

Increasing Commuter Students' Sense of Belonging with Situated Learning in a First-year Computer Programming Course

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This study examines the impact of a situated learning class framework on student learning and sense of belonging in a first-year introductory computer programming course offered at an urban commuter campus. The framework provided students opportunities to engage in hands-on activities embedded in authentic contexts facilitated or led by students from computer science clubs and a service-learning program. Our results suggest that 1) participation in peer interactions within the classroom helped students build learning communities and networks beyond the classroom and strengthened their development of a professional identity; 2) through redesigning curriculum and pedagogy to accommodate students' needs and learning styles, college and university faculty may cultivate a collaborative culture and a sense of belonging at various levels: classroom, department, and campus.

INTRODUCTION

This research is motivated by the need to engage and retain first-year computer science undergraduate students at an urban commuter campus. According to the U.S. Bureau of Labor Statistics, the demand for computing talent is projected to grow 15% from 2021 to 2031, much faster than the average for all occupations. This increase is expected to result in about 682,800 new jobs over the decade, and about 418,500 openings each year are projected to come from growth and replacement needs (U.S. Bureau of Labor Statistics, 2023). At the same time, diversity in the computing workforce needs significant improvement. In 2020, only 3.74% of the total 53,722 computer science degrees awarded went to Black or African American students, and 8.49% went to Hispanic students. At the bachelor's degree level, 82.4% of degrees awarded went to men, 17.6% to women, 2.8% to Black or African American men, and only 0.8% to Black or African American women (Data USA, n.d.).

A particularly challenging point in the path to careers in computer science comes in the first year of college. In the U.S., the retention rates for part-time first-year Black and Latinx students in 2021 were 38.2% and 46.6%, respectively ((*Persistence and Retention – 2021 Appendix (XLSX)* | *National Student Clearinghouse Research Center*, n.d.). At the urban commuter campus where we conducted this study, only 28.6% of the first-year computer science and information technology majors who took their first programming course in Fall 2021 enrolled in the required next-level programming course in Spring 2022. According to the literature, engaging and strengthening first-year students' science identity and sense of belonging is crucial to retention (Freeman et al., 2007; Jacobs & Archie, 2008).

A commuter student typically refers to any student who lives off campus or does not live within institutionally owned housing (Holloway-Friesen, 2018). A commuter student is also more likely to be a non-traditional-aged student (over age 25) or a part-time student (Whitten et al., 2020). On the urban commuter campus where we conducted this study, part-time students comprised 75% of the Spring 2023 enrollment, of which 55% were Black and 22.8% were Latinx. Researchers have noted that there is a dearth of literature investigating the transition and adjustment processes of commuter students of color after the 1990s; mean-

while, the proportion of commuter students in the U.S. college student population has been growing rapidly (Holloway-Friesen, 2018; Kodama, 2015).

It is widely recognized that commuter students bring unique and complex challenges. Such challenges often include longer work hours, additional family obligations, and longer distance or travel time to campus (Holloway-Friesen, 2018; Whitten et al., 2020). Involvement with campus becomes more unrealistic for commuter students as these other challenges compete for their attention. There is also evidence that commuter status is often associated with poor outcomes in degree completion and psychological well-being (Holloway-Friesen, 2018).

Engaging and retaining first-year commuter students is crucial for broadening participation in computing. We tackle this problem by examining the impact of a situated-learning class framework on first-year commuter students' learning and sense of belonging in an introductory computer programming course.

THEORETICAL FRAMEWORK

Situated Learning Theory

Situated learning theory (SLT) posits that knowledge is a product of the activity, context, and culture in which it is obtained, developed, and used, resulting from the learner's interactions with the environment (Brown et al., 1989). Knowledge needs to be presented in a personally meaningful situation so that the learner can see the relevance of the school curriculum to their personal goals (Chen et al., 2022). In addition, for knowledge to be useful, students should be able to re-contextualize abstract concepts into specific problem situations (Roberts & Sayer, 2017). Teaching based on SLT facilitates the transfer of school knowledge to authentic contexts where knowledge is most likely useful. Teachers may need to redesign their classroom settings to resemble authentic contexts that students would likely encounter in real life, such as homes, communities, and workplaces (Catalano, 2015; Chiou, 2021).

