Supporting Teachers to Integrate Computational Thinking Equitably

Merijke Coenraad
College of Education
University of Maryland
College Park, Maryland, USA
mcoenraa@umd.edu

Kelly Mills
Digital Promise Global
Washington, D.C., USA
kmills@digitalpromise.org

Virginia L. Byrne
College of Education
University of Maryland
College Park, Maryland, USA
vbyrne@umd.edu

Diane Jass Ketelhut
College of Education
University of Maryland
College Park, Maryland, USA
djk@umd.edu

***Abstract*— Broadening participation and increasing equity in computer science (CS) have been goals of the computing field for decades. Initiatives seeking to increase access to CS have led to an increase in elementary schools teaching computational thinking (CT), but students are often instructed by classroom teachers who have no formal training in CT or CS. Our project prepares in-service and pre-service elementary teachers to integrate CT into their science lessons. While our overall goal was to increase CT access for all students, we found some teachers enacted CT in ways that did not always provide equal access to all students. Although our professional development adopted a *CS for All* approach, without explicit supports, a group of teachers implemented CT in ways often upholding the current trends of inequity and power structures within CS. Our findings suggest teachers would benefit from explicit support to provide opportunities for students currently underrepresented in CS and to offer more equitable opportunities to students regardless of their CS background.**

Keywords—computational thinking, professional development, equity, computer science education, science education

I. Introduction

Computer science (CS) historically and presently is characterized by an underrepresentation of women, people of minoritized races and ethnicities, and people with disabilities across the school to career pipeline [1]. *CS for All* has become a rallying cry for increasing CS opportunities across students' educational experiences. To help students learn CS, computational thinking (CT) is introduced to teach "the thought processes involved in formulating problems…so that the solutions…can be effectively carried out by an information-processing agent" [2]. Exposure to CT in elementary school gives students a foundation on which to pursue CS through their education and possibly into their career choices [3].

To work within the time constraints of a school day and the multidisciplinary nature of CT, educators are integrating CT education throughout the curriculum [4]. For this integration to be successful, elementary teachers need support in CT during their teacher education program or professional development (PD). Current efforts provide teachers with learning experiences in knowledge of CT concepts, tools, and practices including the role of CT in everyday life and CT pedagogy. However, researchers have recently begun to investigate how to support teachers to integrate CT into their disciplines [5], [6].

We offer exploratory data of how teachers presented CT to their students and the equity challenges they faced. Our findings suggest teachers would benefit from more explicit support to integrate CT equitably and provide opportunities that break down gendered and ableist power structures in CT.

II. Methods

Our project supports teachers to integrate CT in elementary science. Pre-service and in-service teachers met once per month for four months to discuss the core practices of CT and design CT infused science lessons. In total, 40 teachers participated (37 women, 3 men; 21 pre-service, 19 in-service). At the culmination of the PD, teachers wrote and implemented a CT-infused lesson plan in their science classes.

We analyzed researcher field notes and teacher focus group transcripts. Multiple researchers recorded field notes during and following each session. In the final PD session, teachers shared their experiences in focus groups of 2-5 teachers and a researcher. These focus groups were audio and video recorded, and professionally transcribed.

These data were analyzed inductively. First, researchers used open ended initial coding [7] to note areas of interest related to equity and teacher attitudes in the lesson plans. The researchers met to discuss their inductive coding and determine a codebook [7]. Then, a researcher coded the data using a set of codes derived from the open coding: teacher understanding, perceived student ability, students overcoming expectations, giving technology to tech-oriented students, student experts, and opportunities for advanced students. Based on this coding, two major themes emerged: *Opportunities for Advanced Students* and *Using Students as Experts*.

III. Findings

Within the data, we found six teachers discussed providing *Opportunities for Advanced Students* and eleven teachers *Using Students as Experts*. In the following sections, we present these two themes. For clarity and length, these trends are explored as representative cases of two teachers' CT integration.

A. *Adrienne: Opportunities for Advanced Students*

Adrienne is an in-service teacher who teaches 3rd grade and has been teaching for 15 years. She teaches at a school with 10.3% students with disabilities, 41.3% students receiving free and reduced priced lunch, and 10% English Language Learners. Her school is 80.3% underrepresented minorities. In her lesson plan, Adrienne focused on data analysis. She led a simulation game about fish finding resources within their habitat. The class

National Science Foundation STEM + C Grant 1639891

978-1-7281-7172-2/20/$31.00 ©2020 IEEE

collected data and analyzed the changing population by creating a graph. While in this lesson plan Adrienne gave her full class the opportunity to engage in CT through data analysis, on multiple occasions, Adrienne discussed giving more complex CT opportunities to her advanced students. Researchers noted that Adrienne discusses integrating CT by highlighting CT as an *"opportunity for above average students to learn…[and] explore at their own pace."* Adrienne mentioned in the focus group that, *"it's good for TAG [Talented and Gifted] students. Because I use computational thinking as extensions all the time."* These comments indicate Adrienne viewed CT as most beneficial to her advanced students and as an extra activity for students who finished early or needed a challenge.

