WIP: Examining the role of university support in aiding an out-of-field middle-school teacher to deliver arts-integrated computing instruction.

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[Work in Progress] Examining the benefits of undergraduate service learners aiding an out-of-field middle-school teacher to deliver arts-integrated computing instruction.

Introduction and Literature

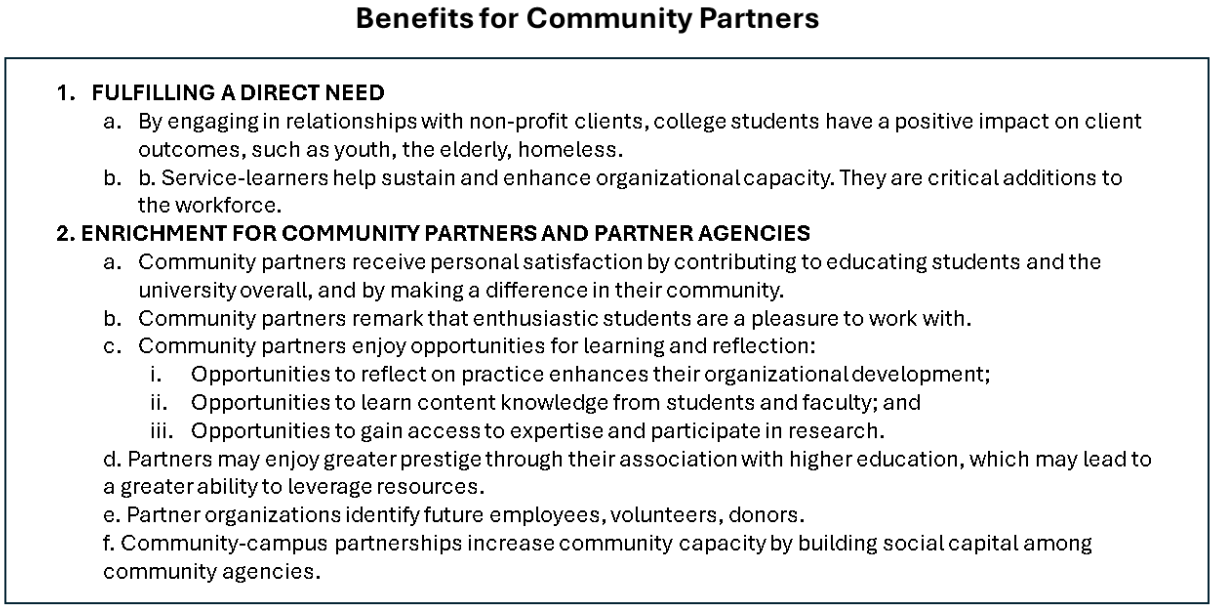
It has been almost a decade since the Computer Science For All initiative was introduced in 2016 [1]. The aim of this initiative, to provide computer science education for all K-12 students in the United States, was adopted by most states and has been carried out to varying degrees of success [2]. Computer Science skills are crucial to improving national and personal economic growth [3]. Many European countries, Saudi Arabia, and Australia have implemented mandatory CS-focused instruction in primary and secondary schools [3]. CS-focused instruction in the United States is gaining traction in standards at the state level, but still has a long way to go to help all students learn CS [2]. Urban, rural, and small pre-college schools and those serving Black, Hispanic, and Native American students are struggling to implement computer science education for their students, and only 37% of middle schools offer computer science [2]. Multi-subject, credentialled teachers are not typically trained in computer science. For these teachers, computer science is out of their field of training (out-of-field), thus posing a barrier to CS instruction in middle school. The lack of trained multi-subject credentialed teachers who feel comfortable delivering computer science instruction at the middle-school level may be mitigated through university outreach efforts to support schools and teachers integrating computer science instruction into their classrooms. One means of outreach is through K-16 partnerships that include undergraduate service learning.

