Coaching as a Means to Support Teacher Development of Computer Science Knowledge and Skills

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Abstract: *Problem.* With many teachers in the United States just starting to learn how to teach computer science (CS), many do not have others nearby with CS teaching experience to provide support on CS practices and concepts. To address this gap, we piloted a one-year remote coaching program designed to provide that missing individualized support to teachers. *Research Question.* Our research question for this project was: How does teachers' ability to apply CS practices and knowledge of CS concepts change after the coaching process? *Methodology.* Our mixed-methods study leveraged three primary forms of data from teachers who were coached (coachees) and teachers providing coaching (coaches): pre- and post-surveys, coaching logs, and self-reflection checklists. *Findings.* CS coachees' reported CS knowledge and skills and their ability to apply CS practices related to Standard 1 were significantly higher after the coaching intervention. *Implications*. As more teachers continue to learn how to teach CS and hone their skills and practices, engaging these teachers in coaching can be powerful in improving their student's learning. Professional development providers and regional education agencies (districts and schools) could leverage the processes formed through this intervention (which is based on professional development practices with solid evidence for positive impacts) to provide similar coaching to teachers just learning how to teach CS.

Introduction

Coaching is a process where an experienced educator (coach) supports a teacher in developing and refining their teaching practice. While coaching in several forms is embedded in many schools, coaching in computer science is relatively new. For subjects such as English or Math, teachers are supported in improving their practice through district-supported leadership and systems such as principals, curriculum specialists, coaches, and professional learning communities. With over half of all high schools in the United States offering at least one CS course and eight states with policies requiring CS to graduate (Code.org et al., 2023), the CS for All movement continues to grow. To continue to support the scaling of critical systems change, the CS education community needs to turn attention to how best to support and scale coaching within schools as a means of ongoing support for CS teachers.

Currently, many CS educators access professional development (PD) through events from the Computer Science Teachers Association (CSTA), as well as curriculum and PD providers, however, after educators complete initial CS PD, there are few opportunities for ongoing PD including individual feedback on their classroom practice. Less than a third of CS teachers report having access to ongoing one-on-one coaching (Koshy et al., 2021). This is traditionally the role of school and district leaders (e.g., principals, curriculum specialists, and instructional coaches), but few of them have CS experience and only a limited number of districts have had CS specialists and/or coaches for any length of time. Early adopters of CS coaching include Chicago Public Schools and the Cornell Tech Teacher-in-Residence program (Ray et al., 2018; Wachen et al., 2021).

The coaching model used in this study is designed around the CSTA Standards for CS Teachers (CSTA, 2020) and accompanying resources and to focus specifically on equitable teaching practices. These practices are woven throughout the standards and resources and are central to the coaching process as coaches and coachees work to identify and meet the needs of students from historically marginalized backgrounds in CS courses. The primary purpose of this study was to provide individual professional development through a remote coaching program, studying the impact on teachers' content knowledge of computer science. Our research question for understanding coaching's impact was: How does teachers' ability to apply CS practices and knowledge of CS concepts change after the coaching process?

This study is important as our field starts to apply well-known and researched practices for professional development in other education fields to computer science. This intervention can also serve as a model for future coaching initiatives that target Standard 1 of the CSTA Standards for CS Teachers: CS Knowledge and Skills.

Background

Coaching as a Form of Professional Development

While many teachers engage in professional development (PD), coaching provides an opportunity for differentiated PD focused on the individual teacher's needs and is incorporated into their day-to-day activities. Unlike one-time PD's, coaching can provide teachers an opportunity for deep reflection surrounding pedagogical limitations, while establishing a professional learning community where educators can feel safe to address limitations to their practice (Margolis et al., 2017), which may increase job satisfaction and retention (Orstrand et al., 2020). According to Knight (2016), "coaches partner with teachers to analyze current reality, set goals, identify and explain teaching strategies to hit the goals, and provide support until the goals are met." While many forms of coaching exist in schools (e.g. peer coaching, cognitive coaching, instructional coaching), coaching often includes these features:

- Coaching is long-term: teachers need 50+ hours of professional development in a given area to improve their skills and their students' learning (Darling-Hammond et al., 2017).
- Coaching is supportive: CS teachers need to master new CS content and pedagogy (Margolis et al., 2017), all of which can be supported by a CS coach to ease the transition to teaching a new subject area.
- Coaching is differentiated: PD is custom and provided in a just-in-time format; this personalization creates greater investment (Joyce & Showers, 2002).
- Coaching is reflective: coaches guide teacher reflection and provide accountability; having a critical friend and structures makes goal setting, self-reflection, and targeted PD more likely to happen (Knight, 2016).
- Coaching builds resilient educators: coaches provide encouragement and support, and they help teachers recognize their strengths and ability to persevere and succeed (Pierce & Buysse, 2014).

