

BootUp Professional Development Report

District A (June 2020)

Evaluated by:

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1. Executive Summary

In the summer of 2019, BootUp partnered with a Colorado school district (District A) to provide professional development (PD) to elementary classroom teachers on how to teach elementary coding. BootUp PD consists of several day-long workshops spread throughout the school year. Workshops are supported by teacher and student resources, hands-on activities, in-classroom modeling, and peer site visits. This report provides an independent analysis of BootUp's efforts to train District A teachers during the 2019-2020 school year.

Stakeholders

Three primary stakeholders were considered in this evaluation: District A, teachers participating in the BootUp training, and BootUp facilitators. Secondary stakeholders would consist of those affected by the training indirectly (e.g., students and other faculty). This report focuses primarily on District A participating teachers' experiences in learning to code through the BootUp professional development workshops.

Key Findings

1. District A teachers started with a high valuation of the importance of coding and this increased through experience;
2. About half of District A teachers are teaching coding once a week or more often, while the other half teach once a month or less;
3. All participating District A teachers increased in their confidence to teach elementary coding through BootUp PD participation;
4. District A coding teachers found teaching demonstrations and hands-on activities to be the most helpful methods to learn to code;
5. Teachers describe their success with learning to code in terms of high student interest in and success with coding;
6. Teachers are less confident in their understanding of conditional logic and abstractions;
7. Teachers need more practice fostering computational practices such as debugging;

2. Methods

This evaluation was performed by Peter Rich, PhD, of Brigham Young University. Dr. Rich teaches undergraduate and graduate courses on the design, development, and psychology of instruction. Dr. Rich's research over the past decade has focused on how to teach coding to elementary-aged children, resulting in over a dozen publications on this topic. For this evaluation, BootUp coordinated the desired outcomes and research questions with Dr. Rich. Beyond that coordination, BootUp has allowed Dr. Rich complete independence to analyze and interpret data collected via teacher surveys.

2.1. Data collection

Prior to the first training of the year, teachers completed an instrument called the "Teachers' Beliefs about Coding and Computational Thinking" (TBaCCT). The TBaCCT is a validated instrument created to measure changes in teachers' value for and confidence in teaching coding and computational thinking in the classroom (Rich, Larsen, & Mason, *in press*).

2.2. At the final BootUp workshop of the year, teachers again complete the TBaCCT. They also answer several additional questions about their: (a) coding-related teaching practices throughout the school year, (b) confidence with specific coding concepts, practices, and perspectives, and (c) personal experiences teaching coding, and (d) feedback and evaluation of BootUp's professional development.

2.3. Data Analysis

Both quantitative and qualitative data were collected via pre and post surveys for this evaluation. Quantitative data were primarily summarized using descriptive statistics, while qualitative data were analyzed by using an emergent cross-comparative analysis (Rich, 2012). Pre and Post quantitative data were further analyzed using a paired sample t-test to gauge statistical significance. Cohen's *d* was also calculated to determine the effect size of the noted changes.

Rich, P. J. (2012) Inside the black box: Revealing the process in applying a grounded theory analysis. *The Qualitative Report*, 17(49), 1-23.



3. Results

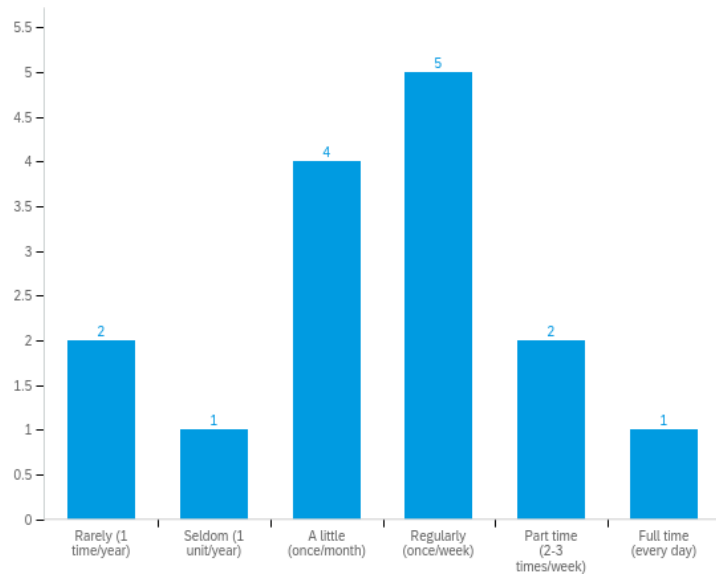
In the following sections, we first present a profile of the participating teachers. We then discuss teachers’ classroom practices and their experiences in teaching coding. We follow up with an analysis of teachers’ confidence for coding and for teaching it in the classroom. Finally, we present teachers’ evaluation and feedback of the various components of BootUp’s professional development experience.