K-16 partnerships are an effective way to engage the community and improve K-12 graduation rates and college readiness. These partnerships come in many forms, such as tutoring programs, teacher training, and curriculum development [4]. In one partnership between a university and a school district in the U.S. West, undergraduate students were hired as tutors for the school district's students and teachers [4]. For community partnerships focused on engineering, service-learning can also play a significant role in community engagement [5]. For example, in a freshman engineering course, students developed lesson plans to help teachers with limited robotics experience. They worked with middle-school teachers and student teams for 8 weeks to design robots for a competition [6]. Teachers in this program appreciated the freshmen "engineering experts" because this was their and their students' sole exposure to engineering [6].

Undergraduates who work with the community through K-16 partnerships often do so as part of a service-learning course. Sandy's (2007) work on service-learning identified what community partner organizations saw as the distinct benefits of participating in service-learning partnerships with universities (BCP). According to BCP, service-learning partnerships fulfill a direct need and provide enrichment for community partners in areas such as enhancing organizational capacity, providing enthusiastic role models, and positively impacting youth [7]. Figure 1 briefly outlines the benefits for community partners [7]. While university-community partnerships have shown statistically significant benefits, little is known about how partnerships achieve these results [4]. Additionally, universities engaged in K-12 school partnerships often do not understand the community or engage the stakeholders in limited ways. [8] One area ripe for exploration for community partnerships that employ undergraduate service-learning is examining undergraduate

students' roles in engineering service-learning outreach to K-12 schools. We need a better understanding of how undergraduate service learners can contribute to the K-12 learning community.

Figure 1. Benefits for community partners in service-learning projects as defined by Sandy [7, p. 20]



*NOTE: The words in this figure are directly quoted from Sandy [7, p. 20].

The importance of the learning community in children's education is emphasized in Vygotsky's learning theories. Vygotsky's theories surrounding the zone of proximal development rely on sociocultural aspects of the environment and collaboration between the learner and a more knowledgeable other (MKO) [9]. In the K-12 classroom, an MKO can be the teacher or a peer. Undergraduates participating in engineering-focused service-learning may contribute to the K-12 classroom environment by acting as more knowledgeable others. The addition of undergraduate students into the K-12 classroom in an interjacent role, lying somewhere between the teacher and students, will affect the classroom's participation structure. Jordan and Henderson's work on interaction analysis [10] focuses on the participation structure of the classroom because analyzing participation structures is"essential to understanding interaction in a formal school setting" [10, p. 69]. These interactions, analyzed at the micro-level, examine in detail what people say, do, and think during the experience [11]. Examining the micro-level interactions between undergraduates, students, and teachers in the classroom may give us insight into how undergraduate service-learning benefits K-12 community partners at a micro-level. Because combinations of micro-level interactions can be amalgamated into macrophenomena, [11] by examining the micro-level interactions in the classroom, we can look for patterns of interactions that, when combined, help form the phenomena described bySandy's study on the BCP in service learning. While we theorize that undergraduate service learning will offer similar benefits to the classroom as the larger organizational level benefits identified in Sandy's BCP, we can not know

this without understanding how the teacher views the benefits of undergraduate service learners. Thus, we must first investigate if BCP elements manifest at the classroom level.

For the entire study, we ask two questions. We seek to investigate only the first question for this work-in-progress paper (WIP).

1. What benefits does the out-of-field teacher receive from having university students engaged in service learning in the middle-school classroom as aligned with elements in Sandy's (2007) Benefits to Community Partners?
2. What types of micro-level interactions do undergraduate service learners engage in when working in the classroom and how do these interactions amalgamate to fulfill the benefits of service learning as recognized by the teacher and characterized by the Benefits to Community Partners?

Methods

Setting

We conducted the study at a middle school in a mid-sized city in the Western U.S. An undergraduate-focused Minority Serving University partnered with the middle school for a continuing pilot of a K-16 partnership involving undergraduate service learning. The middle school partnered with the university to deliver arts-integrated physical computing and engineering design instruction through a program called TechArt. The middle-school student population is 60% African American, 26% Hispanic, 6% Multiracial, 1% Caucasian, 1%American Indian, and the remaining unknown. The university student population is 38% Hispanic, 22% White, 20% Asian, 6% African American, 6% Multiracial, 1% Pacific Islander <1% American Indian and the remaining unknown or international. 60% of the university's students are from the surrounding metropolitan area, and 30% are first-generation college students.