Impacts of Coaching on Content Knowledge

Unlike many other subject areas, teachers have little or no formal coursework in computer science as part of their teacher preparation programs. Most teachers are new to CS as a subject and have a wide range of backgrounds when first learning to teach CS. They often complete professional development (e.g., one week in the summer with some academic year support) in order to learn how to teach CS, including not just content, but curriculum and pedagogical content knowledge specific to CS. A core tenet of equity in CS includes access to rigorous courses. Teachers need a solid foundation in CS to provide rigorous learning environments for students. CSTA Teacher Standard 1 (CS Knowledge and Skills) has five indicators, the first of which is to Apply CS Practices while the others focus on the five concepts outlined in the CSTA K-12 Standards for students.

In an Exploring Computer Science coaching program, teachers reported that coaching increased their understanding of CS content as the coaches were able to provide just-in-time PD where teachers received answers to their specific questions and concerns about the content (Margolis et al., 2017; Wachen, 2021). Modeling and co-teaching are two strategies coaches can use to support learning new CS skills and practices and are linked to improvements in both teacher practice and learner outcomes (Pierce & Buysse, 2014). Several studies have demonstrated the effectiveness of coaching in the transfer of learning from PD to the classroom, improving adoption rates of teaching practices from 20-80% or more in some cases (Darling-Hammond et al., 2017; Joyce & Showers, 2002; Pierce & Buysee, 2014; Orstrand et al., 2020). Coaching can be more effective than PD alone at changing what teachers actually do in the classroom, having a greater potential impact on students and their learning.

Remote Coaching

One challenge to coaching in computer science, however, is the relative isolation of CS teachers (Yadav, 2017). Online communities have helped to address this isolation, providing a professional learning community whether it is through a CSTA chapter or as part of professional development (Goode et al., 2020; Rosato et al., 2017). While not as common, using online tools can be effective in coaching as well and may address some of the barriers to scaling CS coaching programs (Margolis et al., 2017). Teachers can record video of their classroom instruction, allowing both the teacher and coach to review and reflect as part of the feedback process. This model has been used with both in-person and virtual coaching (Israel et al., 2013; Wachen et al., 2021) as well as in online PD (Lucarelli et al., 2017) to create a culture of reflection on teaching practice. In one study, teachers reflecting on their own teaching practice via video helped develop critical thinking and pedagogical skills, thereby improving their teaching practice (Barlow et al., 2013). Another study found that teachers developed deeper, more thoughtful reflections while participating in observation and video recording (Calandra et al., 2001).

Coaching for Equity

One challenge to addressing equity in CS classrooms is that teachers lack the knowledge and experience required to provide robust learning opportunities to learners from historically marginalized backgrounds. In order for every child to cultivate their unique talents, it is best that they be presented with an extensive range of learning opportunities, experiences, and material. Within the scholarship that is most concerned with inequitable access to learning opportunities, the data reveals prominent and longstanding issues centering the focal populations for whom our work is in service. For example, learners who identify as racial minorities (Bali & Alvarez, 2004) and students with learning disabilities (Schwartz et al., 2021) are still lagging behind in academic achievement, as defined by standardized testing measures. Furthermore, the research on learners who identify as female and gender non-binary, along with students with learning disabilities show they are more likely to experience social bias in their classrooms across academic disciplines (Briskin, 2001).

Consequently, we relied on a Coaching for Equity model to support coachees work with historically marginalized learners in their CS classrooms. Coaching for equity means seeing inequities and knowing what to do about them, while supporting another educator to develop systems for noticing beliefs and practices that promote or detract from equitable ways of teaching. The coaching program infuses inquiry practices that support culturally sustaining innovations in CS classrooms. Culturally sustaining innovations centers the importance of culturally relevant pedagogies with the necessity to be creative in pursuits to develop the pedagogical skills required to be effective with historically marginalized groups like racial minorities, female and gender non-binary, and students with learning disabilities (Paris & Alim, 2017).

