Leveraging Prior Pedagogy: A Case Study of an Out-of-Field Teacher Adapting to After-School CS

A Thesis

by

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Introduction

After-school programs are educational, recreational, or caretaking programs that provide a safe environment for children to learn in the hours between 3 to 6 pm (Afterschool Alliance, 2020). There, children receive a plethora of enrichment opportunities with benefits such as emotional growth, recreational development, and homework support (Durlak & Weissberg, 2007). In 2020, these after-school programs served 7.8 million, or 18% of children in the United States (US) making the informal after-school environment widespread throughout the country (Afterschool Alliance, 2020). Programs can take a wide variety of forms but are largely defined by their embedding in local communities, hands-on engaging activity, and informal learning environment (Uchidiuno et al., 2023).

Broadening STEM Participation through After-school Programming

With 73% of parents reporting that a STEM program was offered in their local program, STEM has become a staple in after-school programming (Afterschool Alliance, 2021). Not only this, but it is impactful. Exposure to STEM topics in informal learning environments has been shown to increase children's identification with STEM (Hirsch et al., 2011). In addition, these engagements' quality and length significantly influence student outcomes. Children who engaged in after-school STEM activities reported an increase in STEM identification, career interest, and career knowledge with those who participated in higher-quality and longer programs reporting larger gains (Allen et al., 2019). This is significant as science identity is a predictor of pursuing STEM in higher education and as a career (Stets et al., 2017).

After-school attendance demographics cut against the underrepresentation seen in STEM fields in higher education and industry. While, in 2015, only 21.9% of students taking the AP Computer Science A AP exam were female, boys and girls were equally as likely to attend after-school programs (Afterschool Alliance, 2014). In 2020, Black children made up 19% of after-school program participants and were more than two times as likely to attend an after-school program than their White counterparts (Afterschool Alliance, 2021). Consequently, after-school programs represent an invaluable opportunity to broaden participation in STEM by exposing children to the topic in an engaging hands-on manner at a young age.

Access to After-school Programs in the United States

However, realizing this potential for broadening participation is significantly hampered by widespread inequities in access to after-school programs themselves. Parents in the highest income bracket are more than 25% more likely to enroll their child in an after-school, extracurricular, or summer program. Since 2014, there has been a double-digit increase in parents reporting that cost, lack of availability, and a lack of a safe way to come home stopped them from enrolling their child in an after-school program. With program accessibility being a greater barrier for parents of color than White parents, inequitable access to these impactful programs is not just a function of income level. So, while demand for after-school programming has risen in the 10 past years, unmet demand for after-school programming is at an all-time high with low-income parents and parents of color's needs remaining the most unmet (Afterschool Alliance, 2020).

After-School Staffing in the United States

In light of past health and safety protocols related to COVID-19, as recently as 2021, more than half of after-school providers serving students in-person were operating at reduced capacity (Afterschool Alliance, 2021). This reduced operational capacity intensifies existing inequitable accessibility, particularly impacting low-income communities, which have historically faced greater barriers to accessing after-school programming. The primary factor reported by providers as limiting their ability to return to pre-pandemic service levels is staffing, driven by challenges such as the inability to offer competitive wages amidst stagnant funding and rising living costs, significantly affecting recruitment and retention efforts (Afterschool Alliance, 2021). This is of particular concern as supportive relationships with staff is a key factor in promoting a sense of belonging, feelings of personal efficacy and positive social norms in the after school setting (Rhodes, 2004). The relationships built after school with nonfamilial adult staff provide a potential valuable source of social capital for youth in low-resource communities which is associated with youth's resilience in challenging environments (Bottrell, 2008; Jones & Deutsch, 2010). After school programs then become key pieces of infrastructure to allow these relationships to develop.

A factor predicting relationship closeness and outcomes in mentor-mentee relationships in school- and community-based youth mentoring programs is time. Grossman and Rhodes (2002) found that youth who were in mentorship relationships for a year or more reported improvements in academic, psychosocial and behavioral outcomes. Fewer effects emerged for those in relationships from 6 months to a year with negative outcomes associated with relationships that were terminated after just 3 months. This sentiment is echoed qualitatively by Worsley (2022) in which she stresses accountability, consistency and transparency as an integral factor in building trusting relationships with students. Thus, priorities of staffing go beyond just filling vacancies at all costs. Efforts to reduce staffing turnover and retain quality staff members should be a top priority as well.

In light of this, sustainable and quality staffing is important to the success of STEM after school programming. But, it is not without its challenges. Drawing from literature on STEM teachers in schools, there is a shortage of teachers in the STEM fields (Hutchison, 2012). Staff can help build student identity with the subject. Schools are struggling to attract, train and retain these STEM teachers. Generally, in the US, teacher turnover is too high, but is especially concentrated in high-poverty low-income areas (Simon & Johnson, 2015).

Failures of Previous Educational Reform to Account for Local and Marginalized Communities

More after-school programming is needed to meet the rising demand. And, this need is a clear opportunity to widen participation in STEM. However, the US has a storied history with educational reform, which has had varying degrees of success. The Rand Corporation's large-scale deployment of prepackaged programs in the 1960s is a particularly informative case study for deployments targeting schools on a local level. In response to the US school system's poor performance at the time and effort to spread "educational innovation," the federal government supported the Rand Corporation's deployment of several programs such as reading literacy and dual language programs. However, in Berman and McLaughlin's (1975) evaluation of the effort, they reported that successful projects were not sustainable nor transferable between school districts. The project took on the challenge of reform from a top-down approach. It was prescriptive in its programming, and consequently was critiqued as it failed to account for the cultural norms of individual schools. As a case study, it speaks to the massive variation of needs, culture and interests in local schools across the US and even Berman and McLaughlin note that success of a particular project was due to local staffing not the material provided by the federal government.

In contrast to such top-down approaches, the Maker Movement offers an example of a grassroots effort that achieved widespread adoption. The Maker Movement is a grassroots movement that started in the Bay area in 2005 and encourages people to nourish their identities as “makers” (Dougherty, 2012). Sparked by an online creative and open-source community, the movement has grown rapidly notably with the help of President Barack Obama’s Nation of Makers initiative (White House, 2014). The Maker Movement has had widespread and inspiring effect, encouraging youth to engage with STEM and engineering in active and personal ways. But, more recently, the Maker Movement faced scholarly critique in the Human Computer Interaction (HCI) community for its roots in technosolutionism (Lindtner et al., 2016). Common tropes found in the maker communities such as “be excellent to each other”, fail to explicitly address the real systemic issue surrounding the lack of access to STEM education and can create environments where the most powerful continue to dominate. As such, youth of underrepresented identities in STEM still were at risk of feeling unwelcome in these spaces (Toombs, 2017). Consequently, many in the HCI community criticize the Maker Movement for its lack of sustainability in many regards (Roedl et al., 2015; Vossoughi & Gutiérrez, 2014). While it is an example of a “successful” community-led STEM education movement, it failed to center underrepresented youth’s culture and political struggle. Thus, it left those in need of the most support behind.