B. Eleanor: Using Students as Experts

Eleanor is a 3rd grade in-service teacher with 13 years of experience. She teaches at a school with 8.8% students with disabilities, 9.9% students receiving free and reduced priced lunch, and 11.6% English Language Learners. 21.1% of her school is underrepresented minorities. Eleanor began Scratch [8] activities with her entire class by integrating the activities into science and other disciplines. Yet, the experience of integrating Scratch was not always smooth for Eleanor. When Eleanor shared her experiences, she *"was frustrated with not being able to help"* with questions about programming in Scratch. Instead, Eleanor assigned three students to be the experts in the class. This contributed to an expert student wanting to *"make his own [Scratch] account"* based on his leadership experience. Eleanor reports, *"she would do it [Scratch] again and that the kids loved it,"* but she hopes *"to be more knowledgeable next time so she can help students more."*

IV. Discussion

When the teachers included CT in their lesson plans, the implementations of some resulted in mixed success regarding our *CS for All* goals. While we aimed to get all students involved in CT through integration in elementary science classes, teachers needed more support to break down the structural inequities within the broader computing field. One possible explanation for teachers implementing CT this way is we included only limited conversations on how to create opportunities for all students and how using CT selectively can perpetuate structural inequity. Additionally, we did not provide teachers with enough pedagogical and tool knowledge and some teachers were only prepared to use CT as extensions or opportunities for students who already had the skills. Teachers gave *Opportunities to Advanced Students* who did not need assistance and *Used Student Experts* to help other students. Unfortunately, in doing so, the teachers may have signaled to students who among them was good at CT. Teachers often referred to their experts with *"he"* and *"him,"* highlighting the choice of boys as experts. Additionally, the students who were selected as experts had often been exposed to programming outside of school.

Teachers would benefit from more support in developing content knowledge and pedagogical knowledge of how to integrate CT with their students, as well as knowledge of CT tools to support all students in learning and using CT rather than advanced or experienced students. Based on our experiences we recommend PD opportunities provide teachers with:

- Strategies for utilizing expert students in a manner that does not inadvertently signal only certain students are knowledgeable in CT
- Explicit discussions about underrepresented groups in CS and the stereotypes around who is capable of CT
- Structure during co-design lesson planning to allow teachers to think through CT implementation challenges with a researcher familiar with CT
- Support in answering questions that come up during CT integrated lessons and time to share questions that have come up within classrooms
- Concentrated support on the practices perceived to be more difficult such as systems thinking and programming

To meet the *CS for All* goals of our project and the broader community, teacher education programs need to have explicit conversations about the populations currently underrepresented in computing, common stereotypes within computing, and strategies for helping to counteract the stereotypes to broaden participation. Additionally, PD sessions need to provide further support for teachers to not only find resources, but also to use CT tools and knowledge and integrate them in their pedagogy. In learning from our experiences, projects with a *CS for All* goal should include learning objectives about the goals of increasing CS and CT opportunities for all students through integration in general subjects, and prepare teachers in strategies for overcoming the subtle but inequitable practices contributing to the underrepresentation of women, marginalized populations, and individuals with disabilities.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1639891.

References

[1] S. Zweben and B. Bizot, "2017 CRA Taulbee Survey: Another year of record undergrad enrollment; Doctoral degree production steady while master's production rises again," Comput. Res. Assoc. News, vol. 30, no. 5, pp. 1–47, 2018.

[2] J. Cuny, L. Snyder, and J. Wing, "Demystifying computational thinking for noncomputer scientists," 2010.

[3] National Research Council, "Report of a workshop on the scope and nature of computational thinking," Washington, DC, 2010.

[4] M. Israel, J. N. Pearson, T. Tapia, Q. M. Wherfel, and G. Reese, "Supporting all learners in school-wide computational thinking: A cross-case qualitative analysis," Comput. Educ., vol. 82, pp. 263–279, 2015.

[5] C. Mouza, H. Yang, Y. C. Pan, S. Yilmaz Ozden, and L. Pollock, "Resetting educational technology coursework for pre-service teachers: A computational thinking approach to the development of technological pedagogical content knowledge (TPACK)," Australas. J. Educ. Technol., vol. 33, no. 3, pp. 61–76, 2017.

[6] A. Yadav, N. Zhou, C. Mayfield, S. Hambrusch, and J. T. Korb, "Introducing computational thinking in education courses," in Proceedings of the 42nd ACM technical symposium on Computer science education - SIGCSE '11, 2011, pp. 465–470.

[7] J. Saldaña, The coding manual for qualitative researchers, 3rd Editio. Thousand Oaks, CA: Sage, 2015.

[8] M. Resnick et al., "Scratch: Programming for All.," Commun. ACM, vol. 52, no. 11, pp. 60–67, 2009.