3.1. Teacher Demographics

Overall, 16 teachers completed the year-end survey, which was completed at the BootUp training on March 4. District A teachers mostly represented two different groups of teachers: certified classroom teachers (N = 7) and media specialists (N = 7). In addition to this, one teacher self-identified as a STEM/STEAM teacher and another as the district instructional coach. These participants represent a group of experienced classroom teachers. Thirteen (81%) of teachers reported having earned a master’s degree, while the other three all had earned a bachelor’s degree. On average, teachers reported 19 years of teaching experience, having taught the same grade for half (9.5) of those years¹. The majority of teachers also reported teaching multiple grades of students (usually K-5), indicating that they are specialists. Despite this, the average participant only had a single year of experience teaching coding by the end of the 2020 school year. In summary, *this was an experienced group of teachers but nearly all were learning to teach coding for the first time this year.*

3.2. Teaching Practices

In this section, we report District A teachers’ practices in actually teaching coding throughout the year. Teachers self-reported that about half taught coding once a week or more often while the other half taught once a month or less (see Figure 1). Further analysis reveals that this same pattern emerged when asked how often District A teachers taught coding to the same group of students (with 8 teaching once per week and 7 teaching less than once per week). Nearly all teachers reported that their classroom coding lessons were 31-45 minutes long.



¹ The average was calculated using medians to account for the effect of outliers

3.3. Classroom Coding Experience

In this section, we take a more qualitative look at teachers' experience as they taught coding. Specifically, we asked teachers to report their successes and challenges.

3.3.1. Main Successes

When asked what successes they had experienced with coding this past school year, $\frac{2}{3}$ of teachers couched their replies in terms of their students. Student-centered Successes tended to emphasize students' interest in coding and their increased knowledge for coding, as exemplified by the following quotes.

Student Interest in Coding

- **The students' enthusiasm for coding is very high** and they are always excited to see what they can create- overall student engagement is very high!
- **Students love it! They are eager to learn.** I count that as a success.
- **My students love it. They ask for it.** I am feeling more and more comfortable using it.
- **The students get excited and become very engaged.** I have worked with one teacher in Kindergarten and she is very excited about incorporating code into her lessons.

Increased Student Knowledge

- "I have some students that have written an app. They taught themselves. I had students that said they were bad at coding on day 1 and now they teach others. **Teachers are allowing students to present assignments in Scratch, because the kids asked if they could do that instead of a PowerPoint. The teachers said they were the best projects they have ever seen.**"
- I've been teaching it daily for twenty minutes a day to 3rd, 4th, and 5th graders. **I have seen some really awesome stuff come out of their coding work.**
- **I expected my 4th and 5th graders to be successful, but it's been very exciting to see the 1st graders doing well and getting excited about it.**
- Whenever the light bulb appears over the heads of children is a success for all of us. I notice that some children just dive in and work and work. Others, think about what they are learning and then begin the coding task or project. **Coding levels the learning field for children. I revel in this diversity!**

Teacher-centered successes tended to emphasize that a teacher had learned to integrate coding with other subjects. For example:

- More projects that are tied to curriculum and authentic responses/creations.
- The ability to cross curriculum with coding.
- I have had success with unplugged activities, integrating Scratch and Makey Makey, student collaboration as well as collaborating with other teachers. I am also pushing myself to try new things that are out of my comfort zone which is always an adventure.

3.3.2. Main Challenges

A reversed pattern emerged with teacher challenges. Whereas successes were couched in terms of students $\frac{2}{3}$ of the time, challenges were couched in terms of the teacher $\frac{2}{3}$ of the time. Teachers primarily struggled with their own coding knowledge and with time.