Study Context

Exploring pathways towards sustainable staffing models for after-school CS education, especially in underserved communities, this thesis investigates the CS Ambassador program. It is run by Georgia Tech’s Play and Learn lab in conjunction with the College of Computing’s outreach team, and aims to increase Computer Science (CS) instruction access in low-income Atlanta communities through after-school programming. We train homework helpers or program coordinators with little to no previous experience with CS to teach CS in their local communities. Previous work involving the program found that the recently trained instructors had low self-efficacy in their teaching and internalize failures in student outcomes (Lim et al., 2024). This thesis provides further insight into how the instructor's teaching was challenged by their limited experience with CS but was supplemented by local and cultural knowledge of the community. We provide qualitative analysis of classroom observation and semi-structured interviews with each instructor to explore the following research questions: How does the instructor's out-of-field (OOF) teaching and previous pedagogical knowledge influence the way they teach in an out-of-school setting? How does the learning environment impact the instructor's teaching? Finally, based on these findings, we offer recommendations to improve professional development and curriculum for CS after school programs.

Literature Review

Our novel approach to CS after-school programming in low-income communities lies at a unique intersection of challenges and strengths. The after-school informal learning environment totes unique expectations from students. With multiple options for activity being available, learning experiences can be expected to be engaging and hands-on or else suffer lower attendance from students as seen in Uchidiuno and colleagues (2023) work with after-school programming. However, newly trained instructors in the CS Ambassador program can face a host of challenges to meet that expectation. Drawing from previous literature based in formal in-school settings, I review the relationship between OOF teaching with instruction quality and the unique challenges that lie in CS professional development (PD). Then, we review work relating to culturally relevant pedagogical approaches to teaching STEM and CS to contextualize the unique importance of critical relationship-building in after school programs.

Challenges of Teaching CS as an Out-of-field Practitioner

A widely held consensus among researchers is that teacher quality positively correlates with student achievement. Several factors comprise a teacher's quality including Subject Matter Knowledge (SMK), years of experience, and certification status, all of which are linked to student achievement with varying effect sizes (Darling‑Hammond, 2000).

However, another important area to consider is a teacher's pedagogical content knowledge (PCK) which has also been linked to student achievement (Hill et al., 2005; Callingham et al., 2015). Initially viewed as a blend of a teacher's SMK and pedagogical knowledge (PK), it has evolved to refer to the knowledge teachers use to effectively communicate SMK (Gess‑Newsome, 2006). PCK was further expanded by Carlson and colleagues (2019) with the development of the refined consensus model (RCM). They propose three realms of PCK. Collective PCK (cPCK) is PCK that is shared within a professional community through shared documentation. Personal PCK (pPCK) is a teacher's own internalized form of PCK which they draw upon to teach. Finally, Enacted PCK (ePCK) is PCK when it is applied in the classroom. It only exists in action and is defined as a subset of pPCK when they use it in class (Carlson et al., 2019).

Out-of-field Teaching

Out-of-field (OOF) teaching refers to a mismatch between teachers' qualifications and the subject they're teaching. More formally, a teacher is considered 'out-of-field' if they hold no certification, license, or formal education in the subject matter (Ingersoll, 1998). In formal school settings, teacher qualifications have been shown to correlate with student achievement positively in a host of literature across multiple fields (Wayne & Youngs, 2003; Dee & Cohodes, 2008; Darling‑Hammond, 2000) As such, it's garnered a lot of attention in literature, for those trying to figure out its causes, effects and locality.

There are several reasonings that try to explain why OOF teaching is seen in formal school settings. Ingersoll (1998) postulates that it is a symptom of the high turnover rates of teachers in the United States. In turn, this produces an environment in which under-qualified teachers are hired to fill vacancies and then must cover subjects that they are unprepared for. This is supported by Darling‑Hammond (2000) who notes that licensure variability comes in times of high demand for teachers.

OOF teaching affects the teachers themselves as well. OOF teachers report low levels of self-efficacy, self-confidence, and greater issues in building relationships with students (Plessis, 2015; Sharplin, 2014; Fitchett et al., 2019; Hobbs, 2012). They've been observed to avoid challenging subject matter and rely upon textbooks or teacher talk (Sanders et al., 1993).

It's clear that OOF teaching can create a dysfunctional learning environment for students. The lack of ability to engage students is of particular concern in the after-school contexts because activities are expected to be fun. With initially limited SMK in CS, instructors may lack the ability to make rich connections between the content and student interests.

CS Licensure and Curricula Standards

OOF teaching is of particular concern in CS because of the inconsistencies found in national licensure in the US (Gal‐Ezer & Stephenson, 2010). Gal‐Ezer & Stephenson (2010) of the Computer Science Teachers Association (CSTA) Teacher Certification Task Force warns that when no clear standardized process exists for licensing teachers, then teachers with little or no CS training are assigned to teach it. Since then, CS certifications have become more widely available, increasing from 28 states of the 50 offering certification in 2017 to 43 in 2023 (CSTA, 2017; CSTA, 2023). Encouragingly, there is widespread adoption of the CSTA national curricula standards, but they are often only partially implemented or delivered in conjunction with another related subject (Guo & Ottenbreit-Leftwich, 2020).

Another significant national advocate for CS education in the US is Code.org. They are a non-profit that provides a multitude of CS education resources to students, educators and policy makers including, but limited to, an online coding platform, online professional development courses, and national reports synthesizing CS education adoption (Code.org, 2024).

So, while state-level CS education standards are still murky when compared to STEM field staples such as Math, national efforts have helped move CS education in the US to be more standardized. However, pedagogically, teaching CS still holds unique challenges.

Challenges of Teaching CS

There have been a host of challenges unique to CS instruction documented in literature. Socially, CS teachers report feeling isolated, as they could be one of the few in their building that teach the subject (Yadav et al., 2016; Goode et al., 2020; Simmonds et al., 2019). Logistically, CS curriculums require students to use a computer to practice writing code. This then entails coordination and support from the school's Information Technology (IT) to make sure the appropriate applications are accessible on student devices. Then, keeping students on task and undistracted while on their own devices, often with access to the internet, is a unique pedagogical challenge (Yadav et al., 2016).

An instructor outside of the CS field teaching it for the first time faces compounding challenges from both OOF teaching and CS instruction. Together they pose serious threats to instruction quality and staffing retention.

