

Professional Development for Computer Science Education: Design and Outcomes from a Case Study Teacher

Scott Sheridan
College of Education and Human Development
University of Delaware
stsherid@udel.edu

Chrystalla Mouza
College of Education and Human Development
University of Delaware
cmouza@udel.edu

Lori Pollock
Department of Computer and Information Sciences
University of Delaware
pollock@udel.edu

Abstract: As the role of technology in modern society increases, so too does the importance of computational thinking and computer science (CS) principles. To incorporate CS into K-12 curricula, teachers require training, continuing support, and access to computing hardware and software. Over the course of a semester, we followed one case study teacher as she applied CS principles in her school curriculum following her participation in a professional development program offered by a university team. The professional development program included two key elements: a week-long Summer Institute on CS principles and follow-up classroom support offered by university undergraduates with background in CS. Data collected from observations, an interview and student artifacts, revealed several barriers hindered Brenda's ability to incorporate CS into her lessons, but also demonstrated that these barriers could be largely overcome with support from CS undergraduates. This work has implications for teacher preparation and support around computational thinking.

Introduction and Purpose

In recent years, nationwide initiatives such as *Computer Science for All*, have generated renewed interest and attention on the role and importance of computer science (CS) education across all levels of the K-12 system (National Research Council, 2011). The goals of this movement have been generally described in the literature under the term computational thinking (Wing, 2006). Broadly speaking, “computational thinking involves “solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science” (Wing, 2006, p.33). According to Yadav, Hong and Stephenson (2016), computational thinking is not only necessary for preparing students to succeed in a technology-driven society, but it can also support disciplinary learning through integration in content area instruction. Promoting computational thinking in K-12 settings, however, is challenging because few teachers have the knowledge and skills needed to embed computational thinking in school curricula by drawing on CS principles (Barr & Stephenson, 2011). As a result, professional development is a critical element in efforts to meet the goals of *Computer Science for All*. Specifically, Barr and Stevenson (2011) identified two major areas of need for teacher professional learning: (a) a clear definition of how computational thinking applies to students and content; and (b) explicit, ongoing training and support.

This work is part of a larger study being conducted at a Mid-Atlantic University in the United States designed to help teachers incorporate CS teaching principles into K-12 classrooms. Through a series of grants from the National Science Foundation, our research team has created a three-tiered program designed to support teachers

in learning and integrating CS principles into K-12 content-driven curricula: (a) an annual week-long professional development Summer Institute for teachers organized around two tracks: the *Integration Track*, which focuses on helping teachers in grades 5-12 integrate CS principles with disciplinary standards and curricula, and the *Course Track*, which focuses on helping high school teachers implement a stand-alone high school CS course; (b) a college field-experience course in which undergraduate students with a CS background support teachers directly in their classrooms with the design and implementation of CS activities; and (c) sustained partnerships with local public and private schools. This paper follows one case study teacher, Brenda Highsmith¹, who took part in the Summer Institute and partnered with undergraduate students taking part in the field-experience course at the university to see how she incorporated what she had learned during the Summer Institute into her lessons with and without support. Specifically, we investigate the following research question: *In what ways did one middle school teacher apply CS knowledge and practices acquired through a summer professional development institute into her classroom with and without direct follow-up support?*

Methods

Participant

Brenda, our case study participant, is an African American woman in her mid-40s who has been employed as a science teacher in both public and private schools for over 15 years. Brenda was chosen as a focal case because she had taken part in the Summer Institute and had expressed an interest in partnering with the field-service program, and she worked in a school with a stated commitment to technology use where students and teachers had reasonable access to technology. Based on the training Brenda had received during the summer, the continuing support offered to her through the service-learning program and the technology hardware and software available at her school, Brenda was well positioned to use technology to support the integration of CS principles into her school curricula.