Pilot Project Background

The data for this study comes from the second semester of the second year of a pilot service-learning program in partnership with a small local middle school that predominantly serves Black and Latino students. During the pilot's first year, two university professors worked with teachers who received apprenticeship-style training to deliver a loosely structured curriculum. The program taught all middle-school students how to code a micro:bit controller with a Hummingbird kit and its accompanying sensors and actuators. Students combined this knowledge with simple mechanisms and arts/crafts techniques to create interactive artworks for display at a culminating event, the TechArt Summit.

In the second year of the pilot, the middle school changed staffing and selected a new person to teach the elective TechArt class. The teacher, unfamiliar with the content, received limited training during the summer before the first semester of the class. During the first semester of teaching (Fall), the teacher expressed his need for more support in teaching the class. At the beginning of the second semester (Spring), one university professor from the first pilot collaborated with the teacher and two undergraduates to create a more structured, scripted

curriculum. The scripted curriculum aimed to provide the out-of-field teacher with scaffolding and independence in teaching the class since he had not participated in the pilot's first year and felt under-prepared.

The curriculum centers on engaging students in the engineering design process (EDP) using arts-integrated physical computing. The curriculum prepared students to combine coding a micro:bit with artistic and craft construction techniques to create exhibit pieces for the university's TechArt summit. Student teams were free to design any creation of their choosing with the requirement that each creation contain at least one sensor and one actuator. The elective class occurred twice per week during the 16-week semester. The teacher only covered the curriculum on days that the undergraduate students were in the classroom. Additionally, the professor for the undergraduate service-learning class attended most sessions to collect data and aid the teacher and undergraduate students on a limited basis.

Participants

The study participants were one middle school teacher, one behavioral specialist, two undergraduates, approximately twenty middle school students, and one university professor. For this WIP paper, we only focus on the teacher.

The teacher for the middle school class, Mr. Clay (pseudonym), an African-American male, was trained and hired as a social worker for the school and assigned by the school administration to teach the coding class. The novice teacher received training over the summer at the university. The teacher was also apprenticed by the university engineering professor and a computer science undergraduate in coding-focused instruction during the semester preceding our study (Fall.) It is important to note that Mr. Clay continuously expressed apprehension about teaching the class during his initial training and throughout the Fall semester during his apprenticeship. The school administration assigned Mr. Clay to teach the elective class, but he did not feel confident because the subject was outside his training. Although Mr. Clay received additional training on the class content, the training was not enough to make him comfortable delivering the curriculum independently. He expressed the need for more support. This need for more support was the impetus for modifying the loosely structured TechArt curriculum used during the pilot's first year by co-creating a scripted curriculum Mr. Clay could follow.

The undergraduates were seniors majoring in computer science (Micah) and design (Daniel). Both are African-American males.

Data Collection

We collected data from teacher interviews and classroom video recordings for the entire study. This WIP paper only addresses the teacher interview data, which speaks directly to RQ1.

<u>Teacher Interviews</u>

Mr. Clay was interviewed at the beginning of the semester and again after the semester ended. The researcher also held several informal conversations with Mr. Clay while setting up and tearing down the video equipment. Through the interviews with the teacher, we elicited their feelings about the class and the type of support they needed to deliver the class successfully. We also asked the teacher to discuss the middle-school students' attitudes toward the class and the

undergraduate students. Our goal was to identify what the teacher found helpful in the partnership without explicitly asking him about the benefits of having undergraduate service learners in the class. Sample questions from the interviews include: 1. What were your initial feelings about teaching this class? 2. What ongoing support do you need, and from whom to continue this class? 3. What do students need to be successful in this class? 4. Do you see a difference in how students respond to this class versus their other classes?

Classroom Video Recordings

We have over twenty-three hours of classroom video. This data will be used in our subsequent efforts to answer RQ2 in a future publication that covers the entire study beyond this WIP paper.

Data Analysis

Teacher Interviews

Because the BCP framework looks at community partners from the organizational level, we need to investigate if these elements exist at a classroom level. We examined the teacher interview data to determine if and how the teacher's experiences in a classroom aligned with elements of the BCP. In our analysis, we aimed to see if their sentiments aligned with the literature as expressed by Sandy's (2007) Benefits for Community Partners (BCP) [7]. Examining alignment between the teacher's sentiments and elements of the BCP was the first crucial step of the study because the remaining research question about undergraduates' beneficial role could not be answered without this alignment.