Situated learning emphasizes the importance of providing novices with intensive firsthand and tangible experiences and is often coupled with problem-based learning, experiential learning, and learning by doing (Abril & Robinson, 2019; Chiou, 2021; Wang et al., 2021). Situated learning often adopts a "hands-on" education

modality that employs physically embodied pedagogical agents to involve students' whole bodies (Al Hakim et al., 2022). For example, in a study, Al Hakim et al. found in a robotics education course that students who were given opportunities to interact with physical robots outperformed students who interacted with robots in a virtual environment and those who did not interact with robots at all. In situated Learning, learners are at the center of knowledge generation, constantly connecting new information with their previous knowledge (Lave & Wenger, 1991). They co-construct knowledge mentally or cognitively through social interactions and collaborations in the classroom (Vygotsky, 1978).

Lave and Wenger (1991) characterize the social process of situated learning as legitimate peripheral participation (LPP), which describes how newcomers in an apprenticeship system become experienced members and eventually old-timers of a community of practice. For example, LPP allows beginning learners to participate from the periphery of a learning community when they have little experience or knowledge related to a collaborative project. At least one expert, usually the instructor and possibly more capable peers, is accessible to the peripheral member. In other words, some students may learn from others; others may have opportunities to mentor peers. As beginners gain more confidence by accumulating more experience or knowledge, they can become full participants in the learning community, including taking on leadership roles or becoming mentors.

Stein (1998) identified four critical elements of a situated learning environment: content, context, community of practice, and participation. Based on the work of Stein, Pérez-Sanagustín et al. (2015) defined the four elements as:

- Content: the tasks and processes that learners have to perform,
- Context: the situations and environmental cues surrounding learners,
- Community: the group of people with whom learners communicate to create negotiated meanings,
- Participation: through which learners become the center of the learning process, working together with others in their communities. (p. 71)

Situated Learning has long been investigated by the Scholarship of Teaching and Learning (SoTL) community. Herrington and Oliver (2000) identified critical characteristics of a situated learning environment, designed a multimedia program with these characteristics, and investigated students' perceptions of their experiences in this program. Their findings suggested that the situated learning framework appeared to provide effective guidelines for designing an instructional environment for advanced knowledge acquisition. Rathburn (2015) examined how contextualization influenced students' abilities to build connections between their learning and their lives and suggested that contextualization combined with reflection allows students to express their knowledge and apply it to novel situations. Contextualization was defined as connecting academic skills to specific content that is meaningful and useful to students in the context of students' past experiences, future careers, or interests. Another study on teacher education found that employing a contextualized learning approach, such as situated learning theory, can close the gap between higher education and the real world and successfully prepare students for the teaching arena (Green et al., 2018).

Sense of Belonging

According to Goodenow and Grady (1993), sense of belonging is "the extent to which students feel personally accepted, respected, included, and supported by others in the school social environment" (p. 80). Strayhorn (2019) found that sense of belonging and academic involvement (Astin, 1984) form a positive feedback loop and can mutually enhance each other. A student with a sense of belonging is more likely to invest time and energy in academic, co-curricular, and extra-curricular activities. On the other hand, if a student is more involved in these activities, they are more likely to build a sense of belonging through their involvement.

Tinto's (1993) early work on persistence points out that students persist in higher education when they become integrated in two ways: academically and socially. Academic integration is often marked by developing an interest in learning, whereas social integration usually means forming relationships and networks outside the classroom. Tinto (1998) also emphasized academic integration over social integration and believed that involvement in the classroom could be "a vehicle for involvement beyond the classroom" (p. 169), e.g., meaningful relationships formed through collaborative learning in classrooms may extend beyond the classrooms.

Moreover, Tinto (2006) pointed out that when too much emphasis was placed on contacts outside of class, well-intended policies for promoting sense of belonging may inadvertently favor more privileged students who can afford to live on campus and have more leisure time to engage in campus activities. Research has shown that, for most commuters and other non-traditional students, social integration is not a priority for them. Since their primary goal is often to obtain a good grade that will lead to post-graduation employment, participation in social activities such as sports and leisure activities is undervalued by commuter students and seen as of little relevance to them (Hunt & Loxley, 2021). Instead, socialization integrated with academic interactions can more effectively cultivate a sense of belonging among commuter students.

