area teachers: Seeking ways for integrating CS. Several teachers saw themselves as content-area teachers (e.g., math) when teaching the CS/DL curriculum. These teachers did not naturally see their role in teaching CS at the beginning:

> Teacher I: "One [thing] I struggled with was, I have no background knowledge like a lot of people do. There is definitely a time I feel I am not at the right place."

Through the PL, they were seeking ways to integrate CS knowledge into the content areas they were currently teaching. Teacher G shared in detail how content teachers and tech teachers could take their own roles and eventually impart CS knowledge to their students:

> Teacher G: "I'm not going to be building this multi-tiered app [introduced in the PL]. But what I am going to do is to try to get my kids talking about apps. So, it's like, how can we do that on an introductory level, whereas tech teachers might be able to do that more advanced app."

Another content area teacher (Teacher E) expressed similar ideas of being less comfortable with working on advanced apps due to the lack of CS skills, e.g., debugging:

> Teacher E: "I don't see myself doing some of the harder apps, like how to problem solve with real-time bugs. I don't want to bring that level into the classroom until I feel more confident in my ability to debug it. But the lower level stuff, like the simpler apps, I could definitely do… I don't want to limit the kids. I also don't want to put myself in charge of something that I can't help them fix."

Meanwhile, Teacher G believed that the way she was using her role as content-area teacher to teach CS could also send an encouraging message to her students:

> Teacher G: "I think the more kids see that a quote unquote 'non-computer teacher' can give them the skills they need. It's like, wow, anybody can do this."

Tech teachers: Adjusting course plan. Tech teacher participants felt they had some advantages in terms of understanding the CS/DL curriculum. For example:

> Teacher F: "I had some understanding of how the structure of those things worked, where I don't think that some of my colleagues did. Not that you had to have that, but I think it did give me a little bit of an advantage in terms of understanding how the applications run things, like run a call for a function."

Therefore, they would work on adjusting their curriculum to integrate CS/DL. Teacher C also mentioned that the PL made her completely change her technology curriculum planning for the next year to include CS/DL:

> Teacher C: "[CS] can be adapted to [sixth grade] … It's totally changed my curriculum planning for next year. I'm revising the whole sixth grade curriculum to be this, at least for the first half of the year."

Experienced teachers: Volunteering as teacher leaders. One experienced tech teacher (Teacher D) gained confidence from the PL and felt like she had acquired the skills necessary to become a lead teacher for the project. She was comfortable seeing herself taking the role to train and support others in implementing CS/DL into their curriculum. Another two teachers (Teacher A and Techer E), who had not taught CS before, would also like to take on leadership roles, but would be more comfortable with helping new teachers in their own schools.

> Teacher A: "I'm willing to help new tech teachers in my building. It's too hard to work district-wide because every middle school does tech differently."

4.4 Building Professional Learning Community

During the interviews, all teachers stated that they formed some positive connections, either within their own school districts or outside their own district (with teachers from other school districts or researchers). Teachers used the network to share resources and experience. Exposure to different resources and ideas could encourage other teachers to adapt some ideas to their own classrooms. Even though they might not teach the same content area, they found that they could collaborate due to the cross-curricular nature of CS. For example, Teacher G described the collaboration between the other tech teacher and herself as a "nice marriage."

Teachers reported that the benefits of the PL meeting in terms of strengthened connections with other project teachers within and outside their districts/schools:

> Teacher E: "I have a colleague I work with in the same building. He and I have gotten a lot closer just from doing this… I would say within my building I feel better knowing that there are other people who have taken this [PL] with me and are trying to further that cause also. It's a lot easier when you don't feel like you're on an island, so I appreciated it for that."

Teachers suggested the following future improvements or opportunities for building a professional learning community: (1) having on-going support from peer teachers, district leads, and project researchers; (2) adding break-out meetings for same content area teachers; (3) making a repository for sharing and accessing all the resources.

4.5 Teaching Challenges and Needed Support

Through the post survey, teachers reported three types of challenges they experienced: (1) Challenges during Spring 2020, including the delay of the CS/DL curriculum implementation owing to school closure, uncertainty related to remote learning, and school scheduling in the coming year, as well as having more difficulty finding time for PL; (2) Lack access to devices (tablets for testing apps), as those devices were still being purchased; (3) More learning needed to strengthen their CS knowledge and skills.

When asked what resources and support they need for the coming year, teachers asked for (1) more curriculum-specific support, such as more guidance on curriculum sequence and integration strategies, researchers helping with troubleshooting app development problems, and ongoing peer teacher support (e.g., experience sharing, paired with more experienced teachers); (2) curriculum resources, such as example apps and app tutorials for students; (3) more time to practice app development and plan lessons. Some of this needed support echoes what teachers suggested for fostering the project professional learning community (Section 4.4).

Through the interviews, a few teachers further elaborated what they struggled with and what they would like to work on next. Teacher I appreciated the project was open-ended, offering "flexibility and ability to do a lot [...] on your own." But this was also challenging for her. She would like to find out "how App Inventor would play out in a Math classroom." Teacher D, an experienced tech teacher, wanted more time to plan and adjust the lessons for her own class.

5 LESSON LEARNED

5.1 Challenges for CS RPP

RPP projects can help bridge the gap between research and practice by bringing together people with different skills sets and assumptions to conduct rigorous and meaningful research in CS education research [2]. During the first year of our project, we explored ways to serve the professional learning needs of heterogeneous groups of teachers: those with varied backgrounds with respect to CS and their teaching areas.

The project's charge for integration across subject-area boundaries presented challenges. It's more challenging to integrate across subjects than to adopt an existing computer science course, and we recognized the need for specific time dedicated to computer science in the school curriculum.

As teachers transitioned to remote learning, we observed that they reported anxieties related to student attendance and engagement in remote learning, especially those from underrepresented groups.

5.2 Opportunities for CS RPP

Owing to the response to the pandemic, we found two lasting benefits: **(1) Technology access**: At the beginning of the project, only one of our three partner districts was already well underway with 1:1 device access. The other two districts had difficulty marshalling resources that could be dedicated to computer science education (e.g., access to computers and network connectivity). With the urgency of supporting remote learning for all students, these districts have moved to 1:1 device structure. **(2) Unifying the project:** Because it was necessary to work in a remote fashion, it became feasible for all three districts to work together using video-conferencing tools. This allowed the whole project team and teachers to jointly address project challenges, including recognition of the three levels of implementation-action (project, district, and teacher).

6 CONCLUSION AND FUTURE WORK

With successful trust-building among project partners, the CS Education researchers have a special role in facilitating communication and consensus-building among district leads, principals, and teachers. Reflecting on teacher questions led to insights into the structure of the RPP partnership, and facilitated elevating teacher questions to district leads.

Looking ahead, the team will focus on supporting teachers in (1) developing culturally-responsive practices for teaching computer science, (2) building their own resource library, and (3) approaches for remote learning that meet the needs of underrepresented students and their families.

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