Summer Institute

Brenda began her partnership when she enrolled in the Summer Institute, a week-long professional development opportunity that has run every year in June since its inception in 2013. Since its founding, the Summer Institute has grown significantly. At present, teachers must fill out applications for a limited number of spaces. Brenda was one of 33 teachers who took part in the Summer Institute, chosen from an applicant pool of 77. Brenda took part in the Integration Track, intended primarily for teachers who want to infuse CS principles into existing STEM lessons. The goals of the integration track were: (a) learning CS content and pedagogy, (b) obtaining the ability to integrate CS principles into existing STEM curricula, (c) building a community of practice, and (d) identifying strategies meant to expand participation in computing. The professional development sessions were taught by university faculty, a group of teacher leaders who had a relationship with the university and had a proven track record for excellence in integrating CS into their own lessons, and graduate research assistants with prior teaching experience and expertise in issues of equity and diversity.

Each day, Brenda took on the role of a student in a STEM class while the facilitators modeled strategies effective for CS integration (Table 1). In these lessons, facilitators introduced Brenda to a wide range of computational tools including: (a) Scratch (an object-oriented programming environment), Micro:bits (a small programmable computer with led light display), MakeyMakey (a closed loop electrical signal invention kit), Finchbots (a block-based coding language programmable robot), Edison Robots (a multi-programming language programmable robot), Arduino Kits (open-source microcontroller device building kits) and Ozobots (pocket-sized color-coding program robots). In addition, Brenda took part in a series of CS unplugged activities (i.e., kinesthetic activities that introduce CS concepts without the use of technology) which incorporated the CS principles of programming, networking, cybersecurity and data transfer. Using what she learned from these lessons, Brenda then worked with her peers in a small group to develop a series of lessons which integrated CS principles and tools of her choice to meet state standards for her particular content area. After creating these lessons, Brenda and her partners shared their ideas with the entire cohort, received feedback and were able to augment their lesson to better meet learning goals.

[¹] All names of people and places have been replaced with pseudonyms.

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-10:15	Introductions, Program Purpose & Overview + CS Unplugged Icebreaker	Scratch and Paired Programming	Data Evaluation & Sources Unplugged-Outbreak Data Power Data Sources	CS Toys: Exploring Different CT/Curriculum Kits	Lesson Development
10:15-10:30	Break				
10:30-11:45	Introduce CSTA Standards, Ex Lesson Unit: Mars Rescue	Creativity with Scratch	Cybersecurity and Data	Culturally Responsive (1/2 hour) & Peer Feedback	Lesson Sharing
11:45-12:30	Lunch				Adjourn
12:30-1:00	Broadening Participation in Computing	Culturally Responsive CS	Broadening Participation in Computing	CS Unplugged-Network Simulation	
1:00-2:15	Continuation of Mars Rescue and Discussion	CSP: Creativity-Assessing Programs for Learning and Creativity	Micro:bit Unplugged-Hack-a-Ball	CSP: Internet-Teaching Web Programming	
2:15-2:30	Break				
2:30-3:45	Culturally Responsive (1/2 hour), Lesson Planning	Lesson Development & Peer Feedback	Culturally Responsive (1/2 hour), Lesson Development & Peer Feedback	Projects for Web Programming	
3:45-4:00	Reflection on Learning	Reflection on Learning	Reflection on Learning	Reflection on Learning	

Table 1. Summer Institute PD Schedule (Integration Track)

Field Experience

After taking part in the Summer Institute, Brenda extended her partnership with the university by becoming a teacher partner to undergraduate students taking part in the university's field experience course, a semester long course open to undergraduates in STEM fields who have completed a minimum of one CS course. Brenda was partnered with two undergraduates enrolled in the field experience course. Brenda's undergraduate partners expressed a desire to share their understanding of CS with younger learners and to bolster their own skills in communicating technical information with lay people. Brenda's undergraduate partners attend weekly 75-minute classes at the university which revolve around four major themes: (a) the use of CS Tools and Resources for learning; (b) CS Curricula and Standards; (c) CS Pedagogy, including lesson preparation and analysis, the use of CS unplugged activities and peer-programming; (d) Reflections on field experiences. In addition to these classes, Brenda's undergraduate partners met with her to plan lessons and facilitate classroom activities.