Thus, sense of class or department belonging can be more important than university-level belonging for commuter students. Freeman et al. (2007) found that while university-level belonging is more related to social acceptance, students' academic self-efficacy and intrinsic motivation are closely related to class-level belonging, which in turn is linked to the instructor's warmth, openness, organization, and encouragement. In a case study of five scholarship recipients in physics and chemistry, Kang et al. (2023) found that academic involvement (e.g., academic club membership, research groups) and classroom experience played a more important role than social acceptance in the scholars' decision to stay with or leave their department. All five scholars in their study decided to stay with the university, but only two chose to remain in their field of study or department. The authors concluded that department-level retention and college-level retention are likely to be influenced by different factors, and social acceptance may have a stronger impact on college-level retention but is not adequate for department-level retention. However, empirical studies on the association between teaching practices and classroom or department-level belonging are rare (Knekt et al., 2020).

Sense of belonging has recently attracted the attention of the SoTL community. Adler-Kassner et al. (2022) investigated how students experienced a sense of belonging in in-person and virtual learning environments to inform faculty and staff prac-

tices. They found that connections with instructors and peers contribute to students' sense of belonging. They recommended that university educators use the community of practice framework to guide teaching practices and intentionally create opportunities for students to collaborate and participate in teamwork.

In another study, scholars of teaching and learning examined an academically oriented peer-mentoring program at St. John's University (Hall et al., 2020). The program matched at-risk students with difficulty transitioning to college with trained student mentors within their major discipline to increase the first-year students' sense of belonging, GPA, and retention. Their findings confirmed the at-risk students "felt an increased sense of belonging at the university over the course of the program, and they were retained at a higher rate than were the students who qualified for the program but chose not to participate" (p. 195).

This study examines the impact of a situated-learning class framework, which we designed for a first-year introductory computer programming course to increase commuter students' sense of belonging and retain first-year students within the computer science program. We systematically investigated student learning experiences to answer the following questions:

1. **How does the implementation of a situated-learning pedagogy affect first-year computer science students' learning experiences in an introductory computer programming course?**
2. **How does the implementation of a situated-learning pedagogy affect first-year computer science students' perceived sense of belonging to an introductory computer programming course and to the computer science department?**

METHOD

The Course Design

We designed a first-year computer science situated-learning class framework (see Figure 1) and implemented it in Computer Science I (CS I), the second introductory course in computer programming required for the bachelor's programs in the Computer Science Department. This fifteen-week course met twice a week, each time for a one-hour and twenty-minute lecture followed by a fifty-minute lab. The topics of this class included Java structure, selections, loops, methods, objects, and classes, which were fundamental to the students' success in subsequent courses. Students of two computing clubs in the department, the Association of Computing Machinery (ACM) and ACM-Women (ACM-W), and the Excellence in Computing and Information Technology (ExCITE) service-learning program led the situated-learning activities in this class.

Our framework focused on three aspects: a) situating course content in activities, b) creating authentic contexts, and c) situating learning in relationships to build a departmental learning community and encourage active participation. We explain each of them in the following paragraphs.

Situating content in activities.

Author I designed activities to embody CS I concepts in real-world applications, such as robotics and hands-on workshops that encourage problem-solving, creativity, experimentation, and inquiry.