Culturally Relevant STEM Instruction in Informal Learning Environments

There are many examples of studies targeting informal learning environments with the goal of expanding access to CS education in the United States (Cateté et al., 2014; Hirsch et al., 2011; Schanzer et al., 2013; Denner et al., 2012; Sullivan et al., 2015; Mouza et al., 2016). Each focus on broadening participation in CS from underrepresented minorities (URM) in the field. Interestingly, while they show success in their impact on participants, they do not employ culturally relevant pedagogical practices. Lachney (2017) warns of the risks of this as he analyzes different ways in which African American culture has previously been integrated in computational thinking artifacts. By not consciously centering the culture from which an artifact or curriculum draws, you risk reproducing assimilationist logics if a community is not represented in tandem with their own cultural capital. In addition, none of the studies source instructors from the communities themselves and all of the studies use instructors that are qualified to teach CS. So, to review informal programming that does pedagogically align with culturally relevant teaching, we must draw from the larger body of literature on Informal STEM Programming (ISP).

Equity Focused Informal STEM Programming

There were broad critiques of the Maker Movement's failures to broaden participation in STEM from URM. It built an image of a maker who was largely white and male. Thus, programming centered around youth's identities in STEM becomes essential for youth to create their own counternarratives to what is traditionally represented in STEM. The program Making 4 Change (M4C) focused on these goals while situating itself in the Maker Movement. It was set in a community-based Maker Space and took place after school. It focused on making access to these after school experiences equitable and showcased student agency as a unique aspect of the after school learning environment (Barton et al., 2017). They note that some youth would attend the M4C program entirely as a social endeavor, and highlighted vignettes about youth building their own maker identities separate from the ones they carried in school.

I AM STEM is a community-based, non-residential summer program for Black girls in grades 4-8 (King & Pringle, 2018). It focuses on helping Black girls build identity in STEM through meaningful experiences in STEM. A critical component of these programs as identified by students was discussion of the role of race in their formal STEM experiences. As such, King & Pringle (2018) stresses the need for culturally competent teachers, as they were able to provide the most meaningful and enriching experiences.

Uchidiuno and colleagues (2023) give a sweeping review of the challenges they faced in implementing a 20-week co-design program in 6 different after school centers. They present 4 archetypes of after-school programs: Safe Havens, Recreation Centers, Homework Helpers, and STEM Enrichment Centers. They discuss how they adapt the co-design process to each archetype, and, because of the wide variations in culture and logistics, they recommend engaging with after school program administrators meaningfully to leave them with a core understanding of the program and improve the sustainability of these after school community engagements.

Black Love Framework

Above are examples of sustainable success within building identity in STEM. Worsley (2022) crystalizes her success in building an accepting STEM environment by defining the Black Love framework. It's a formalization of her pedagogical practices and values she developed through her work with Black youth in grades 6-12 at a community-based informal STEM makerspace. It's composed of two tenets. The first is STEM-related Onto-Epistemologies in which youth are encouraged to build STEM knowledge and identity through high-expectations, just-in-time teaching, and culturally stimulating engaging material. The second tenet is critical relationality focused on integration of youth voice interest in which building trust through collaboration and accountability is a key factor. Throughout her work, Worsley continues to stress the importance of her interpersonal relationships with youth and her sustained engagement of them to the success of their enjoyment of the material.

Similarly, Yuen and colleagues (2016) provide clear requirements to culturally relevant pedagogical practices in CS education in order to broaden participation in the field. Among the requirements shared are empowering students to understand their socio-political positions in the CS field and mentorship for students of underrepresented minorities. In many ways, the Black Love framework is aligned with the pedagogical requirements laid out by Yuen and colleagues (2016). It gives recommendations for mentorship from those of similar backgrounds, integrating student culture into curriculum, and providing meaningful authentic learning experiences.

However, other than its focus on STEM programming, the Black Love framework differs from Yuen and colleagues' (2016) recommendations by placing special emphasis on youth autonomy, critical relationship building, and politicized care. This emphasis takes greater advantage of the defining characteristics of the informal learning environment found in after school programs. Student autonomy and opportunities to build social capital with non-familial adults are central advantages of the after school learning environment which the Black Love framework fully appreciates.

The Present Study

Influenced by Uchidiuno et al. (2023) and their recommendation for community-improving interventions in after-school programs, Lim et al. (2024) began work with the CS Ambassador program. They recruited 3 after-school instructors in low-income communities to teach CS. Instructors participated in a 10-hour asynchronous virtual training course and then delivered a mix of curriculum present on Code.org. Through qualitative analysis, they found that instructors had a lower self-efficacy in teaching CS when delivering the curriculum. This was highlighted by the fact that teachers seemed to internalize student success or failure as a reflection of their teaching skills. Significantly, this is similar to other work related to out-of-field instruction in schools which found that OOF teachers had lower confidence when delivering material (Hobbs, 2012; Plessis, 2015). However, teachers faced challenges bespoke to the after-school informal learning environment.

Often, attendance varied between sessions, and, due to the structured nature of the Code.org curriculum, sometimes content had to be repeated for students who were not present at previous sessions (Lim et al., 2024).

In light of the previous work on OOF teaching, CS PD, and culturally relevant CS pedagogy, there is much more nuance to be explored between OOF teachers' PCK, previous teaching experience, cultural knowledge, and facilitation of pre-packaged curriculum. In the current literature, there is much discussion about how OOF teaching affects teachers and students in formal learning settings. However, no literature explores how OOF teaching affects these stakeholders in informal settings such as after-school programs. This thesis explores how CS Ambassador instructors face these challenges through qualitative analysis of classroom observation and semi-structured interviews. We explore how their local knowledge and cultural knowledge help mitigate these challenges to make recommendations to improve the quality and sustainability of CS after-school programs that center student culture and fun.

Methodology

A qualitative single case study approach was used to explore one instructor's (henceforth referred to as "the instructor") experience teaching CS after school with the CS ambassador program. The exploratory single case study approach was chosen to better understand how the instructor navigated teaching OOF and the after-school environment. We hope to elicit initial themes and findings to structure a larger study exploring how to build sustainable after-school CS programming. Via a partnership with After School Alliance, we obtained a list of teachers interested in participating in an after-school program as paid instructors. From this email list, we sent a program introduction email, detailing the CS Ambassador goals, time commitment, and logistics. We were able to successfully recruit three teachers in local low-income areas to teach CS in an after-school setting, one of whom was the instructor chosen for this case study.

The instructor was paid $50 an hour for their time and typically taught twice a week with each session lasting approximately one hour. However, this schedule was flexible as she set her own schedule. In addition, the after-school program was understaffed during this year and the instructor often had multiple roles during this time. A prominent consequence of this understaffing was the instructor's occasional dual responsibility: simultaneously facilitating the CS Ambassador session for older children while also supervising a kindergarten cohort, whom she often kept engaged with laptops.

The Instructor's Previous Background

At the time of the study, the instructor was an early-career educator with four years of classroom teaching experience. Her formal education included a bachelor's degree in sociology and a master's degree in elementary education. While teaching kindergarten as her primary role, she had no prior formal training or experience teaching CS.