Teacher Knowledge

- **I often don't know the answers**, but the kids usually will help me figure it out.
- I feel that **my knowledge is inadequate** to answer specific questions. I am learning alongside most of my students. I certainly could use more training.
- Sometimes **I can't help debug stuff** so I have to ask for help or really go into it and work on trying to figure out the issues.
- Sometimes **the debugging process is a challenge**. I want to have all of the answers, but I do not at this time.

Time

- The challenge I have had teaching code is **trying to find time to play with the programs** so I can help the students and teachers. Another challenge is just trying to get teachers to try something new.
- **Finding time to do it**. Time will be built into my schedule next year. :o)
- I become frustrated with our school day being so short as teachers are not willing to integrate something new into their day. I understand this, yet I truly wish that teachers were more welcoming to other teachers collaborating on computer coding classes. Next year...we will see what a new administration dictates and how receptive teachers will be to trying new things.
- Finding the time to fit it into the day as much as I would like.
- Time, lack of technology.

Another important pattern that emerged in regards to challenges was actually student knowledge (which was one of teachers' main successes, curiously enough). Specifically, teachers appeared to struggle with the diversity of students' ability levels. Consider the following teacher quotes about their students' knowledge of coding:

- Challenges are that **students' skill set are at different levels**. Meeting with all the grade levels makes it a challenge to know skill sets of kids. Other challenges are having enough time to work with students. Then there are the students that have a low threshold to try and problem solve when things don't go right the first time. That is a life skill to learn...Coding will always be a challenge like any other content area to meet the needs of the students and meet them at their different levels.
- **Some kids have a difficult time understanding the underlying concepts of coding**, and of course, there are always frustrations when trying to get the program to do what you want it to do. Helping students through those feelings of frustration is sometimes challenging.
- **Breaking students' pre-formed habits** in how they chose to do algorithms for coding.
- Learning a **good starting point for different grades**.

3.4. Confidence with Coding

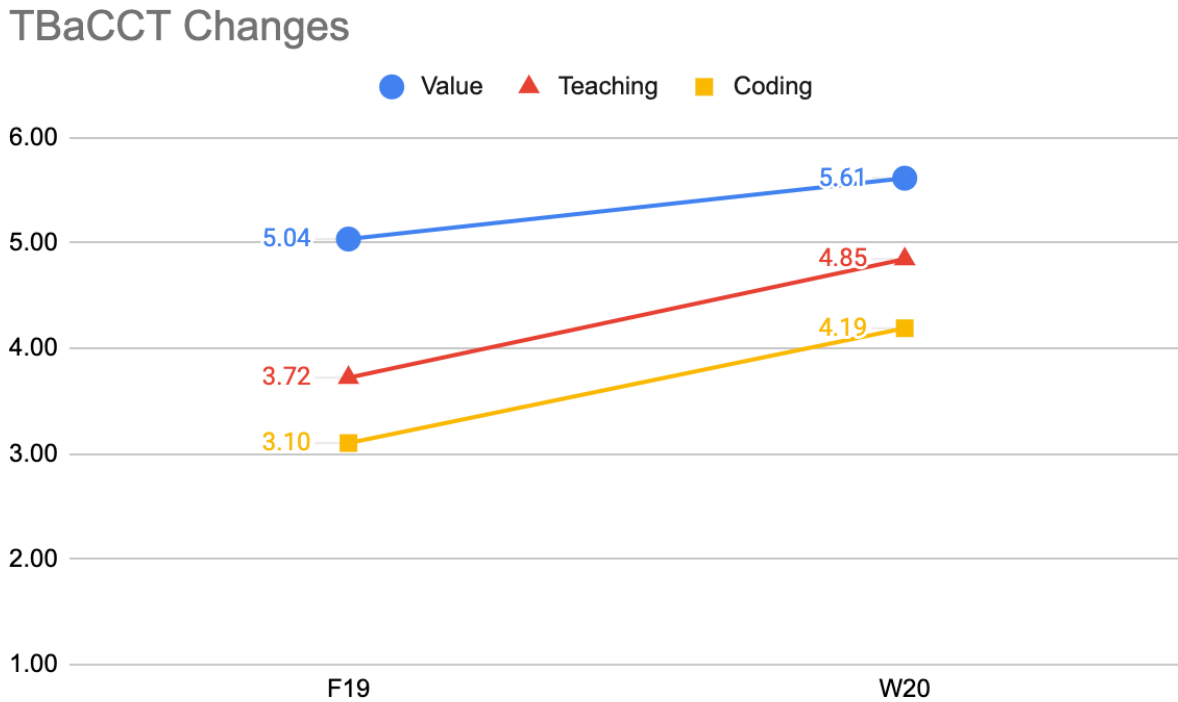
In this section, we report District A teachers' confidence with teaching coding. There were two main ways in which we measured this confidence across a variety of measures. To measure growth over time, we used the Teachers' Beliefs about Coding and Computational Thinking (TBaCCT) scale. This scale asks questions in such a way that teachers can answer questions about their confidence with coding and teaching coding prior to learning about these. Teachers completed the TBaCCT at the first workshop and again at the final in-person BootUp workshop of the year. At the final workshop, we also asked teachers more specific questions about their confidence with coding that required a better understanding of coding itself (and coding-related jargon). Results from each of these are described in the following subsections. Overall, it can be stated that District A teachers' confidence to teach computing grew significantly—both statistically and practically—through their participation in BooUp PD during 2019-2020.