We transcribed the teacher interviews and coded them according to items from the Benefits for Community Partners (BCP) study [7] using NVivo software. During the coding process, we looked for instances where the teacher discussed how partnership 1. filled a direct need or 2. enriched the experience of the teacher, middle-school students, or school. When identified, the matching items were further analyzed to determine which sub-benefits were specifically identified: two possible sub-benefits for Fulfilling a Direct Need and six possible sub-benefits for Enrichment for the Community Partner (see Figure 1.)

Classroom Video Recordings

We will analyze the video data in our subsequent efforts to answer RQ2. We plan to use MAXQDA to code the video data. We plan to cycle through several phases of inductive video analysis as we examine the interactions between undergraduate service learners and middle school students and teachers [12].

Findings

We discuss findings from our analysis of the teacher interviews.

Teacher Interviews and Benefits to Community Partners

We identified five BCP elements from the teacher interviews corresponding to teacher sentiments. The elements are: 1a. Positive impact on client outcomes, 1b. Sustain and enhance

organizational capacity, 2b. Enthusiastic students are a pleasure, 2cii. Learn content knowledge from students and faculty, 2ciii. Gain access to expertise.

In an early interview, Mr. Clay shared: “Honestly, the more support, the better because I feel like you could get any type of training, but if that’s not what you do, that’s not what you do. You know that they [undergraduate students] know this [subject]. This is what they love to do. You know I’m doing it because I have to do it. That’s not what I love to do. I have to do it, you know? …. I could train for three months, but that’s not what I want to do. Micah and Daniel, they know this work, and they like that, you know, and that’s different… I feel like having a person is very key for a teacher that this is not their … field” (2cii, 2ciii).

Mr. Clay’s sentiments indicate that he expects to gain access to the level of expertise that the undergraduate students have because they study similar content at the university. As Mr. Clay began the spring semester, he drew upon the university’s resources of the scripted curriculum and the undergraduate service learners in support of his class delivery.

> “Micah and Daniel, they give me the advice, they give me the confidence like every day, like, OH, Mr. Clay, keep it up. And even I look at them like, man, you guys are doing great, man. I feed off their energy because when I see what they do, I try to put it inside me so I could show the kids too. So it’s like it’s good to have [university name] support like that. It’s been amazing; you guys have been nothing but first-class service. And I feel like that is needed when you do something like that because the kids [get to] see another person, too. Yeah, you can be a teacher, but they [have got] to see [someone]who’s done it before and knows other ways about it than just someone who’s been doing the training. “(2b, 2cii, 2ciii)

In this excerpt, we see several elements of the BCP at play. Mr. Clay receives pleasure and encouragement from the enthusiastic and supportive undergraduates (2b.) He gleans subject matter content knowledge by watching them as they operate in the classroom (2ciii.) Mr. Clay alludes to his appreciation of the university’s expertise when he mentions“first-class service.” Additionally, he comments on the positive impact his students receive from having access to undergraduate students' experiences in the subject matter content (1a.)

In another portion of the interview, Mr. Clay discussed the vital role of university support for his students.

> “We have me and you. Micah. Daniel. Like, it's like OK, it's not only Mr. Clay doing this. Because that's what the kids asked me, like Mr. Clay, we need … They want other people around, and I hear them out. They want other people around because it makes them feel good. It makes them feel like alright somebody with knowledge, also that's going to school that they want to go to college, they could look up to that, they always ask for that. They love Micah. They love Daniel. They're like, we look up to these guys. So that's something that helped out a lot.”

Mr. Clay and the middle school students are positively impacted (1a) by the university's involvement through service learning. However, it is too early to evaluate any long-term impact on outcomes. One short-term impact was the successful completion of their TechArt designs and presentation to hundreds of attendees at the TechArt summit. We also see how the university supports enhanced the capacity of Mr. Clay to teach the class by providing knowledgeable role models whose relative expertise helped support him and the students (1b, 2cii, 2ciii.)