Site Description-Brown Middle School

At the time of the study, Brenda had just begun her second year at Brown Middle-School, a local middle school with strong ties to the university. According to the most recently published district records, Brown Middle School has a total of 654 students in grades 6-8. The student community is racially diverse. The student body is identified as 34.3% Caucasian, 36.4% African American, 18.2% Latinx, 6.3% Asian and 4.9% Multi-Racial or other, and 38.7% of the student body is considered low-SES.

Brown Middle School's mission states, the school is structured "to meet 21st century standards" is a "diverse and technologically progressive community of learners" which uses "innovative teaching methods and resources" to "educate each student to excel academically." In keeping with the mission's stated commitment to technology use in the pursuit of learning, each classroom at Brown Middle School contains a Smartboard, or comparable touch screen presentation technology. Each teacher is provided with a laptop computer, and some classrooms also have desktop computers for teachers to use as well. Additionally, there are three computer labs with 30+ desktop computers for teachers to use with their classes. These labs can be used during any period of the school day; to use these computer labs, teachers need only sign up to use them before their colleagues. In addition to the 90+ computers in the computer labs, the library contains an additional 30+ computers for student use. And beyond the 120+ desktop computers available in the computer labs and the library, Brown Middle School has a minimum of six laptop carts. Each of the carts has space for 30 Lenovo laptop computers. Like the computer labs, these laptop carts can also be signed out for class use during any period of the day. Therefore, in total, teachers at Brown Middle

School who want to use computers with their classes have access to approximately 300 computers. Although this is not a 1:1 environment, there is a substantial number of computers for teacher and student use at Brown Middle School. In addition to the hardware available at Brown Middle School, each teacher and student also has a Schoology Learning Management System account. Schoology allows teachers to organize any learning content in an online environment so that students can access it at any time and from anywhere they have an internet connection.

Data Collection and Analysis

Data were gathered over the course of one semester in Brenda's classroom. Total observations exceeded 25 hours, with 20 hours dedicated to Brenda's teaching of her classes alone and five hours dedicated to observing classes that were facilitated by university undergraduate partner students. Due to scheduling time constraints, nearly all the observations took place during the final three periods of the school day. However, due to Brown Middle School's rotating schedule, all eight of Brenda's science classes and the schoolwide "Elective" class were observed at least once. The university undergraduate partners only facilitated lessons during Brenda's "Elective" class once or twice weekly for 8 weeks during the semester, of which a total of five lessons were observed. During all the observations detailed notes were taken on what transpired during the class and close attention was paid to Brenda's and her students' use of technology in relation to the professional development materials covered in the Summer Institute. Midway through the semester, Brenda also took part in a semi-structured interview regarding her access to, use of and beliefs about technology use in schools. This interview was transcribed for further analysis.

Artifacts were also gathered to supplement the field notes. These artifacts included pictures of the technology that was present and available for use within the school, technology as it was being used by Brenda or her students. In addition to these pictures, all of Brenda's course assignments were collected along with links to any online resources used during class. Additionally, any resources referenced in conversations with Brenda as well as online resources that offered background information about the school, school district and state department of education were reviewed.

All the field notes, interview transcript, and artifacts were read, and a preliminary coding scheme was developed from emergent themes found in the data (Given, 2008). Themes were organized into three main categories: Barriers to Computing Applications, Computing User, and Computing Purpose. This coding scheme was then applied to a portion of the data for testing, the coding scheme was further modified, and a coding dictionary was developed (Table 2). After the development of the coding dictionary, all data were uploaded into Dedoose and coded from the dictionary. All coded excerpts were then reread and recoded to ensure accuracy in applications of the coding scheme. The data were then sorted based on the codes for further analysis and a determination of the prevalence of emergent themes. For the purposes of this work we focus on barriers that appeared to impede Brenda's efforts to apply learning from professional development back to her classroom.