3.4.1. Teachers' Beliefs About Coding and Computational Thinking

The TBaCCT measures 4 aspects of teachers' beliefs about computing: values, coding efficacy, computational thinking efficacy, and teaching efficacy. Beliefs are important to measure as they are related to and influence action. For example, beliefs about the value of a subject not only influence whether or not a teacher will actually address that subject, but also the importance that teacher communicates about a particular subject to her students. In the TBaCCT, we measure teachers' value beliefs by asking questions such as, "Computing content and principles CAN be understood by elementary school children." A teacher who does not agree with this statement will approach the teaching of coding much differently than one who does. In the TBaCCT, teachers answer the extent to which they agree with each statement on a scale of 1 (strongly disagree) to 6 (strongly agree). Teachers also answer questions about their own confidence with coding and computational thinking as well as their belief in their ability to teach coding. Overall, there are 36 questions that inform these constructs.

An average score above a 5 in any of the areas measured by the TBaCCT should be considered extremely strong. As noted in Figure 2, District A teachers began the year with a very high valuation for teaching coding. This observation is supported by many teachers' comments about how they felt about computing prior to the BootUp workshops (see section 3.5.2). Despite this initially high valuation, teachers actually increased in the overall importance that they ascribed to coding. This increase was both statistically ($p < .001$) and practically significant (*Cohen's d* = .918). Statistical significance indicates that this change was unlikely due to occur by chance. Practical significance (using *Cohen's d*) is a measure of the magnitude of the change. Measurements in *Cohen's d* are standard deviations. This means that District A teachers' valuation of coding at the final BootUp workshop increased 9/10 of a standard deviation. In educational studies, a .4 effect sizes above .4 are considered the standard for success. Effect sizes above .8 are considered to be very strong (Hattie, 2016).

Figure 2. Teachers' Changes in their Beliefs about Teaching Coding



As noted in Figure 2, District A teachers were much less confident in their self-beliefs about coding. Specifically, they were nearly neutral in their confidence with coding concepts in general (3.10/6.00) and only slightly more confident in their ability to teach coding (3.72/6.00). This should be unsurprising given teachers' reported inexperience with coding. This higher confidence to teach a subject they were unfamiliar with is common amongst experienced teachers and highlights the difference between content knowledge and pedagogical knowledge. In both cases (coding knowledge and teaching knowledge), teachers' confidence increased over the course of the year. Efficacy for coding ($p = .004$, Cohen's $d = 1.01$) and Teaching ($p = .001$, Cohen's $d = .756$) both increased statistically and practically in strongly significant ways. In lay terms, District A teachers went from barely being confident to teach coding to being confident. While there is still room for growth into a strongly confident area, this amount of growth in confidence to teach coding in a matter of months bodes well for future growth.

3.4.2. Teachers' Coding and CT-specific Confidence

At the end of year survey, we were able to dig deeper in regards to District A teachers' confidence for coding principles, practices, and perspectives. These three constructs pertain to content knowledge, pedagogical content knowledge and dispositions that are relevant to computer science education, as promoted by the <https://k12cs.org/> framework. We used the same 6-point scale so as to avoid neutral responses.