Discussion

The out-of-field teacher identified two primary benefits to his class from the university partnership that aligned with the high-level elements of the BCP: 1. Fulfilling a direct need and 2. Enrichment for community partners and partner agencies. The sub-level BCP elements echoed by the teacher's sentiments were centered on benefits that had a positive impact on the classroom environment (1a), enhanced the teacher's capacity in the classroom (1b), allowed teacher and students to learn from undergraduates (2cii), expressed the pleasure of working with undergraduates (2b) and accessing their expertise (2ciii.)

We did not see several sub-level BCP elements in the teacher interviews. Building social capital (2f), organizational prestige (2d), identifying future staff (2e), and enhancing organizational development (2ci) did not seem to play a factor in his mind. This is understandable because these benefits are more important at an administrative or organizational level than at the day-to-day classroom level. We also didn't see the teacher mention gaining personal satisfaction from working with undergraduates (2a.) This may be because our interview protocol did not include any questions specifically about the undergraduates or the teachers' feelings about helping them.

In our next phase of work, we will look at the specific micro-interactions undergraduates engaged in through service-learning in the classroom. We aim to identify how those interactions contributed to the BCP elements the teacher identified. Under BCP #1: Fulfilling a direct need of the classroom teacher, we will look for instances where undergraduate students assisted the teacher. Under BCP #2: Enrichment for community partners and partner agencies, we will examine how the undergraduates provided enrichment for the TechArt program. What roles did they take on, and how did they act as MKOs in the classroom? In what ways did undergraduate students enhance the organization's capacity to conduct the TechArt class and serve as essential partners and a "critical addition to the workforce" [7, p. 20].

We aim to discover the exact elements of undergraduate behaviors that contribute to teachers seeing undergraduate service learners as beneficial in the classroom. This may help us better coach service learners in supporting out-of-field teachers and the students they serve. It may also help to strengthen K-16 partnerships by showing partners the benefits to teachers and students when undergraduate service learners are incorporated into the classroom.

Implications

The classroom teacher, who engaged in teaching computer science, an out-of-field subject for him, identified the benefits of having undergraduate service learners in the classroom. His

sentiments echo those identified in Benefits to Community Partners described in Sandy's (2007) study of service learning. Undergraduates fulfilled a direct need and acted to enrich the capacity of the community partner, namely the classroom teachers and students. The teacher in this study confirms that the BCP elements were present in his classroom interactions with undergraduate service learners. Now that we have confirmed an alignment between the teacher's perceived benefits and several elements of the BCP, our next step is to perform an interaction analysis of the classroom video. In the next phase of analysis, we will aim to identify the exact types of interactions contributing to the beneficial role of undergraduates in the classroom.

This work holds promise for expanding the ability of schools with out-of-field teachers to incorporate computing and engineering design instruction through K-16 partnerships that incorporate undergraduates in the classroom to assist teachers and students. Given the dearth of computer science teachers and the variable nature of CS training for multi-subject credentialled teachers, K-16 partnerships involving undergraduate service-learning may help bridge the gap for out-of-field teachers as they take on the challenge of teaching computer science in middle schools.

Limitations

As this is a work-in-progress study, its limitations are inherent. The study, in its current state, includes only one classroom. While qualitative studies do not rely on a large sample size, it would be beneficial to study more teachers who follow this model to confirm that the alignment to BCP is consistent across multiple teachers. The interview questions were not explicitly geared toward elements of the BCP. However, the researcher's goal was to solicit the teacher's unbiased feelings and sentiments without swaying them toward elements of the BCP via questions directly about the BCP.

Trustworthiness and Positionality

To ensure the trustworthiness of this study, we employed strategies to enhance credibility through prolonged engagement with the participants and practicing reflexivity during the collection and analysis of data. We also provide thick descriptions of the context, participants, and methods to increase transferability. Additionally, we sought feedback from peers to increase the confirmability of our analysis and findings [13].