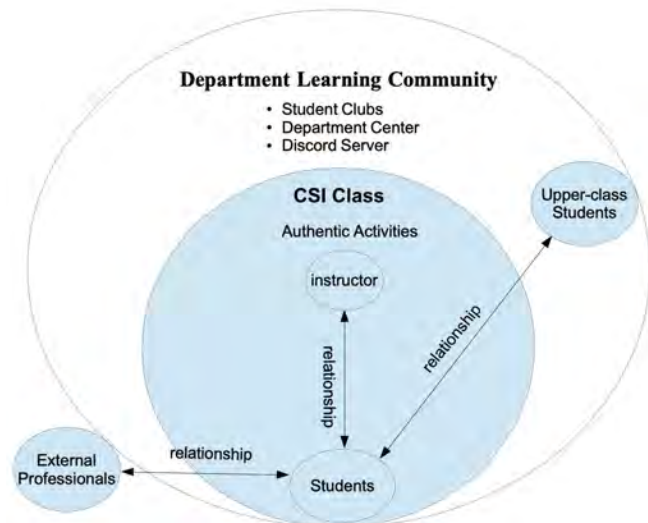


Figure 1. First-year Computer Science Situated-Learning Class Framework

Creating authentic contexts

To create a personally authentic learning context, Author I selected 1) activities that reflected students' interests, identities, and backgrounds (personal authenticity) and 2) student presenters/facilitators with diverse backgrounds (e.g., sophomore, junior, senior, male, and female, from outside of or within the class). In selecting these activities, she also carefully considered mirroring the practices of the communities of computing professionals (professional authenticity).

Situating learning in relationships

She also invited ExCITE presenters, who were upper-class students, to demonstrate these applications and offer hands-on workshops during the C.S. I lab sessions. She worked with the clubs to invite their representatives to the CS I class and arranged club events, such as a computer take-apart event and a robotics programming workshop, immediately after the CS I class to maximize student participation. CS I students were encouraged to join the clubs and the ExCITE program during these events. Sample enrichment activities are shown in Table 1, along with a brief description of each activity. In addition, a computer take-apart event and a robotics programming workshop are featured in Figure 2 and Figure 3, respectively.

A Department Community Center was established with both in-person and virtual spaces to build relationships further. The in-person space was a lab equipped with a projector, a whiteboard, five desktop computers, and miscellaneous computing equipment and supplies, such as various robots and electronic parts. The two ExCITE work-study students were assigned lab hours to keep it open. Access to the lab was also given to the ACM and ACM-W club officers, who were responsible for coordinating events in the Center and sending out announcements.

Author I created a social media group on Discord (an app that allows voice, text, and video chat in an online community; also see <https://discord.com/>), where she hosts the following text channels for resource sharing and discussions: ACM, ACM-W, ExCITE, CS I, scholarships, conferences, internships, learning resources, competitions, mentoring, etc. Author I invited the CS I students to join the virtual space by a shared link. Two student leaders were assigned as officers of the server and allowed to

Table 1. Summary of Sample Enrichment Activities Presented by ExCITE Program or ACM/ACM-W Members							
Activities	Description	Fall 22		Spring 23		Fall 23	
		Held	In class	Held	In class	Held	In class
A.I. and Dance Workshop (45 minutes)	Students experiment with software that detects, through a camera, their body movements and generates the corresponding visual effects using Artificial Intelligence (A.I.) computing.	X	X	X	Partial		
Edison Robot Demo (20 minutes)	This demonstration shows how a robot follows the torchlight of a cellphone, illustrating how loops and branches in programming can be used to make robot movement decisions.	X	X	X	X	X	X
Lingo Project Demo (20 minutes)	This demonstration shows how a program allowed a micro-controller to detect objects with an ultrasonic sensor, turn on a light, and sound an alarm, similar to how an auto-driving car avoids obstacles.	X	X				
Computer Take-apart Event (50 minutes)	In this event, students work together to figure out how to disassemble used computers and identify the parts.	X	X	X	X	X	X
Robot Programming Workshop (50 minutes)	In this workshop, students learn how to program a robot (e.g., GiggleBot, Edison Robot).	X	X	X	X	X	X
Cryptologic Museum Presentation (50 minutes)	This is a virtual seminar on women's role in cryptography history.			X	Partial		
Microbit Programming (50 minutes)	This hands-on activity helps students understand the array concept by programming microbits, which are minicomputers with arrays of LEDs that can light up according to the code they execute.			X	X	X	X
Mini Meet & Greet (duration varies)	CSI I students meet ACM and ACM-W club members and graduate students.			X	X	X	X

create new channels. Both faculty and students on the Discord server can post messages.

Figure 1 shows the above contextualized SLT practices: the CSI I class is situated in the Department Learning Community and supported by the student clubs, the department community center, and the Discord server. The class contains authentic activities, facilitating students in developing relationships with not only the instructor but also the upper-class students and external professionals to increase students' sense of belonging.



