Supporting Teachers to Integrate Computational Thinking Equitably

Merijke Coenraad
College of Education
University of Maryland
College Park, Matyland, USA
mcoenraa@tund.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
vby:me@t und.edu

Diat1e Jass Ketellmt
College of Education
University of Maryland
College Park, Maiyland, USA
djk@llllld.edu

***Abstract*- Broadening participation and increasing equity in computer science (CS) have been goals of the computing field for decades. Initiatives seeking to incre.ase access to CS have led to an increase in elementary schools teaching computational thinking (Cl), but students are often instm cted 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** accessfor all students, we found someteachers enacted CT in ways **that did not always provide equal access to all students. Although om· professional development adopted a *CS for All* approach,** without explicit supports, a group of teachers implemented CT in **ways often upholding the cu1Tent h·ends of inequi ty and power stm ctures within CS. Our findings suggest teachers would benefit from explicit support to provide opportunities for students cu1Tentl y unde1Tepre se nted in CS and to offer more equitable opportunities to students regardless of their CS background.**

Keywords---computatio11al thi11ki11g, professional development, *equity, computer scie11ce education, science education*

I. INTRODUCTION

Comp uter science (CS) historically and presently is characterized by an undeITepresentation of women, people of minoritized races and ethnicities, and people with disabilities across the school to career pipeline [l]. *CS for All* has become a rallying c1y 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 fo1mulating problems... so that the solutions...can be effectively caITied out by an infom ration-processing agent" [2]. Exposme to CT in elementaiy school gives students a foundation on which to pursue CS through their education and possibly into their cai·eer choices [3].

To work within tlte time constraints of a school day and the multidisciplinaiy nature of CT, educators are integrating CT education tltroughout tlte cmTiculum [4]. For tltis integration to be successful, elementa1y teachers need supp011 in CT dming their teacher education program or professional development (PD). CmTent effo11s provide teachers witlt learning expe1iences in knowledge of CT concepts , tools, and practices including tl1e role of CT in eve1yday life and CT pedagogy. However, researchers have recently begun to investigate how to suppo11 teachers to integrate CT into their disciplines [5], [6].

We offer explorato1y data of how teachers presented CT to their students and tlte equity challenges they faced. Our findings suggest teachers would benefit from more explicit suppo11to integrate CT equitably and provide opp01tmlities that break down gendered ai1d ab leist power stmctures in CT.

II. METIIODS

Our project supports teachers to integrate CT in elementaiy science. Pre-service and in-service teachers met once per montlt for four months to discuss the core practices of CT and design CT infused science lessons. In total, 40 teachers paiticipated (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 reseai·cher field notes and teacher focus group transcripts. Multipleresearchers recorded field notes during and following ea.ch session . In tlte final PD session, teachers shai·ed their experiences in focus groups of 2-5 teachers and a reseai·cher.These focus groups were audio and video recorded, ai1d professionally transcribed.

These data were analyzed inductively. First, reseai·chers used open ended initial coding [7] to note areas of interest related to equity and teacher attitudes in the lesson plans. The researchersmet to discuss their inductive coding and detemline a codebook [7]. Then, a reseai·cher coded tlte data. using a. set of codes derived from the open coding: teacher m1derstanding, perceived student ability, students overconling expectations, giving technology to tech-oriented students , student expe11,sand opp01tunities for advanced students. Based on tltis coding, two major tltemes emerged: *Opportunities for Advanced Students* ai1d *Using Students as Experts.*

ill . FINDJNGS

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

A. Adrienne: Opportunities for Advanced Students

Ad1iellle is an in-service teacher who teaches 3rd grade and has been teaching for 15 yeai·s. She teaches at a school witl1 10.3% student s with disabilities, 41.3% students receiving free and reduced priced llllch, and l 0% English Language Leainers. Her school is 80.3% m1de1Tepresented min01ities. In her lesson plan, Adtiellle focused on data. analysis. She led a simulation game about fish finding resources witllin their habitat. The class

National Science Foundation STEM + C Grant 1639891

978-l-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 foll class the opp01tunity 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 byhighlighting CT as an *" opportunity for above average students to learn...[and] explore at their own pace.*" Adriem1e mentioned in the focus group that, *"it 's goodfor TAG {Talented and Gifted] s f11dents. 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 : UsingStudents 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 p1iced lunch, and 11.6% English Language Learners. 21.1% of her school is unde1Tepresen ted minmities. Eleanor began Scratch [8] activities with her entire class by integrating the activities into science and other disciplines. Yet, the expe1ience 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 expe11s in the class. This contributed to an expe1t studen t wanting to *"make his own {Scratch] account"* based on his leadership expe1ience. Eleanor repo1ts, *"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 sf11dents more.*"

IV. D ISCUSSION

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 getallstudents involved in CTthrough integration inelementaty scienceclasses, teachers needed more suppo11 to break down the stmctural inequities within thebroader computing field. One possible explanationfor teachers implementing CT this way is we included only limited conversations on how tocreate oppmtunities for all students and how using CT selectively can pe1petuate stmc tural 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 ah·eady had the skills. Teachers gave *Opporhmities to Advanced Students* who did not need assistance and *Used Student Experts* to help other students. Unfortunately, in doing so, the teachers may havesignaledto students who among them was good at CT. Teachers often referred to their experts with *" he"* and *" him,* " highlighting the choice of boys as expe1ts. Addi tionally, the students who were selected as expe1ts had often been exposed to programining outsideof school.

Teachers would benefit from more suppo11in developing content knowledge and pedagogical knowledge of how to integrate CT with their students, as well as knowledge of CT tools to supp01tall students in learning and usingCT rather than advanced or experienced students. Based on our expe1iences we recommend PD opp01tunities provide teachers·with:

- Strategies for utilizing expert students in a mam1er that does not inadve1tently signal only ce1tain students are knowledgeable in CT
- Explicit discussions about underrepresentedgroupsin CS and the stereotypes arow1d who is capable of CT
- Stmcture dwing co-design lesson planning to allow teachers to think tluough CT implementationchallenges with a researcherfamiliar with CT
- Suppo11 in answering questions that come up during CT integrated lessons and time to share questions that have come up within classrolllS
- Concentrated suppmt on the practices perceived to be more difficult such as syste1nsthinking and programming

To meet the *CS for All* goals of our project and the broader c01mnunity, teacher education programs need to have explicit conversations about the populations currently underrepresented in computing, co1mnon stereo types within computing, and strategies for helping to counteract the stereotypes to broaden pa1ticipation. Additionally, PD sessions need to provide fmther 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 witha *CS for All* goal should include learning objectives about the goals of increasing CS and CT opportunities for all studentsthrough integration in general subjects, and prepare teachers in strategies for overcoming the subtle but inequitable practices contributing to the underrepresentation of women, marginalizedpopulations, and individuals withdisabilities.

ACKNOWIEDGMENTS

This material is based upon work supp01ted by the National Science Foundation wider Grant No. 1639891.

REFERENCES

[1] S. Zweben and B. Bizot, "2017 CRA Taulbee Smvey: Another year of record Wldergrad 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 noncomputerscientists," 2010.

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

[4] M. Israei J. N. Pearson T. Tapia, Q. M. Wherfei and G. Reese, "Supporting all learners in school-wide computational thinking: A cross-casequalitative 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 42ndACMtechnical symposium on Computer science education - SIGCSE '11, 2011, pp. 465--470.

[7] J. Saldana, 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. 6 7, 2009.