In this project we sent out a call for experienced educators of CS who engage in equitable, culturally responsive teaching practices. After pairing these experienced educators (coaches) with less experienced educators of CS (coachees), we trained the coaches on a Coaching for Equity model. The model centers on the wisdom of scholar Elena Aguilar and her work in *Coaching for Equity: Conversations that Change Practice.* Following a thorough reflection of this work, we conduct monthly conversations with the coaches, including role-play and discussions of strategies that are working with historically marginalized learners in their CS classrooms. These conversations reveal significant barriers to teaching these students effectively, barriers to student and teacher efficacy, and opportunities to practice asset-based perspectives and feedback (Aguilar, 2020).

Positionality

The authors of the paper bring a social justice orientation to the project with the goal of supporting equity-mindsets among CS teachers. The authors include five researchers from a variety of backgrounds who self-identify as advocates for educational equity within and across CS classrooms. Our research centers the pursuit of educational justice and how to achieve that within CS classrooms while recognizing the systemic harms experienced by minoritized learners in all classrooms. The authors are grounded by the belief that all children deserve teachers who have a strong knowledge of CS and the belief that all children can learn, particularly when educators enact authentic variations of their own culturally sustaining pedagogies (Paris & Alim, 2017).

Methodology

The remote coaching program included two organizations, one of which was focused on teachers in a single midwestern state in the U.S. teaching any type of high school CS, and the other organization was focused on teachers from across the U.S. teaching Advanced Placement CS (CSP and/or CSA). Each organization hired coaches, who completed 25 hours of professional development in the summer before the school year, focused on learning about the coaching process, supporting equity in the classroom, and the needs of students in the focal populations targeted in the project. Each organization also recruited coachees to participate in the program. Coaches and coachees were matched based on their experience teaching similar courses or curriculum and, in the case of the midwest program, based on their geographic proximity.

Coaches and coachees met online for a pre-coaching meeting in the fall of the school year to start building a relationship, learn more about each other's backgrounds and teaching contexts, and to establish goals for the school year. Goals were aligned to at least one of the indicators from the CSTA Standards for CS Teachers. Coachees also identified one of three focal populations (females, students with disabilities, or English learners) as a lens for examining equity in their classroom. Most coaches and coachees completed 3-4 cycles of coaching throughout the school year with each cycle including a planning meeting, implementation of a lesson, and a reflection meeting. In the planning meeting, coachees and coaches examined a lesson and adaptations to it that would help the coachee achieve their goal for the year. If just in time PD was needed to help understand CS practices and concepts, coaches provided that then or followed up with more information. During implementation, the coachee recorded their classroom lesson so that coaches could watch it online. After reviewing the video, they met to review how the adaptations went and progress towards meeting the goal. At the end of the year, a post-coaching closeout meeting was held to reflect on progress and to set next year's goals.

Participants

A position description for coaches was created and was advertised widely among each organization's networks. Twelve coaches (six in each organization) were selected based on their previous experience in teaching CS, their understanding of and commitment to working with adult learners, and their experience in supporting students marginalized in computing. Coachee participants (n = 16) were high school teachers in the U.S. who had taught CS for less than 3 years. Participants were recruited through each organization's networks of teachers who had participated in previous PD, through social media, and through email listservs. Almost half of the coachees were women (n = 7), most (n = 15) were White (one identified as Hispanic/Latinx), and 4 reported having a disability. Coachees had been teaching for an average of 15.35 years (SD = 6.45; min = 3, max = 27; $median$ = 16) with licenses in math, CS, science, or business and a few had licenses in special education and English as a second language. In terms of CS experience, backgrounds varied widely with a few having held jobs in CS; 12 (75%) took at least one CS course in college, and 12 (75%) had seven years or less of CS teaching experience.

Data Collection

Year 1 of the intervention took place in the 2022-23 school year and involved the first cohort of both coaches and coachees. Data was collected using pre- and post-surveys, coaching logs, and self-reflection checklists, each of which provided insight into how coaching changed coachees' content knowledge. The pre- and post-surveys were nearly identical and included information about CS concepts and practices prior to coaching and after the conclusion of the full school year of coaching sessions. The coaching logs were completed after each coaching session. The self-reflection checklists were also completed at the start of the coaching year and after the last coaching session.