Codes	Description	Example
Barriers-Access	Computing use is limited by access to functioning technology.	"Students are logging on to their computers. One student has a mouse that doesn't work and a second has a malfunctioning keyboard."
Barriers-Beliefs	Computing use is limited by the teacher's beliefs	"I think technology should have a role, but it should not dominate. Personally, I just believe we are losing our kids."
Barriers-Support	Computing use is limited by a lack of technical support	"When I walked in the building and there's a note, handwritten, 'internet is down today'. We don't know when it's coming back on."
Barriers-Technical Knowledge	Computing use is limited by a lack of technical knowledge	"To be honest with you, I haven't been trained for Smartboard, so, I wouldn't know how to use it even if I could."
Computing Purpose-Academic	Computing is used by students for academic purposes	"A student looks up information on his phone"
Computing Purpose-Collaboration	Computing is used for collaboration	"So, other states have adopted this TCM science curriculum, so maybe we perform one of the mini-labs together, with a Delaware class and a Nevada class; you know, at the same time."
Computing Purpose-Communication	Computing is used for communication	"The reading and writing exercises had been shared with teachers electronically"
Computing Purpose-Documentation	Computing is used for documentation	"Brenda begins to take attendance in eSchool Plus..."
Computing Purpose-Entertainment	Computing is used for entertainment	"The students are on the computers, mostly playing games in Scratch."
Computing Purpose-	Computing is used for presentation	"Brenda explains that she has a video to show them from the

Presentation		"Flowcabulary" website and opens the video on her computer and it shows on the smartboard."
Computing Purpose-Unintended/Underutilized	Computing is underutilized or used in a way that was not intended, i.e. a Smartboard is used as a projection screen.	"So, I use the projector, I guess that's what you call it because I'm not using the Smartboard the way it was intended"
Computing User-Admin Tech Use	Computing is used by administrators	As the students take the test, I watch the assistant principal observing the class. She is holding an iPad mini, and although I cannot see the screen, it is apparent that she is scrolling, typing and checking off boxes (or something similar) while she looks around the room.
Computing User-Student Tech Use	Computing is used by students	"Two boys sitting next to each other work together to debug some code."
Computing User-Teacher Tech Use	Computing is used by Brenda	"Brenda goes to edWeb.net to watch webinars when she has questions about student engagement."

Table 2. Coding Scheme

Findings

Application of Learning into Practice with Undergraduate CS Support

When the undergraduate students with whom Brenda was partnered came to help facilitate lessons, her students used technologies and engaged in CS learning. The undergraduates created and taught CS lessons as part of Brenda's elective course. According to Brenda, the curriculum for the elective course focused on engineering, and CS was one of the units of the elective course's curriculum. In three of the observed elective course classes, undergraduates led lessons they had created on programming using Scratch and in two others undergraduates taught lessons in which students programmed Micro:bits. While the undergraduates led the lessons, Brenda focused on ensuring that the students were paying attention, and occasionally, Brenda paraphrased information presented by the undergraduates to make it more accessible to her students. The main objectives of the Scratch lessons were for the students to create their own version of a racing game to which they were given a basic template that included the background and two sprites (characters). Students were shown how to program using the Scratch block based programming language using a projector, were offered oral directions, were provided with handouts containing directions on how to program their sprites to move around the track, were provided with individual assistance when they had problems and were encouraged to help one another if they ran into a problem they could not solve on their own or if they were finished with the assignment before their classmates. The goal of the Micro:bits lesson was for the students to program their Micro:bit to display the image of a rock, paper or scissor when it was shaken. In the Micro:bits lesson, students were again shown how to program with the Micro:bits block based programming language via a projector, were offered oral instructions, were provided with a handout containing directions on how to program their Micro:bits, were provided with individual assistance when they had problems and were encouraged to help one another when they had problems or when they had completed the task. (For examples of student work, see Figure 1).