Tables 1 and 2 report on teachers’ specific content knowledge of coding and computational thinking. By the final BootUp PD workshop, District A teachers had crossed into the “confident” region (4.00-4.99), as opposed to the barely “somewhat confident” region (3.00-3.99) they started at. The only exception was with the notion of abstraction, which appears to be the area where District A teachers are less confident with their computational thinking at this point.

Table 1. Teachers’ Confidence for Specific CT Concepts by the Last PD

CT Knowledge				
How confident are you in YOUR OWN computational thinking knowledge of...				
	Mean	SD	Max	Min
...pattern recognition	4.47	1.30	6.00	2.00
...algorithms	4.07	1.44	6.00	2.00
...decomposition	4.07	1.33	6.00	2.00
...evaluation/analysis (debugging)	4.00	1.41	6.00	1.00
...abstraction	3.80	1.32	6.00	2.00

Table 2. Teachers’ Confidence for Specific Coding Concepts by the last PD

Coding Concepts				
Rate your confidence with each of the following coding concepts				
	Mean	SD	Max	Min
Sequence	4.67	1.11	6.00	3.00
Loops	4.60	1.55	6.00	1.00
Algorithms	4.20	1.47	6.00	1.00
Variables	4.13	1.25	6.00	2.00
Functions	4.07	1.03	6.00	3.00
Conditionals	4.00	1.36	6.00	2.00

In regards to coding-specific content knowledge, District A teachers are most confident with sequences and loops. They demonstrated some confidence for algorithms and variables and are just confident with functions and conditionals. This should come as no surprise for a few reasons. First, variables, functions, and conditionals are all more advanced coding concepts (though fundamental to coding). Second, these ideas were not introduced until later BootUp workshops. Thus, District A teachers would have had much less training and practice with these concepts. Sequences and loops, on the other hand, are concepts that teachers make use of in almost every coding project. It will be interesting to track teachers’ growth in their content knowledge over the next few years. If the type of coding projects they engage their students only make use of sequences and



loops only, it may be that we see a greater separation between their confidence for basic and more advanced coding concepts.

3.4.3. Teachers' Confidence for Teaching Coding and CT

Tables 3 and 4 report on teachers' pedagogical content knowledge of teaching coding in specific ways. Namely, to what extent do teachers feel confident in their ability to engage in practices that promote effective computational thinking. Also, how well do they foster productive dispositions as they engage with coding?

Table 3. Teachers' Confidence to Foster CT Practices by the last PD

CT Practices				
How confident are you in your ability to...	Mean	SD	Max	Min
...collaborate around computing	4.53	1.25	6.00	3.00
...foster an inclusive computer culture	4.07	1.62	6.00	1.00
...recognize and define computational problems	4.00	1.41	6.00	2.00
...communicate about computing	3.87	1.30	6.00	2.00
...test and refine computational artifacts	3.47	1.60	6.00	1.00
...create computational artifacts	3.33	1.45	6.00	1.00
...develop and use abstractions	3.20	1.21	5.00	2.00

Table 4. Teachers' Confidence to Promote CT Perspectives by the last PD

Perspectives				
Rate your confidence in TEACHING each of the following computational practices/perspectives...	Mean	SD	Max	Min
Creating	5.20	0.77	6.00	4.00
Collaborating	5.20	0.77	6.00	4.00
Persistence	4.93	0.96	6.00	3.00
Tinkering/Remixing	4.60	1.06	6.00	3.00
Debugging	4.13	1.25	6.00	2.00

Table 3 shows the area where teachers felt the least confident of our measured constructs. While they felt more comfortable collaborating with computing, they were less comfortable communicating about computing (i.e., talking about it in real-world contexts) and in areas that required more content knowledge and experience, such as testing and creating computational artifacts and using abstractions. These practices are specifically more creative in nature and could be placed at the highest level of Bloom's

taxonomy of the cognitive domain. Thus, they represent higher order thinking that is required by coding teachers. It is likely that as they gain more experience coding and (especially) debugging programs, they will grow in their confidence in fostering these practices.