As the lead researcher, my approach to this study was influenced by my role as the lead faculty for TechArt. I actively co-developed the scripted curriculum and supported the teacher and undergraduate service learners, which may have shaped participants' responses to my questions. My position as a university researcher and advocate for service learning could introduce bias in interpreting the benefits of the partnership. I employed reflexivity through analytical memos, direct participant quotes, and alignment with Sandy's (2007) Benefits to Community Partners framework to mitigate potential bias. While my insights provide context, I aim to center the teacher's experiences and perspectives, ensuring his voice guides the study's conclusions.

References

[1] "FACT SHEET: President Obama Announces Computer Science For All Initiative," whitehouse.gov. Accessed: Mar. 19, 2024. [Online]. Available: https://obamawhitehouse.archives.gov/the-press-office/2016/01/30/fact-sheet-president-obama-announces-computer-science-all-initiative-0

[2] "2024 State of Computer Science Education Report," Code.org, CSTE, ECEP Alliance (2025), 2024. Accessed: Jan. 10, 2025. [Online]. Available: https://advocacy.code.org/stateofcs/

[3] "Building skills for life: How to expand and improve computer science education around the world," The Brookings Institute, 2021. Accessed: Mar. 02, 2024. [Online]. Available: https://www.brookings.edu/articles/building-skills-for-life-how-to-expand-and-improve-computer-science-education-around-the-world/

[4] T. Domina and E. Ruzek, "Paving the Way: K-16 Partnerships for Higher Education Diversity and High School Reform," *Educational Policy*, vol. 26, no. 2, pp. 243–267, Mar. 2012, doi: 10.1177/0895904810386586.

[5] R. G. Bringle and J. A. Hatcher, "Innovative practices in service-learning and curricular engagement," *New Directions for Higher Education*, vol. 2009, no. 147, pp. 37–46, 2009, doi: 10.1002/he.356.

[6] T. Karp, "Teaching a service learning introductory engineering course — Lessons learned and improvements made," in *2011 Frontiers in Education Conference (FIE)*, Oct. 2011, pp. F1E-1-F1E-5. doi: 10.1109/FIE.2011.6142769.

[7] M. Sandy, "Community Voices: A California Campus Compact study on partnerships," San Francisco: California Campus Compact, San Francisco, CA, Apr. 2007. Accessed: Sep. 21, 2024. [Online]. Available: https://compact.org/resources/community-voices-a-california-campus-compact-study-on-partnerships-final-report

[8] D. E. Collins, A. T. Weinbaum, G. Ramón, and D. Vaughan, "Laying the Groundwork: The Constant Gardening of Community—University— School Partnerships for Postsecondary Access and Success," *Journal of Hispanic Higher Education*, vol. 8, no. 4, pp. 394–417, Oct. 2009, doi: 10.1177/1538192709347848.

[9] J. Tudge and S. Scrimsher, "Lev S. Vygotsky on Education: A Cultural-Historical, Interpersonal, and Individual Approach to Development," in *Educational Psychology: A Century of Contributions: A Project of Division 15 (educational Psychology) of the American Psychological Society*, B. J. Zimmerman and D. H. Schunk, Eds., New York: Routledge, 2014, p. 22. doi: 10.4324/9781315734255.

[10] B. Jordan and A. Henderson, "Interaction Analysis: Foundations and Practice," *Journal of the Learning Sciences*, vol. 4, no. 1, pp. 39–103, Jan. 1995, doi: 10.1207/s15327809jls0401_2.

[11] R. Collins, "On the Microfoundations of Macrosociology," *American Journal of Sociology*, vol. 86, no. 5, pp. 984–1014, 1981.

[12] F. Erickson, "Definition and Analysis of Data from Videotape: Some Research Procedures and Their Rationales," in *Handbook of Complementary Methods in Education Research*, J. L. Green, J. Green, G. Camilli, P. B. Elmore, and P. Elmore, Eds., Oxford, UNITED KINGDOM: Taylor & Francis Group, 2006. Accessed: Sep. 06, 2024. [Online]. Available: http://ebookcentral.proquest.com/lib/purdue/detail.action?docID=446575

[13] S. K. Ahmed, “The pillars of trustworthiness in qualitative research,” *Journal of Medicine, Surgery, and Public Health*, vol. 2, p. 100051, Apr. 2024, doi: 10.1016/j.glmedi.2024.100051.