Code.org Curriculum

Before teaching, the instructor had to complete 10 hours of training. She was asked to schedule a 30-minute introduction training call where she was introduced to the research team, the program, and Code.org's CS Fundamentals: Express Course. After this introduction, she worked independently and asynchronously to complete the CS Fundamentals: Express Course. She was sent weekly reminders to complete her course via email. Upon completion, she sent her completion certificates to our team and scheduled a follow-up meeting to begin teaching.

Once teaching, the instructor taught activities from the CS Fundamentals: Express Course. She created a Code.org class and login credentials for her class of students and taught one or multiple activities out of the curriculum per teaching session. For the most part, each student had their own laptop provided to them by the after-school program's administration.

Virtual & Physical Robotics Curriculum

In addition to the Code.org curriculum that was typically taught during the teaching sessions, a robotics curriculum was designed for the instructor for the last two weeks of the school year. Before the beginning of the program, a Lego EV3 robot was given to the instructor, along with a curriculum document. It contained video tutorials on how to use the Lego EV3 IDE to download and run programs on the robot. Additionally, it contained a link to each unit and its activities. For the physical robotics section of the curriculum, a video containing an example of successful completion of the activity was provided as well. The instructor was asked to review this content before she started teaching this curriculum. Four undergraduate students were recruited to assist in the in-person facilitation of the robotics curriculum. Before each session, they were asked to review each activity.

Data Collection and Analysis

During the period the instructor was teaching, the research team scheduled monthly observations to document her teaching. Audio recorders were placed around the room to capture the instructor's interaction with the students, and video was captured from the back of the room at an angle to avoid showing student faces. After each session the research team observed, the instructor participated in semi-structured informal interviews to discuss their reflections on the session. 1-3 researchers attended each observation session and each took individual observation notes in an unstructured manner. After the session, the research team gathered to discuss their notes, impressions, and highlights. This was also recorded.

Along with the monthly observations, the instructor was tasked with submitting reflective pieces after each lesson she taught. In these free-response reflections, she was asked to elaborate on the degree of student involvement, any challenging moments encountered, and any other thoughts they had about the session. See Appendix A for the full reflection questions.

Finally, the instructor participated in an online hour-long semi-structured interview. See Appendix C for the full interview protocol. Generally, we prompted her to reflect upon the following topics:

- The challenges you faced participating in the CS Ambassador program
- The student's experiences

- Your administration’s perception of the CS Ambassador program

A grounded inductive analysis approach was taken to analyze the sources of data gathered. First, the hour-long semi-structured interview was transcribed on the Dovetail platform. The first author then conducted a thematic analysis with the interview transcript. First, a set of codes were generated representing key concepts and common patterns within the interview. Then, from these codes salient themes were constructed in which influential factors to the instructor’s teaching methods were identified (Braun & Clarke, 2006). The complete coding scheme, including themes, supporting codes, and illustrative data excerpts, is detailed in Appendix B. To strengthen the validity of these emerging themes, the teacher observations and reflections were then reviewed, providing additional evidence through data triangulation. This research was approved by the Georgia Tech IRB.

Results

To address our research questions of "How does the instructor's OOF teaching and prior PK influence the way they teach in an out-of-school setting" and "How does the learning environment impact the instructor's teaching?", we examine salient themes that emerged from our analysis of classroom observations, a post-program interview, and the instructor's written session reflections. Our analysis revealed several key themes that provide insight into these questions. First, we explore how the instructor's OOF status in CS presented specific challenges in her teaching, while her strong foundation in PK enabled her to develop effective teaching strategies. Then, we examine how the unique characteristics of the case study's after-school environment, particularly its student-centric nature and emphasis on social dynamics, shaped her instructional approach and decisions.

Navigating OOF Teaching Challenges

Based on observations, interviews, and teacher reflections, the after-school instructor encountered several significant challenges while implementing the CS curriculum. These challenges stemmed primarily from her limited CS background and various technical constraints in the after-school environment. We explore in detail how these challenges manifested in our data sources.

Limited CS Content Knowledge and Vocabulary

In addition to her role as an after school instructor, the instructor was a kindergarten teacher. She had limited experience in CS and no formal background meaning she was an OOF teacher with regard to the CS domain. Our interview suggested that the instructor faced challenges in several aspects of facilitating the CS curriculum. For example, with little prior experience in CS, the instructor had to master unfamiliar content before teaching it. During our interview, she reflected on her response to these frustrating moments of learning in the professional development program, noting:

> I would find myself getting stuck on like, some of the coding things…I'm the type of person that growing up, I was labeled gifted. So, if I wasn't good at something, I would give up, so it was hard to push myself to not give up on this and just close the laptop

The instructor also grappled with technical communication, specifically within the CS domain. She discussed her struggles adapting some of the curriculum's content with appropriate vocabulary:

> I would look at the stuff beforehand trying to figure out a simplified way to explain what some of the functions were and how we could use them. That was kind of a challenge because sometimes I wouldn't have the correct words or like, I'm trying to bring it down to their level…but I can only say it this one way

In her written reflections, she continued to emphasize her focus on effective communication. After her first session, when asked "Do you plan to change your teaching approach in any way moving forward?" She focused on improving her ability to explain technical content: "Making sure I know how to explain the videos that students are supposed to view before they start a lesson." She responded similarly as well after her second session. This consistent focus across both interviews and reflections highlights how central the challenge of technical communication was to her experience as an OOF instructor.

Her struggle with technical communication manifested concretely in her terminology. For instance, during the interview, as she reflected on her observation of students completing challenges on the Code.org platform, she mistakenly referred to code blocks as “buttons,” which could suggest an unfamiliarity with CS vocabulary: “I enjoyed watching them struggle. It was kind of funny, but it would be interesting to watch like, how are you going to solve this problem? ... Are you gonna put 50 million of these buttons on here?” This mistake persisted throughout our observations and her teacher’s reflections where she used the term “repeat button.”

Her OOF background may have contributed to challenges with debugging student’s code–during the physical robotics sessions, the instructor had difficulties debugging unexpected behavior produced by the robot’s limited range of motion, so the research team had to provide an additional explanation of the EV3 robot’s program execution. These observations suggest potential ways her OOF status influenced her curriculum implementation.

Technical Infrastructure Constraints

Interview data and teacher reflections revealed several challenges with the technology that supported instruction. The school network’s blocking of YouTube prevented student access to Code.org’s video content, which required the instructor to make adaptations to her classroom management to ensure students were able to synchronously watch instructional content on her own device. As the instructor noted:

> the intro videos don’t play because they’re Youtube videos and the kids can’t access them on their own. So I have to sort of like pace the kids to stop at certain points and I know some kids move faster than other kids when it comes to some of the activities.

Infrastructure challenges, including intermittent internet connectivity, seemed to necessitate additional adaptations, with the instructor reporting: “One day the internet wasn’t working at all and we had to like pivot and do an in-person activity.”