Data Analysis

Since the pre- and post-survey analysis contained multiple-choice selections and open-ended questions, we used both quantitative and qualitative analysis techniques on the data. For the ordinal data, we used a paired t-test to compare the pre- data to the post-survey for coachees completing both surveys. Paired-samples t-tests allowed us to examine change in teachers' self-reported abilities to apply CS practices and knowledge after the coaching process, in line with our research question. We applied content analysis used to provide general descriptives on coachees' demographic information, professional background and experience. This method was most aligned with the coaching pre- and post-survey data since it supported examining the presence of specific characteristics and experiences in order to make reliable conclusions about coachees' experience related to the coaching program. This method helped to unveil patterns in coachees' experience, uncover differences amongst coachees, and to make connections to research goals used to uncover enactments of equity.

For the analysis of the coaching logs, coaches provided log data that we aligned to our research question from the sections: pre-coach set-up, coaching cycle 1-4, and the post-coaching closeout. Additionally, we used any information that was linked to the coaching logs, such as observation notes, coach or coachee reflections, and coachee lesson plans as evidence to answer our research question. We carefully analyzed each coaching log and, when applicable, we connected direct quotes from the coaching logs and affiliated links to the research question. Upon completion of the analysis of all the coaching logs, themes began to emerge. Finally, for the self-reflection checklists, we conducted several dependent-samples t-tests to determine if there was statistically significant change in the coachees' ratings of their CS knowledge and skills.

Results

CS Knowledge and Skills: Self-Reflection Checklists

Coachees rated their CS knowledge and skills on the pre-checklist (see Table 1), on average, between "Developing" and "Competent" (M=2.43, SD=0.69), while on the post-checklist they rated their CS knowledge and skills between "Competent" and "Accomplished" (M=3.30, SD = 0.71). Thus, coachees increased from pre- to post-checklist by an average of 0.88 points (on the five-point scale), and this difference was statistically significant and had a large effect ($t(15) = 6.05$, $p < .001$, 95% CI [0.57, 1.19], Cohen's $d = 1.51$). Figure 1 shows the average level of competence coachees indicated for their Standard 1 knowledge at pre- and post-checklist. The blue bidirectional arrows represent scores between scale anchors (e.g., 1.5).

Table 1. Results of the self-reflection checklist for Standard 1.

	Mean (SD)	Median	Min-Max
Pre-Coaching Checklist	2.43 (0.69)	2.40	1.00 - 4.00
Post-Coaching Checklist	3.30 (0.71)	3.25	2.00 - 5.00

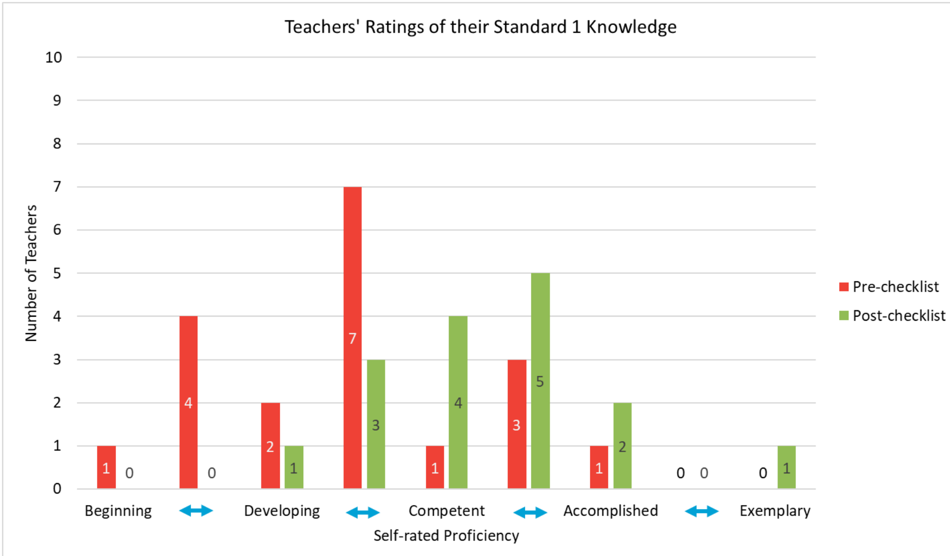

Figure 1. Pre- and post-ratings of teacher self-reported beliefs about their CS knowledge and skills.