While Table 3 reveals that teachers may be less confident in their own ability to create, Table 4 actually shows that they are quite confident in their ability to help their students create and collaborate. They also demonstrate higher confidence in their ability to encourage persistence and an attitude of tinkering. Consistent with the above discussion, they are least confident in their ability to debug. This observation was evident in teachers' open-ended feedback about their challenges, where several mentioned that they were not yet comfortable in debugging students' programs. The ability to debug is strengthened over time as teachers build up a pedagogical content knowledge of coding and the common mistakes that students make in the different projects. As teachers themselves grow in their ability to debug, they may also become more confident fostering a debugging attitude in their students.

3.5. Teacher Evaluation of BootUp PD

District A teachers had the opportunity to provide formative feedback to BootUp facilitators after each workshop through a simple open-ended form that solicited feedback on what they liked and what could be improved. BootUp facilitators reviewed these comments following each workshop and made adjustments based on teachers' feedback.

In this section, we report on teachers' *summative* feedback on the BootUp Professional Development workshops. On average, District A teachers reported attending 3.69 BootUp PD workshops throughout the year. Teachers were asked to rate the workshops overall and also to rate the different components of the BootUp PD model. These ratings were all done on a 10-point scale. For the sake of evaluation, anything above an 8 is considered a good rating. Ratings in 7-8 range indicate that something was generally considered good, but could use some improvement. Items rated below 7 should be thoroughly examined to consider how they might be improved or removed from the PD model.

3.5.1. BootUp Ratings

Overall, District A teachers rated the BootUp PD training favorably, giving it an 8.53 rating in comparison to other PDs they have participated in. When asked to justify their rating, teachers provided a variety of different answers. For some, it was the hands-on and engaging nature of the training. For others, they felt that the training was relevant to contemporary needs and jobs. Some appreciated the time they were given to practice, but wished they could have more time and more training. A few cited the BootUp resources. Thus, it appears that all District A teachers appreciated the BootUp training, but they each found different professional reasons for their valuation of the workshops.

Table 5 breaks down teachers' ratings of the various BootUp PD components. District A teachers rated all BootUp components favorably. They especially found the model teaching and hands-on learning aspects to be useful. They were less enthusiastic about teacher discussions and peer coaching. It appears, however, that not all teachers participated in peer coaching. Since there was not an option to indicate that a teacher did not experience a particular component, it is believed that these teachers marked "0" for that component. Thus, it may be that peer coaching was seen more favorably amongst those teachers who participated in that experience.

Table 5. District A Teachers' Summative Evaluation of the BootUp PD Components

BootUp Component	Mean	Min	Max	SD	Count
Model Teaching					
BootUp facilitators demonstrating the lesson as a teacher.	9.07	7	10	1	15
Hands-on Learning					
Practice completing projects during PD	8.93	7	10	1.06	15
Coder Resource					
Student materials, including video walk-throughs and debugging slides.	8.53	5	10	1.41	15
Videos:					
Walk-throughs of completed projects and how to work out each section of a coding project.	8.47	6	10	1.36	15
Sharing Projects/Ideas:					
Time given during PD to discuss and share ideas with peers.	8.47	5	10	1.54	15
Site Visits:					
BootUp facilitators visit teachers at their schools and offer formative feedback/support.	8.2	0	10	2.56	15
Topic Discussions:					
In-person and online venues provided for teachers to discuss specific coding questions and ideas.	7.27	0	10	2.26	15
Peer Coaching					
Peers visit a colleague at their own school and offer feedback.	7.07	0	10	3.19	15

3.5.2. Before and After

To better understand teachers' experiences with BootUp, it is helpful to paint a picture of how teachers' felt before and after the workshops and then to examine how they felt they grew during that time. Table 10 shows a side-by-side comparison of how teachers felt about teaching coding before and after the training. Each row represents comments from the same teacher. There were two different types of teachers. About half the teachers began with a level of intimidation, unsurety or trepidation for coding. The other half already believed it to be fun or important. Even in these cases, we can see that teachers felt a marked level of improvement, interest, or confidence to teach coding after having participated in the BootUp workshops (see Table 6).