These constraints with technological infrastructure, combined with the instructor's reported limited CS background, appeared to influence her throughout her instruction in the after-school environment. While the data suggested these challenges affected her, her interview, our observations, and her teacher reflections indicated she developed various strategies to address them, including implementing unplugged activities and modifying classroom management techniques.

Leveraging Prior Pedagogical Knowledge

The after-school instructor leveraged her PK from teaching kindergarten to structure and engage students in CS learning, despite facing challenges with her instruction. Her experience with classroom management was evident in how she established expectations and routines: "I was kind of telling them like, once we're in here, we're in here because it's like a learning process... So sort of just being more intentional with the commitment for the students."

The instructor demonstrated skilled differentiation, recognizing varying student paces: "I know some kids move faster than other kids when it comes to some of the activities." To maintain engagement, she suggested preparing additional activities for advanced students: "making sure I have, like, a side activity for them to complete." This attention to pacing and differentiation reflects her experience managing diverse learning needs.

She excelled at making CS relevant to different age groups, noting: "I teach kindergarten so I can make anything interesting." For middle school students, she connected CS to career opportunities: "after I start talking about money with the middle schoolers that usually brings them in," while for younger students, she related coding to their gaming interests: "showing the little kids...the connection between, like, somebody had to make this game."

Her kindergarten teaching experience also enhanced her adaptability: “we had to like pivot and do an in person activity. But I wouldn’t say that pivoting is a challenge for me because we do that in kindergarten all the time.” This flexibility allowed her to maintain instructional continuity despite technical challenges.

In her interview, the instructor also demonstrated strong reflective teaching practices through her classroom observations. Revisiting her use of the word “buttons” to refer to Code.org code blocks, we can see that while this terminology highlighted her OOF status, it also revealed her actively developing PCK: “it would be interesting to watch like, how are you going to solve this problem? Like, are you gonna use the loop? Are you gonna put 50 million of these buttons on here?” This is a vocabulary mistake, but it reveals that during the session, she identified a key student misconception about code efficiency (using repetitive blocks instead of loops). As such, this excerpt encapsulates the tension of how she leveraged her pedagogical expertise in student observation to build CS-specific teaching knowledge, even while navigating the challenges of being OOF.

Student-Centered After-School Environment

There were several aspects of the case-study’s after-school environment that emerged as influential factors in the instructor’s teaching. In particular, its student-centric nature and emphasis on student-to-student and instructor-to-student relationships.

Student Choice and Engagement

Throughout the interview, the instructor made multiple statements that would suggest that she perceived student choice to be an important aspect of the after-school environment. She discussed the administration's goal to give students more choice:

> I think that the kids are gonna be able to pick, I'm sure that if there's like issues with behavior and whatnot that she's going to like, sort of like, just let me know and let me decide, but I think there's gonna be more like student, student auto autonomy when it comes to taking their classes this year.

While it's clear that she perceived the administration's intent was to prioritize student choice, she did exhibit her preference to have the ultimate authority on whether a student was placed in her class. However, this wasn't the case this year, due to issues of low staffing in the center, some students were not given the choice to be in the program. The instructor explains, "...the director was picking the children who she put in there…last year it was more so we didn't have enough staff. So they, she was trying to find like just places for them to be." As such, the group of students that the instructor taught was a mix of students that opted to be there and others that were placed there due to capacity challenges.

It was clear that no matter what, students did expect to have fun. A line of questioning in the interview focused on understanding the instructor's perception of the skills needed to be successful as a CS ambassador. When asked to describe what skills she would look for if she had to hire someone to fill her role, she implied the need for an engaging instructor:

> You really gotta be like a people person to be a teacher… it's like some people are joining the profession just to have a job. And so I wouldn't want somebody to just, especially for an after school activity. Like this is something you're choosing to come to… this isn't paying your bills.

While this quote does give a window into her personal values as a teacher, it also illustrates how choice defines the after-school environment for her. She discusses how her students shouldn't be on the computer the whole lesson because "I know they're on computers for most of the day with, their teachers. So just making sure that they're not getting too burned out on the computers and that we have other modes of like, teaching and stuff" The after-school should be distinct, special and fun.

Peer Relationships and Social Dynamics

The instructor's observations suggested that peer relationships played a notable role in student participation and engagement in the after-school CS program. She described instances where student enrollment appeared to be influenced by their friends' participation, noting that "Kids are dropping from coding because their friends are not in it." Conversely, she also observed peer influence working to potentially increase interest in the program, sharing that "there are some kids who weren't in coding but they have friends who are in coding who are asking me about coding." These social dynamics seemed to present both opportunities and challenges for classroom management. While peer connections appeared to generate interest from parents, with the instructor noting that "there were a lot of parents whose kids weren't in here and they were like, wait, how does my kid get signed up for this?", they could also impact student focus during class sessions. The instructor found herself "Sitting the students differently so they are focused on the task" and observed that "some of the kids would get... bored waiting on other friends." The instructor's awareness of peer relationships' impact on both retention and classroom dynamics appeared to influence her teaching approach, suggesting that the informal after-school environment allowed social connections to play a more central role in her instructional decisions.

The Instructor's Multi-Faceted Role

Our observations suggested that the after-school environment required the instructor to balance multiple responsibilities beyond CS instruction. While her primary role was CS facilitation, the informal nature and resource constraints of the setting appeared to expand her duties. For instance, due to limited staffing, she simultaneously supervised a group of kindergarten students who were not part of the CS program, managing their engagement through school laptops and web games. Additionally, she held a broader role in the school community, serving as the volleyball coach—a position through which many students already knew and recognized her. During observations, we noted that she was frequently sought out by students from outside the CS program, leading to brief but warm exchanges that suggested relationship-building. For example, during our interview, she bid farewell to a student with "Bye [student name] have a great weekend. See you Tuesday. Love you." The instructor also appeared to maintain classroom management approaches typically associated with formal school settings, as evidenced by behavioral redirections observed during our interview, such as "[student name], walk" and "go back and walk." This blend of instructional, supervisory, and familiar community roles highlights how the informal setting facilitated multifaceted relationships between the instructor and students.

Through our analysis of the instructor's experience, several interrelated themes emerged that illuminate how OOF teaching, prior PK, and the after-school environment influenced her instruction. While her limited CS background presented challenges in technical communication and debugging, further complicated by technological infrastructure constraints, she actively leveraged her substantial PK from teaching kindergarten to engage students and manage the classroom effectively. The after-school setting's emphasis on student choice and social dynamics appeared to shape her instructional approach, leading her to prioritize student engagement and adapt to peer relationship dynamics. Further, the informal nature of the setting expanded her role beyond CS instruction, requiring her to balance multiple responsibilities. These themes suggest complex interactions between the instructor's background and the unique characteristics of the after-school learning environment.