CS Knowledge and Skills: Coaching Logs

Many coaching logs contained evidence of how the coachees ability to apply CS practices and knowledge of CS concepts increased through the coaching sessions. For example, in post-coaching closeout, two coachees who were new to CS described their desire to continue to learn more about CS and teaching CS concepts. One person stated, "I am going to continue to learn more about coding - in particular Python. I want to become more confident in the content." The other coachee stated they will focus on improving their use of CS vocabulary.

Two coachees with more than three years of experience teaching CS shared their awareness of their own lack of understanding and knowledge with their coach. One person noted, "I'm open with my students that I'm still learning, and I will model for them how I google resources, play around with code, and generally overcome any obstacle that I'm presented with." Another coach shared that their coachee admitted that "students have been self-directed in a lot of their programming. He felt that he did not know enough or hadn't taught enough." The coach responded, "In a project based class, it is really hard to know what type of programming the kids will gravitate toward or what things they will need to know...Don't feel bad about not knowing, but take the time to have them teach you. Look for opportunities to learn more for yourself."

The exchange of advice and suggestions were documented throughout the coaching logs. Several coaches discussed how they had helped their coachee better implement CS concepts. A coach wrote that a coachee "...wasn't sure that the students understood how these blocks of code might fit into a larger program. We discussed how to transition from an unplugged activity to code." The action of the coach giving nuggets of wisdom to the coachee was echoed by multiple coachees who stated their coaches introduced new CS resources they learned from.

According to the post-coaching closeout, many coachees included goals for professional development and growth for the following year to continue to learn CS and CS concepts. These goals ranged from "get to know the foundation of programming more" to "using the Technovation curriculum and incorporate it into their LMS system" to "revisiting cybersecurity curriculum." One person plans to continue to learn from their former coach. They noted, "I will continue to work closely with [coach] and others in the CS field to develop a deeper understanding of CS."

CS Knowledge and Skills: Survey Data

Coachee Confidence in CS Practice. Coachees rated on both pre- and post-surveys their confidence in their abilities on each of the following practices from the CSTA standards:

- *Practice 1: Fostering an Inclusive Computing Culture.* Confidence fostering an inclusive computing culture (e.g., use strategies for incorporating the perspectives and addressing the needs of people from different genders, ethnicities, and abilities).

- *Practice 2: Collaborating around Computing.* Confidence collaborating around computing (e.g., cultivating working relationships with individuals possessing diverse perspectives, skills, and personalities in order to complete computational tasks together).
- *Practice 3: Recognizing and Defining Computational Problems.* Confidence recognizing and defining computational problems (e.g., identify problems that can be solved computationally including steps such as defining the problem, breaking it down into parts, and evaluating each part to determine whether a computational solution is appropriate).
- *Practice 4: Developing and Using Abstractions.* Confidence developing and using abstractions (e.g., identify patterns and common features from specific problems to create generalizations, such as modules or simulations, that are used in computational artifacts).
- *Practice 5: Creating Computational Artifacts.* Confidence creating computational artifacts. Specifically, we asked how confident they felt to create or modify artifacts such as programs, simulations, visualizations, etc. for practical intent, personal expression, or to address a societal issue.
- *Practice 6: Testing and Refining Computational Artifacts.* Confidence testing and refining computational artifacts (e.g., iteratively improve a computational artifact by identifying and fixing errors through scenarios or test cases to enhance its performance, reliability, usability, and accessibility).
- *Practice 7: Communicating about Computing.* Confidence communicating about computing (e.g., communicating with diverse audiences about the use and effects of computation and the appropriateness of computational choices).

Coachees were asked to rate themselves across the seven CS practices using the following scale: Beginning, Developing, Competent, Accomplished, Exemplary. A series of paired-samples t-tests showed that coachees rated their confidence statistically significantly higher at post-survey compared to pre-survey for all seven CS practices (see Table 2). Further, the differences observed were overall quite large regarding practical significance (see Cohen's d values in Table 2). Pre- to post-survey differences in all CS practices displayed a large statistical effect size. The most change occurred in coachees' confidence related to Practices 2 and 7 (regarding magnitude of mean differences) but Practice 4 saw the largest statistical effect size, which indicates that the magnitude of pre- to post-survey differences was more consistent among the sample for Practice 4 than Practices 2 and 7–even though Practice 4 has an average difference smaller than Practices 2 and 7.