Table 6. Before/After Comparison of District A Teachers' Thoughts about Teaching Coding

Before	After
Intimidated	
I don't have time to teach coding. I don't know where to start. I don't have enough technology. Kids will struggle with coding. I have to know everything about coding before I teach others.	Oh my gosh, coding is so much fun! It's okay if I struggle. Often the kids will figure it out and teach me. I have students coding outside of class on independent projects (not assigned). I am so thankful I have this opportunity and now 620 students at my school get this opportunity.
I was worried I would not have all the answers.	I can learn from the students and they can learn from each other.
I didn't know anything about it... so I didn't have feelings about coding at all!	Wow! So cool. Would love to be able to integrate all that I have learned into the classroom. I can see that it is a valuable for students to learn.
I always was interested in learning more, but kind of intimidated by it.	I see that it is accessible to all abilities and levels.
unsure about my competence.	confident that I can do this with my students.
... unsure of the "why's" and "how's" of teaching coding.	Coding is an exciting part of any curriculum for students of all ages. I am considering sponsoring an after school coding club next year.
I did not know much about it, and was not comfortable teaching it.	I feel much more comfortable than before , however I think it will take more time and practice with kids before I feel completely comfortable and confident.
Where do I start?!	Start with Scratch Jr. and Scratch. I also like the non-tech activities
Already Excited	
It's important for students to be as computer literate as possible. However, it's not always practical for homeroom teachers to be the person giving the instruction.	Coding can be incorporated into many content areas and can be used often in the homeroom classroom.
I used coding for a couple different standards.	I use coding across curriculum.
confident that kids would connect with it and use it to demonstrate competency in content areas.	More confident with the open-endedness of Scratch.
Coding is a fun and essential tool to expose to elementary students to gain skills oh how to do step by step procedures to solve a problem. It was a fun thing to do that was out of the box.	My feelings are still the same as above. However, I can make more connections to tie coding in with other content areas to show learning and extend their computer science/coding skills. I have also incorporated more unplugged activities as well.
This is exciting and I want to learn more.	This is exciting and I want to learn more and get

<p>Excited, interested in using it</p>	<p>more teachers to integrate into their classes. Even more excited since I have a better idea about integrating it throughout the curriculums.</p>
<p>Experience with coding is necessary for students, especially starting in elementary school. Learners use problem solving skills, creativity, and critical thinking.</p>	<p>The same. I want to expose my students to even more coding opportunities.</p>

When asked how their confidence to teach coding changed over the year, teachers nearly universally indicated an improvement. Interestingly, they attributed this growth to three sources, with many teachers citing multiple sources. Namely, teachers felt they had grown more confident to teach coding due to the *BootUp training*, but also due to actually *implementing it in the classroom*. Several teachers also cited the fact that they had *wonderful colleagues* whom they could consult with about teaching coding or observe.

4. Conclusion

This evaluation gathered quantitative and qualitative data from District A teachers who participated in BootUp professional development workshops throughout the 2019-2020 school year. Based on the evidence provided herein, the training has been successful, both statistically and practically. Teachers reported growth in their beliefs about the importance of teaching coding, even though they began with a relatively high valuation already in place. Teachers were barely confident in their ability with their coding content knowledge and pedagogical content knowledge and increased significantly in both of these areas. Teachers are the most confident with their ability to teach sequences and loops. They still feel slightly unconfident in their ability to teach more advanced coding concepts, such as abstraction and debugging. Teachers describe their success with coding in terms of their students. Many teachers expressed surprise that even their youngest students love and are able to code.

Despite these successes, there remains room for growth. Only about half of District A participants reported teaching coding once a week or more often. This means that there is still uneven access to coding education for District A students. Teachers' greatest challenges in their efforts to teach coding are embodied in their own lack of knowledge of and experience with coding. However, some teachers are realizing that they do not need to know everything in order to effectively teach elementary coding. As one teacher who initially felt she needed "to know everything about coding before teaching others" put it, "coding is so much fun!...it's ok if I struggle."

District A teachers described several conditions that they felt led to their success this year. They highly valued the BootUp facilitator's modeled lessons as well as the hands-on learning opportunities during the workshops. They also appreciated each others' experience, with many teachers indicating that they felt comfortable talking with their

peers about computing. Teachers who were the most successful were those who taught coding more often. In the end, the BootUp trainings appear to have been effective and have resulted in District A teachers' increased confidence to teach elementary coding.