Discussion

This case study examines an OOF instructor's implementation of CS curricula within an after-school setting. Our findings suggest that while the instructor faced challenges typical of OOF teaching, she drew upon her previous PK to maintain student engagement. Aligning with previous research, the after-school environment presented students with higher agency, which we found was a significant environmental factor that influenced the instructor's approach to classroom management and focus on engagement. We explore the interaction between the teacher's prior experience and learning environment and make recommendations for sustainable CS after-school programming.

How Does the Instructor's OOF Teaching and Prior Pedagogical Knowledge Influence the Way They Teach?

Our findings suggest a nuanced interplay between the instructor's OOF teaching and her ability to leverage her prior PK. While facing challenges typical to OOF teaching, she demonstrated resilience and adaptability in her teaching approach. To better understand how the instructor's OOF status influenced her teaching, we can examine our findings through the RCM. It delineates three PCK realms: collective (cPCK), personal (pPCK), and enacted (ePCK) PCK. cPCK represents the field's collective knowledge resources available to the instructor, while pPCK encompasses an individual teacher's internalized knowledge from experience, reading, and training. ePCK is the application of an instructor's PCK to a specific situation and is a subset of their pPCK (Carlson et al., 2019). In examining our data through this framework, we can better discuss how the instructor's in-domain PCK manifested and transformed.

The Instructor's Challenges with Teaching is Indicative of OOF Teaching

Crafting student-appropriate analogies—transforming abstract or technical ideas into comprehensible representations—was a core challenge that the instructor discussed. This strategy is highly reliant on an instructor's pPCK as it would require the instructor to utilize a rich set of analogies and content knowledge. As such, the instructor's reflection on struggling to translate technical concepts into student-appropriate language could demonstrate a pPCK deficit. This difficulty is further exemplified by her misidentification of code blocks as "buttons" and her difficulty debugging code for the EV3 robots, which could have stemmed from an ill-informed model of program execution in physical computing systems. Prior research suggests that this is a typical consequence of OOF teaching. OOF instructors often find it harder to form rich connections between the material and student interest (Elizabeth Du Plessis, 2013). So it seems that her teaching was influenced and challenged because she was OOF and had limited formal background in CS.

Leveraging Prior PK Despite OOF Status

These observations point to a potentially intriguing aspect of how an OOF teacher might utilize PK from previous experiences while teaching in a new domain. Her prior teaching experience appeared to provide strategies for managing various challenges she encountered. For example, when faced with technical constraints such as blocked YouTube videos and internet connectivity issues, the instructor drew on her kindergarten teaching experience by "pivoting" to maintain instructional continuity. While she may have lacked domain-specific CS knowledge, her general pedagogical strategies for maintaining student engagement and managing classroom dynamics seemed to transfer effectively to this new context, helping her overcome infrastructural challenges that could have otherwise disrupted learning.

The instructor's strong classroom management skills, developed through her kindergarten teaching experience, were particularly evident in how she structured the learning environment. She established clear expectations and routines, emphasizing to students the importance of commitment to the learning process. Her experience with differentiation was apparent in how she recognized and accommodated varying student paces, preparing additional activities for advanced students to maintain engagement. She also demonstrated skill in making CS relevant to different age groups, connecting it to career opportunities for middle school students and gaming interests for younger learners. These examples suggest that while teaching OOF content, she was able to draw upon and adapt fundamental classroom management strategies from her prior teaching experience.

The “buttons” terminology example particularly illustrates this complex interplay between OOF status and PK utilization. While her use of non-standard CS vocabulary reflected her OOF background, her observation of students’ tendency to use repetitive blocks instead of loops demonstrated strong pedagogical observation skills transferred from her prior teaching experience. This suggests that even as she was developing CS-specific PCK, her existing pedagogical expertise allowed her to identify important learning patterns.

The OOF teaching experience has been repeatedly characterized as “stressful” and “anxiety-inducing” and can reduce an instructor’s teaching self-efficacy (TSE) (Elizabeth Du Plessis, 2013). But, significantly, the instructor did not exemplify these negative effects of OOF teaching. She continued to express confidence in her teaching abilities and continued to attempt to engage students. It’s possible that a combination of a high TSE and her role as a kindergarten teacher allowed her to continue to engage students while avoiding some of the more negative effects of OOF teaching. Overall, while the instructor was challenged by some aspects of the OOF teaching, it seems that her TSE, intense focus on student engagement and previous PK allowed her to personalize her students’ learning experience despite teaching OOF.

How does the learning environment impact the instructors’ teaching?

The case study's after-school environment aligned with many of the aspects of the "Recreation Centers" archetype identified by Uchidiuno et al. (2023), particularly in its focus on student agency and play. Furthermore, our findings on relationship-building suggest the center also embodies the "Safe Haven" archetype and aligns with key tenets of the Black Love framework. Our findings suggest this environment influenced the instructor's teaching approach through three primary factors: the tension between intended and actual student choice, the prominence of peer relationships, and the implicit expectations for engaging instruction.

Tension Between Intended and Actual Student Choice

Typically, in these centers, students are encouraged to choose what programs they would be interested in participating in and students expect activities to be fun and distinct from school. Our results suggested that, in some aspects, this was mirrored in our case study's environment. While the administration aimed to allow students to select their after-school activities, staffing constraints necessitated placing some students in programs without their input. This created a mixed classroom dynamic where some students had chosen to participate while others were assigned to the program. However, it seems that the instructor still viewed choice as a key component of the after-school environment. This suggests that agency in the after-school learning environment for students is something that both the administration and instructor held as important. It should be noted that the after-school center also faced challenges that stifled student-agency as well. While they aimed to give each student a choice in what after-school program they attend, the after-school center was not able to fully accommodate this due to short staffing.

The Role of Peer Relationships

The voluntary nature of the after-school environment amplified the role of peer relationships in student participation and engagement. The instructor's observations of students dropping the program due to friends' absence, or expressing interest based on peers' participation, highlighted how social connections influenced the program's attendance. The social aspect of the environment appeared to create a dual effect: while peer relationships could generate program interest and potentially aid in recruitment, they also presented classroom management challenges that required ongoing adaptation of teaching strategies. The instructor's need to balance these social dynamics influenced her approach to instruction and was something she was very much so aware of.