Although the undergraduate students were not practiced teachers, the goals of the lessons were largely met by Brenda's students. The majority of students in the class were able to program their sprites to move around the track with the directional arrow keys. When they had completed the original task, some students went beyond the directions given and explored the Scratch environment, personalizing their sprites by changing them completely or coloring them. And in the Micro:bits lessons, all students were able to program the Micro:bit so that it displayed a rock, paper or scissor at random, some were able to add a lizard and Spock randomized picture as well, and those few who completed this task then helped facilitate the class by aiding their classmates in debugging their own programs.

Equally significant to the relative success of undergraduate facilitated lessons was the relative absence of the use of social media and/or engaging in other behaviors which Brenda had feared. Students used the computers responsibly so long as they were given a meaningful task to accomplish and the necessary direction or scaffolding to do so. Students only reverted to playing games in Scratch when they finished an activity or when they did not have

enough information necessary to perform the activity given to them (Field notes, 10/24; Field Notes, 11/7). Furthermore, students demonstrated a willingness to engage in pro-social behaviors such as aiding their classmates when they faced insurmountable obstacles (Field Notes, 10/24; Field Notes, 11/7), and the students were genuinely excited about the products they were able to create using the technology. For example, at the conclusion of the Micro:bits lesson, one of the girls asked if she could use her phone to record what she had programmed so that she could show her parents (Field Notes, 11/9).

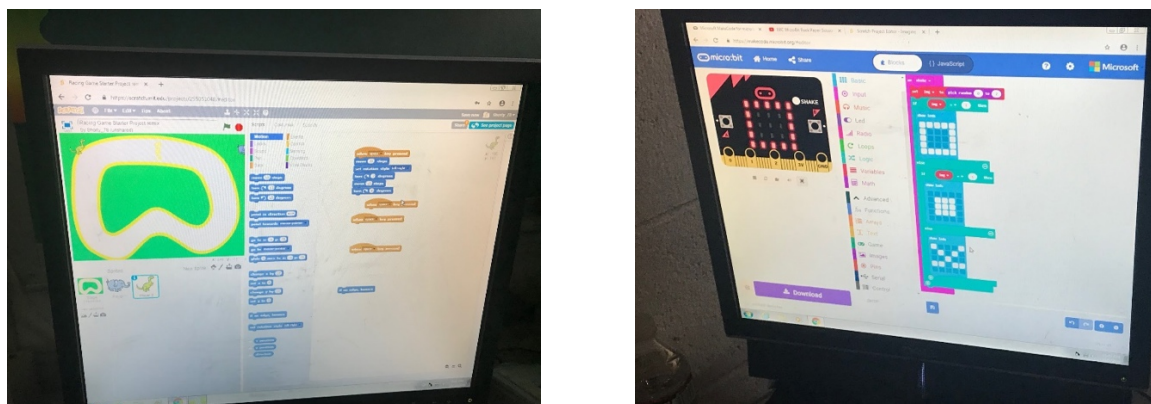


Figure 1. Examples of Student Work

Application of Learning into Practice Without Support

Although Brenda applied learning from the Summer Institute into her elective course when she had support from the CS undergraduates, this was not the case when she taught alone in the classroom. In those observed instances, she used technology sparingly, primarily in the form of projected word documents or PowerPoint presentations, rather than integration of CS principles with disciplinary content in science. Moreover, students were almost never allowed to use technology during lessons. Findings from this work revealed four primary barriers to Brenda's integration of CS principles into her science curricula, including: (a) lack of technical knowledge, (b) lack of access to working technology, (c) Brown Middle School's lack of technical support, and (d) beliefs about student technology use.