Coachee Ability to Apply CS Practices. We asked coachees to rate their ability to apply CS practices using a sliding scale from Beginner (0) to Advanced (10). Paired-samples t-tests indicated that coachees' reported abilities to apply CS practices increased from pre- (M=2.50, SD=2.22) to post-intervention (M=6.13, SD=1.99), and this average increase of 3.63 points (SD=1.54) was statistically significant with a large effect size ($t(15) = 9.39$, $p < .001$, $Cohen's\ d = 2.36$).

Since coachees' perceptions of ability may have been influenced by the intervention, we also compared teacher's post-intervention ratings of their pre-intervention abilities to their post-intervention ratings of post-intervention abilities. This comparison showed that after the intervention, coachees rated their intervention abilities prior to the intervention (M=3.81, SD=2.74) lower than their post-intervention abilities (M=6.13, SD=1.99), and this average increase of 2.31 points (SD=1.19) was statistically significant with a large effect size ($t(15) = 7.74$, $p < .001$, $Cohen's\ d = 1.94$).

We then compared coachees' pre- and post-intervention ratings of their pre-intervention abilities to apply CS practices to see how their ratings may have been informed by the intervention. A paired-samples t-test indicated that indeed, coachees' ratings of their pre-intervention abilities were statistically significantly lower when given before intervention compared to ratings given after intervention ($Mdiff = 1.31$, $SD = 1.78$, $t(15) = 2.95$, $p < .01$).

Table 2. Changes in Coachee Confidence in CS Practices.

	Pre/Post Means	Pre/Post Mean Differences (SD)	*t; p*	95% CI	Cohen's d
Practice 1	2.31/3.38	1.06 (0.99)	4.26; <.001	[0.53, 1.59]	1.07
Practice 2	2.25/3.50	1.25 (1.00)	5.00; <.001	[0.72, 1.87]	1.25
Practice 3	2.69/3.56	0.88 (1.02)	3.42; <.001	[0.33, 1.42]	0.86

Practice 4	2.38/3.31	0.94 (0.69)	5.51; <.001	[0.58, 1.30]	1.36
Practice 5	2.19/3.06	0.88 (0.89)	3.95; <.001	[0.40, 1.35]	0.99
Practice 6	2.00/3.19	1.19 (0.98)	4.84, <.001	[0.66, 1.71]	1.21
Practice 7	2.25/3.50	1.25 (1.00)	5.00; <.001	[0.72, 1.78]	1.25
All Practices	2.29/3.36	1.06 (0.59)	7.12; <.001	[0.74, 1.38]	1.79

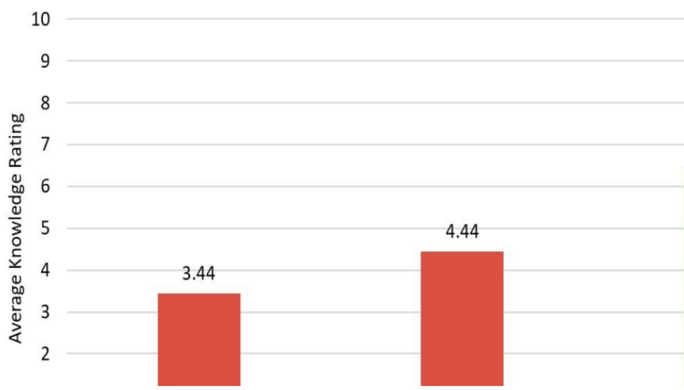

Figure 2. Teachers' Knowledge of CS Concepts.

Coachee Knowledge of CS Concepts. Before the coaching program, we asked coachees to rate their knowledge of CS concepts. Paired-samples t-tests indicated that coachees' reported knowledge of CS concepts increased from pre- (M = 3.44, SD = 2.56) to post-intervention (M = 6.44, SD = 1.83), and this average increase of 3.00 points (SD = 1.83) was statistically significant with a large effect size ($t(15)$ = 6.57, p < .001, $Cohen's\ d$ = 1.64). Since coachees' perceptions of their knowledge may have been influenced by the intervention, we also compared teacher's post-intervention ratings of their pre-intervention knowledge to their post-intervention ratings of post-intervention knowledge (Figure 2). This comparison showed that after the intervention, coachees rated their pre-intervention knowledge (M = 4.44, SD = 2.83) lower than their post-intervention knowledge (M = 6.44, SD = 1.83), and this average increase of 2.00 points (SD = 1.59) was statistically significant with a large effect size ($t(15)$ = 5.03, p < .001, $Cohen's\ d$ = 1.26). Finally, we compared coachees' pre- and post-intervention ratings of their pre-intervention knowledge to see how their ratings may have been informed by the intervention. A paired-samples t-test indicated that indeed, coachees' ratings of their pre-intervention knowledge were statistically significantly lower when given before intervention compared to ratings given after intervention ($Mdiff$ = 1.00, SD = 1.75, $t(15)$ = 2.28, p = .04).