Multiple Roles in the After-School Context

The case study's environment presented both opportunities and challenges as it led the instructor to naturally adopt multiple roles. While these varied responsibilities added complexity to her teaching duties, they also appeared to create unique opportunities for relationship-building with students. The most direct example of this would be her managing another cohort of kindergarten students during the CS program. Due to limited staffing resources in the after-school program, she often had to accommodate additional kindergarten students during her CS instruction time. This environmental constraint likely made her role as a CS instructor more challenging, as she had to divide her attention between facilitating CS activities and supervising students who weren't part of the program. Beyond managing multiple student groups, our findings showed she simultaneously acted as a CS facilitator, volleyball coach, and general authority figure in the after-school space. This multiplicity of roles appeared to facilitate deeper relationship-building with students, evidenced by casual interactions where students outside the CS program would seek her out for brief, positive exchanges. For instance, during our interview, we observed her offering words of encouragement and expressing care to passing students ("Love you"). This aligns with previous research on relationship-building in after-school spaces like the Black Love framework (Worsley, 2022), particularly its emphasis on critical relationality—the intentional, trust-centered relationships between educators and students that are grounded in collaboration, accountability, and care. The informal nature of the after-school environment seemed to naturally enable these multiple roles, allowing the instructor to build rapport with students in ways that might be more constrained in formal classroom settings. Unlike traditional school environments where external motivators like grades can drive participation, the voluntary nature of the after-school program meant that relationship-building became a crucial tool for maintaining student buy-in. This suggests that the multi-faceted nature of her role, while potentially challenging from a resource management perspective, may have actually supported program sustainability by strengthening student-instructor relationships and fostering continued engagement.

Our analysis reveals a complex interplay between the instructor's OOF status, her prior PK, and the unique demands of the after-school environment. While her OOF status in CS presented challenges with technical communication and content knowledge, the after-school environment's emphasis on engagement appeared to allow her to leverage her existing pedagogical strengths in novel ways. Rather than viewing engagement solely as a learning outcome, the instructor seemed to recognize it as essential for program sustainability in this voluntary setting—a recognition that shaped both her teaching strategies and her navigation of multiple roles. This was particularly evident in how she drew upon her prior PK to select and adapt instructional approaches, such as her emphasis on physical robotics and varied teaching modes, which aligned with both student preferences and the after-school environment's distinct characteristics. The informal nature of the setting, while presenting challenges such as managing multiple student groups and peer dynamics, appeared to create opportunities for the instructor to build deeper relationships with students and adapt her teaching approach in ways that might be constrained in formal classroom environments. This suggests that the after-school context may have helped mitigate some typical challenges of

OOF teaching by allowing the instructor to prioritize student engagement and relationship-building over technical expertise, ultimately supporting both program sustainability and her development of CS-specific pedagogical knowledge.

Limitations

As this thesis is a case-study of a single OOF instructor's experience teaching CS in an after-school program, the generalizability of our findings is limited. The case-study methodology was advantageous in allowing us to capture detailed examples of challenges that the instructor faced in the novel context of OOF teaching in the after-school environment. And, it allowed us to better understand the complex interactions that occurred in this context. But, as this is a single case-study, it's difficult to separate the many other factors that may have influenced the instructor's teaching–such as core teaching values–from her OOF status and classroom environment. For example, one of the reasons the instructor had success in the after-school environment was her focus on student engagement. However, while our findings suggest that this focus was influenced by PK she gained as a kindergarten teacher and the student-centric nature of the after-school environment, the extent to which these factors influenced her instruction remains unclear.

It's important to consider the possible effects that the power dynamics between the research team and the instructor could have had. The payment provided to participants for their time may have led them to perceive the post-program interview as an evaluation of their performance, rather than an exploratory discussion. While this was not the stated purpose of the interview, this perception still could have influenced their reporting of student engagement and their willingness to discuss negative aspects of their experience. Additionally, the observation itself, despite the team's attempts to remain unobtrusive, could have impacted the instructor's teaching style and students' actions. While the teacher's reflections offer additional perspectives, these power dynamics and methodological limitations necessitate careful consideration when drawing conclusions about how OOF teachers might generally adapt their PK to new teaching contexts.

Implications & Future Work

Our case study findings suggest theoretical and practical implications for building sustainable CS after-school programs, particularly when working with OOF instructors. On the theoretical side, our findings point to potential extensions of how we conceptualize PCK development for OOF teachers, especially in informal learning spaces. From a practical perspective, the study offers insights for program administrators on instructor recruitment and program sustainability in voluntary educational settings where engagement is paramount. Below, we explore these implications in detail and suggest directions for future research in each area.

Theoretical Implications for PCK Development in OOF Teaching

Theoretically, our case study points to an intriguing, yet under-explored aspect of how an OOF teacher utilizes out-of-domain knowledge to form in-domain PCK. While the RCM conceptualizes PCK as domain-specific, our findings suggest a more fluid potential for knowledge adaptation (Carlson et al., 2019). Specifically, the instructor appeared to synthesize her previous pedagogical practices with the CS subject matter in ways the current theoretical model may not fully capture. For example, her strategy of connecting CS to concepts that were highly relevant to her students is an instance of ePCK. As such, the current RCM model would suggest that this ePCK was formed by filtering her pPCK into action. But, this engagement strategy does not seem to draw on solely her pPCK. Instead, it also draws on her previous experiences teaching these students and her knowledge of the community. Thus, while this example could be viewed as a standard example of a transformation of pPCK to ePCK, this interpretation could potentially exclude the out-of-domain knowledge that could be incorporated to form the in-domain ePCK. This could suggest a limitation with the RCM. Future work should investigate how the RCM could be extended to better account for the role of out-of-domain knowledge in PCK development, particularly examining how OOF teachers' prior pedagogical experiences and teaching values shape their development of domain-specific PCK in informal learning environments.

Practical Implications for After-School CS Program Development

While the instructor was teaching OOF in CS, she maintained a high TSE and successfully engaged students. This cuts against the grain of what would be typically expected of an OOF teacher and could suggest that instructors can utilize prior PK and a high TSE to mitigate the effects of OOF teaching. This suggests that program administrators might benefit from prioritizing candidates' pedagogical strengths and classroom management skills over technical expertise when recruiting for after-school CS programs. Teachers who demonstrate experience in creating engaging, student-centered learning environments and show comfort with adapting curriculum for different learners may be particularly well-suited, even without extensive CS background.

Finally, our case-study's after-school environment was characterized by voluntary participation from multiple stakeholders. Our findings touch upon three key actors with significant decision-making power: the instructor (who chooses to facilitate the curriculum), the students (who opt into the CS program), and the parents (who determine program attendance). This voluntary nature introduces inherent challenges to program sustainability, as no participant is obligated to continue engaging with the program. However, our findings demonstrate how centering student engagement in instruction can mitigate these challenges. The program not only captivated students' interest but also motivated the instructor and generated excitement among parents, suggesting that student engagement, can be more than just a program outcome in the after-school context. But, it could serve as a critical mechanism for maintaining program vitality in voluntary educational settings.

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Appendix A

Free Response Reflection Questions

1. Your name?
2. Date of teaching? (mm/dd/yyyy)
3. What topic did you teach students today?

   [Please include the course name and link to materials]
4. How many students attended this session?
5. What was your strategy for teaching the course materials today

   [Include any changes you made, if you did any prep prior, things you were uncomfortable with etc]
6. How engaged were students with the material?