According to Mishra and Koehler (2006) *technical knowledge* is a prerequisite for employing technology in a lesson. Unfortunately, it was apparent that despite Brenda's participation in the Summer Institute, she continued to lack fundamental technical knowledge. For example, when Brenda wanted to play a video for her students, she used both the desktop and laptop computers in her room because the VGA cable was connected to her laptop while the TRS audio cable was connected to the desktop computer. The result was videos that did not sync with the audio and therefore were difficult for students to follow and frustrating for Brenda as well (Field Notes, 10/2). This could have been easily fixed by connecting either the VGA cable to the desktop or the TRS audio cable to the laptop, thereby allowing for both audio and video to be sourced from one computer. Yet, Brenda did not realize that fixing the problem required so little attention. Additionally, despite having a Smartboard in her classroom, Brenda never used any of its touch screen features, preferring to use it exclusively as a projection screen. When asked why she used the Smartboard the way she did, she replied, "to be honest with you, I haven't been trained for Smartboard, so, I wouldn't know how to use it even if I could" (Interview, 10/16). This lack of understanding extended to the use of Schoology (a learning management system utilized by the school) as well. Prior to the start of the School year, the district had purchased a new science curriculum and had integrated the new curriculum with Schoology, presumably to make it easier for teachers and students to use. However, Brenda avoided using the online version of the curriculum in class and did not seem to understand that every teacher and student in the school had a Schoology account containing the new science curriculum. "What TMC [the curriculum developers] did is they loaded all of our students into Schoology, which I thought was funny because we don't use Schoology, but other districts are Schoology driven" (Interview, 10/16).

Despite Brown Middle School having an inventory of over 300 computers *access* to working technology was extremely problematic. Very few of the computers were in working order when needed. The laptops were often

not put away in the carts (see Figure 2). Instead, they were placed on top of the carts when students were finished with them. This resulted in the laptops being unusable for subsequent classes. Brenda experienced this problem during one of the lessons that the undergraduate students facilitated. The laptop cart she had reserved was delivered on time, but none of the laptops in the cart were charged and therefore, they could not be used. Brenda explained to the undergraduates that “we don’t do a great job of plugging in the laptops, so they might not be usable” (Field notes, 10/24) demonstrating that she was aware of the problem beforehand. Luckily, the nearest computer lab was not being used during this class period and the class was able to move there instead. Regrettably, there were additional hardware problems in the computer lab as well. Several mice and keyboards were not in working order and needed replacing from a box in the corner before all students were able to log on to the computer lab computers (Field notes, 10/24). It was apparent that no one was responsible for the maintenance of the hardware at Brown Middle School, and as a result, no one could be certain that the technology would be in working order when it was needed.



Figure 2. Laptop Carts at Brown Middle School

The problem of access to working technology was exacerbated by the lack of *technical support* available to students and teachers at Brown Middle School. Despite having over 700 faculty, staff and students in the building, Brown Middle School had no on-site IT support staff. Instead, technical support was offered by a teacher who had been given an EPER (extra pay, extra responsibility) position. This proved problematic as this teacher had his own full load of classes and consequently, was not available during the day when problems arose. Any work that the EPER performs must take place after school hours, and anything that is beyond his ability must be escalated to the district level to be addressed when the district IT professional has the time. This resulted in a host of hardware issues in Brenda’s classroom alone. For example, Brenda had a telephone in her room that did not work, and the EPER did not know how to fix it and either the problem had not been escalated to the district level or the district support had not been there to fix it (Field notes, 9/20). Nor was this the only example of inadequate technical support; it was apparent that the Smartboard in Brenda’s room had not been set up correctly. The USB cable required for the Smartboard’s touchscreen and writing pen functions to work was not connected to the Smartboard on one end and did not extend from the wall with the VGA cable at the other end, and therefore, even if Brenda had had the technical knowledge necessary to use the Smartboard, it would not have functioned properly. Moreover, the lack of in-house support had led to internet connectivity problems in the past leading to Brenda’s reluctance to rely on technology. Brenda relayed a story of the internet being out “I walked in the building and there’s a note, handwritten, ‘internet is down today’. We don’t know when it’s coming back on. One time it was down for like three straight days, and it just so happened, oh God is good, that the lesson I had planned didn’t even need technology...Some teachers were like, in a frenzy because their curriculum or their lesson at that stage was technology driven and you’re saying no Internet. You see what I mean. So now they’re finding old worksheets and making tons of copies to supplement” (Interview, 10/16).