Discussion

The self-reflection checklist results indicate that, after the intervention, coachees' reported CS knowledge and skills related to Standard 1 were significantly higher than before intervention, indicating preliminary evidence that the intervention increased CS coachees' reported knowledge and skills. Overall, in the coaching logs, coachees showed growth in their knowledge of CS concepts and ability to apply CS practices. Coaches provided encouragement, advice, suggestions, and reflective questions to help coachees grow in their ability to teach CS. In the survey, coachees' rated their abilities to apply CS concepts significantly higher after the intervention compared to before intervention. Coachees rated their knowledge of CS concepts significantly higher after the intervention compared to before. Coachees' perceptions of both their pre-intervention abilities and knowledge were higher when given after intervention compared to before the intervention.

When synthesizing the findings above, evidence suggested three categories of key takeaways: changes in the seven practices, professional growth, and coaches engagement. With respect to the seven practices, coachees' reported CS knowledge and skills and their ability to apply CS practices related to Standard 1 were significantly higher than before intervention. These results may indicate preliminary evidence that the intervention successfully increased CS coachees' reported knowledge and skills. More specifically related to the surveys, across the seven practices, coachees reported statistically significant increased confidence:

- In their ability to foster an inclusive computing culture

- In their ability to collaborate around computing
- In their ability to recognize and define computational problems
- In their ability to develop and use abstractions
- In creating computational artifacts, coachees' confidence related to this teaching practice standard increased. (While the majority of coachees felt like they were just at the beginning of their practice prior to the coaching program, the post-survey revealed that the majority of coachees felt at least competent when creating artifacts.)
- In their ability to test and refine computational artifacts. Generally, more coachees felt at least competent in this practice standard.
- In their ability to communicate about computing with diverse audiences about the use and effects of computation and the appropriateness of computational choices.

With respect to coachee professional growth, the coaching logs indicated that many coachees have future goals to continue to learn CS and CS concepts. Finally, with respect to coaches' engagement in the process, the coaching logs provided evidence that coaches provided encouragement, advice, suggestions and reflective questions such as, "For example, could the students translate the pseudo-code to Java if given a skeletal structure?" to help coachees grow in their ability to teach CS concepts. In addition to the synthesized findings above, we recommend that future experimental testing should be done to definitively identify causal relationships between coachees' Standard 1 knowledge and the intervention, coachees' prior experiences, and coachees' co-current activities (e.g., engagement in CSTA activities). The coaching for equity model piloted in this project, in a remote context with a focus on equity, has preliminary evidence of effectiveness in increasing teachers' knowledge and skills in CS.

Limitations

As a pilot project, the number of coachees and coaches was relatively small. Caution should be exercised when applying our findings more generally. Additionally, a few coachees did not complete the intervention or the post-surveys; we did not interview these coachees to collect evidence about what they learned during their time as part of the program. Further, we did not conduct experimental testing to definitively identify a causal relationship between the intervention and coachees' CS knowledge and skills. This could help ascertain whether the intervention was the cause of the growth. Finally, we did not collect other types of programming that the coachees may have participated in over the course of the year (e.g., participating in other professional development or professional learning communities). This may help differentiate between what they learned from our intervention when compared to other learning opportunities that they may have engaged in.

Conclusion and Future Work

As computer science continues to expand and more teachers complete initial professional development in computer science, there is a growing need for ongoing support. Coaching is one model of long-term professional development that can positively impact teacher knowledge and practices. The evidence from this study indicates that teachers were more confident in their CS knowledge, both concepts and practices, after a year-long coaching intervention. While content knowledge was not the primary focus of the coaching program, it was a component of coaching conversations and positively impacted. This is one of a few coaching studies and more study of this area is needed to understand elements of coaching programs that are effective in meeting goals of a quality CS education for all students. Sustainability and scalability of coaching programs, including how they might be embedded in school systems, should also be examined to better understand how more computer science teachers could have access to this form of professional development.

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