   [Please be as detailed as you can. What were your favorite moments? What areas did students enjoy? What did students struggle with? Were students generally bored, disengaged, distracted by other things, excited about the material? Do you notice any students engaging more or less with computer science?]
7. What were the most challenging aspects of this session?

   [Include any technical, classroom management, program administration related challenges etc]
8. Do you plan to change your teaching approach in any way moving forward?

Appendix B

Table B1

Thematic Analysis of Instructor Experience Teaching Out-of-Field Computer Science in an After-School Setting: Themes, Codes, and Supporting Data

Theme	Code	Supporting Data	Data Source
Teacher utilizing previous PK	Personalized Learning	"So, just being more intentional about like, activities they're doing in the classroom to cut down on, like, some of the behavior issues,"	Interview
	Emotional Regulation	"I was kind of telling them like, once we're in here, we're in here because it's like a learning process and we have to build on to it. We can't just hop in and hop out when we want to. So sort of just being more intentional with the commitment for the students."	Interview
	Pedagogical Knowledge	"I teach kindergarten so I can make anything interesting"	Interview
		"we had to like pivot and do a an in person activity. But I wouldn't say that pivoting is a challenge for me because we do that in kindergarten all the time."	Interview
		"Explaining skills showed in videos again ahead of time."	Teacher Reflection

	"So I have to sort of like pace the kids to stop at certain points and I know some kids move faster than other kids when it comes to some of the activities. So I noticed that like those kids are getting kind of bored while they're waiting for years to like catch up to the to think."	Interview
	"So me just making sure I have, like, a side activity for them to complete. So that way, so maybe thinking of like, I don't know, like puzzles or worksheets or like, maybe, I don't know if there's coding games, like, as far as, like board games or anything,"	Interview
Relating real-word to CS	"...after I start talking about money with the middle schoolers that usually brings them in…showing the little kids, like, how I see, I had one kid playing games on the computer, like, just showing them the connection between, like, somebody had to make this game"	Interview
	"I started to show them like different jobs you could get by knowing like coding language…and they were very interested, they were like, 'wait, they make that much, what do they do?'"	Interview
	"Relate it to their everyday lives, make it relatable and just make it fun. Have fun doing it."	Interview
Teacher Prep	"Making sure I know how to explain the videos that students are suppose to view before they start a lesson."	Teacher Reflection

Physical robotics was engaging	Robots for behavior management	“I know I keep going back to these robots, but when the kids were actually programming the robots...I was like, this is so nice. Like y’all are actually like sitting here programming things…”	Interview
	Enjoyed Robots	“they really had fun with those [robots]”	Interview
		“they really enjoyed those robots”	Interview
	Hands-on Robots	“they really enjoyed those robots, the hands-on piece.”	Interview
		“I did like that we did the virtual one first… then they got to be with the actual robots. So that was really cool”	Interview
The instructor was challenged by a lack of CS experience	PCK Struggles	“I wouldn’t have the correct words or like, I’m trying to bring it down to their level and it’s like, but I can only say it this one way…if anything that would have been one of the challenging parts of it.”	Interview
	Appropriate Vocabulary	“trying to figure out a simplified way to explain, like what some of the functions were and how we could use them”	Interview
	Instructor Coding Struggles	“I would find myself getting stuck on like, some of the coding things.”	Interview
		“It was hard to push myself to not give up on this and just close the laptop because that’s what I’m used to”	Interview
	Vocabulary Mistake	“I enjoyed watching them struggle. It was kind of funny, but it would be	Interview

	interesting to watch like, how are you going to solve this problem?…Are you gonna put 50 million of these buttons on here?”	
	“I walked around the room and ensured students were focused during lessons and understood how to use the repeat button.”	Teacher Reflection
Technology Struggles	“Videos being blocked by the school”	Teacher Reflection
	“Again ... just the videos not showing up.”	Teacher Reflection
	“Technology (promethean board)”	Teacher Reflection
	“Again, the videos not playing because of the student wifi.”	Teacher Reflection
	“One day the internet wasn’t working at all and we had to like pivot and do a an in person activity.”	Interview
	“the intro videos don’t play because they’re youtube videos and the kids can’t access them on their own. So I have to sort of like pace the kids to stop at certain points and I know some kids move faster than other kids when it comes to some of the activities.”	Interview
	“Ensuring I have the proper cords for my board before I start my lesson and have materials up and ready so we can maximize the amount of time students have to complete the activities.”	Teacher Reflection

Social Apsects of the after-school environment	Classroom management	“Sitting the students differently so they are focused on the task”	Teacher Reflection
	Positive	“Kids are dropping from coding because their friends are not in it.”	Teacher Reflection
		“there are some kids who weren’t in coding but they have friends who are in coding who are asking me about coding.”	Interview
		“there were a lot of parents whose kids weren’t in here and they were like, wait, how does my kid get signed up for this?”	Interview
	Negative	“some of the kids would get… bored waiting on other friends.”	Interview

Appendix C

Semi-Structured Interview Protocol for CS Program Teacher

I. Introduction & Consent

- Establish rapport and reiterate confidentiality.
- State study purpose: Evaluate after-school CS program effectiveness, challenges, and scalability from the instructor's perspective.
- Confirm participant's duration of experience with the program.
- Obtain verbal consent to proceed/record (if applicable).

II. Overall Program Perceptions

- Elicit general assessment of the program.
- Probe overall satisfaction and intent for future participation.

III. Instructional Experiences & Challenges

- Investigate challenges related to instructional delivery (e.g., student pacing, differentiation, classroom management).
- Explore difficulties related to curriculum/materials (e.g., resource accessibility/usability, need for supplemental/unplugged activities).
- Examine strategies used for student engagement, particularly for initially uninterested students.
- Inquire about experiences adapting instruction due to unforeseen circumstances (e.g., technology issues).

IV. Program Logistics & Support

- Discuss logistical aspects (e.g., student recruitment/retention, administrative procedures, payment processes).
- Assess perceived support from school administration and program staff.
- Gauge parental awareness or engagement with the program.

V. Curriculum & Training

- Elicit preferences regarding curriculum structure and sequencing.
- Explore views on the effectiveness and preferred modality of instructor training (e.g., asynchronous vs. synchronous).

VI. Instructor Development & Pedagogy

- Examine perceived impact of program participation on personal teaching practices.
- Probe challenges related to learning CS content for instruction and pedagogical content knowledge (explaining CS concepts effectively).

VII. Perceived Student Impact

- Assess observed changes in student attitudes, interest, or engagement in computer science.
- Inquire about notable rewarding moments or perceived student successes.

VIII. Recommendations & Facilitator Profile

- Solicit specific recommendations for program improvement.

- Elicit advice for prospective program facilitators and identify key skills/attributes deemed necessary for success.

IX. Conclusion

- Provide opportunity for participant questions.
- Confirm any follow-up or logistical details.
- Thank participant for their time and contribution.