Lastly, Brenda’s *beliefs* regarding students’ technology use also appeared to be a barrier to the integration of computing in her curriculum. First, Brenda believed that technology “should have a role [in learning] but that it should not dominate” and that “technology has a good and a bad side, and we’re losing our kids to the bad side of technology” (Interview, 10/16). She blamed technology, in particular social media, for students changes in learning habits. When asked to elaborate on what she meant by the bad side of technology, Brenda stated that “social media

is what I was referencing” that because of social media “students don’t read anymore” and that “their texting is horrific if you look at it from a grammatical or punctuation standpoint, and then they try to do that in their school work. They’re not even thinking, it’s not that they’re being lazy, it’s just they’re so used to communicating that way and it’s spilling over into their school work” (Interview, 10/16). As a result, Brenda preferred students to read and write using paper and pencil and she limited the classroom technology use to that which she deemed appropriate or useful. Further, Brenda feared that if given the chance to use technology students would make poor decisions. She described one experience she had had the previous year, “That was a thing last school year, so you would get a cart and tell your kids ‘Okay go get a laptop from a cart’ ‘OOOH! Ms. Highsmith, and you go running over because you don’t know what the heck is going on and there’s bare breasted women you know, shakin’ what God gave them because the last student got caught and closed the lid but didn’t log out” (Interview, 10/16). Although this story highlights what Brenda feared her students would do, it is important to recognize that it was not Brenda’s student who had engaged in the negative behavior. Yet, the experience offered Brenda concrete proof that with unfettered access to technology, students would make poor choices. Brenda went so far as to say, “I don’t wanna do that [use laptops in the classroom] unless we upload the technology or software so that I can see what every single student is looking at” (Interview, 10/16). These beliefs prevented Brenda from utilizing technology in ways envisioned by her participation in the Summer Institute.

Conclusions

This study shows that despite training, support and a stated commitment to technology use in learning, barriers still exist that hinder the integration of CS principles into lessons. The data obtained during observations and an interview demonstrated that when alone, Brenda’s underlying beliefs, and lack of technical knowledge, coupled with the lack of technical support and access to technology within the school environment led to significant barriers in her use of technology. However, when engaged in a partnership with the university, the problems associated with technical knowledge and teacher beliefs dissipated substantially. By planning and facilitating or leading the lessons, the undergraduates extended their technical knowledge to Brenda effectively bypassing one of the greater barriers to technology integration in the classroom. Furthermore, Brenda’s fears that technology would lead to negative behaviors in the classroom proved to be largely unfounded. When students were offered enough direction and scaffolding in the lesson, very few if any of the students were off task. It was only when students did not know how to proceed or when they had finished the task given to them that they attempted to use social media or otherwise entertain themselves while on the computers. Seeing students engage in positive behaviors while using technology may hopefully combat Brenda’s fears over time.

The fact that the undergraduate students had only limited pedagogical training, and yet were still able to design and facilitate successful lessons that engaged students in CS learning that they would not otherwise have had access to is extremely encouraging. This is of particular importance as we develop different CS integration professional development offerings. Offering the support of undergraduate students may provide the necessary support teachers may need to move forward in integrating CS education into their classrooms

References

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K–12: What is involved and what is the role of the computer science education community? *ACM Inroads*, 2(1), 48–54.

Given, L. M. (2008). *The SAGE encyclopedia of qualitative research methods* (Vols. 1-0). Thousand Oaks, CA: SAGE Publications, Inc.

Mishra, P., & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.

National Research Council. (2011). Committee for the workshops on computational thinking: Report of a workshop of pedagogical aspects of computational thinking. Washington, DC: National Academies Press.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33-35.

Yadav, A., Hong, H., & Stephenson, C. (2016). Computational thinking for all: pedagogical approaches to embedding 21st century problem solving in K-12 classrooms. *TechTrends*, 60(6), 565-568.

Acknowledgements

This work is supported by a grant from the National Science Foundation (Award # 1639649). All opinions are the authors and do not necessarily represent those of the funding agency.