Figure 2. The Computer Take-apart Event

Participants

The study was based on semi-structured interviews with 15 students at a Historically Black College & University (HBCU) in the mid-Atlantic region of the United States, following an approved institutional review board protocol. During the Spring and fall of 2023, an invitation to participate in an interview concerning their experiences and opinions of the Computer Science I course was

sent out to three classes of students who were enrolled in the course during the fall of 2022, spring of 2023, or fall of 2023 (38 students in total). All students who replied within a given time frame were included in interviews. In total, 15 students, 5 females and 10 males, participated in the study. All students were first-year students majoring in computer science. Fourteen students identified themselves as Black or African American, and one as White. Six students were international Black students. Three students were nontraditional-aged (25 years or older). All but one student were full-time students. Since the course allows students to attend classes online, four students chose to take the course as a blended or hybrid course, and the rest took the course entirely in person. All students lived off campus since the study was conducted on a commuter campus.

All 11 students who attended the course in Fall 2022 passed it (C or above), and 3 of the 11 students participated in this study. Among the 19 students who attended the course in Spring 2023, 14 passed it, 1 failed it, and 4 dropped it. Out of the 19 students, 8 participated in this study, and all 8 participants passed the course. All 8 students who attended the course in Fall 2023 passed it, and 4 out of the 8 participated in this study.

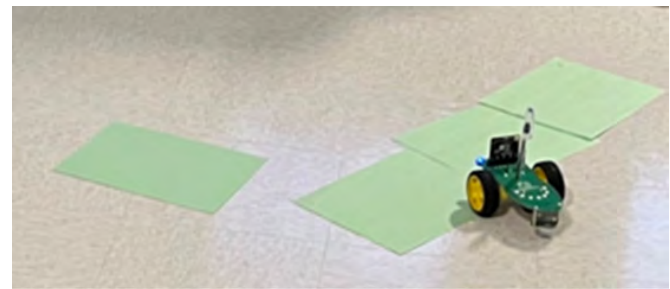


Figure 3. A GiggleBot Roaming and Drawing Lines on Pieces of Paper during a Robotics Workshop

Interviews

Interviews were conducted in early May 2023 for the Fall 2022 and Spring 2023 students and December 2023 for the Fall 2023 students. The aim and structure of the interviews were clearly explained to the students. The second author, who had no connection with the course, conducted the interviews in May 2023; Author 1 and the course instructor conducted the interviews in December 2023. Informed consent was obtained from all students. Although Author 1, as the course instructor, interviewed her own students, the responses between the students interviewed in May and those interviewed in December revealed no apparent bias.

We used focus-group interviews and followed the guidelines of Bloor et al. (2001) and Puchta and Potter (2004). Each focus group involved 3-4 students. The three Fall 2022 students formed a focus group (Students 1-3). The eight Spring 2023 students were divided into two groups, each including four students (Students 4-11). However, one student missed the interview and was interviewed individually (Student 11). The four Fall 2023 students formed a focus group (Students 12-15). All the interviews lasted from 30 to 60 minutes. They included questions about the various aspects of the situated-learning pedagogy implemented in the course and questions related to students' motivation, self-efficacy, goals, and sense of belonging. Sample interview questions appear below:

- Do you find the presentations/workshops conducted by the ExCITE Program students helpful? Why or why not? If helpful, in what ways? If not, please explain why.
- Would you please tell me about your confidence in your ability to do well in this course at the beginning of the course? Why did you feel that way? What about at the end of the course? Is there a change in your self-confidence? If yes, are there any key events or activities that led to this change?
- What are some frequent feelings when you come to the computer science department? Would you please elaborate?
- Do you feel you belong to the department? Why or why not? Do you think your sense of belonging to the department is related to your academic learning, for example, your success in this course? Why or why not?

Thematic Analysis

Interview data were analyzed using thematic analysis (Braun & Clarke, 2006) and aided by the ATLAS.ti.9 software. First, each interview was transcribed verbatim using a standard online transcription service. Author 1 read all transcripts while listening to the interviews to account for any errors in the transcription.

In the first round of coding, inductive, open coding was applied to search for themes in the data (Saldaña, 2016). Although we mainly relied on inductive coding, we also used key concepts in the situated learning and sense of belonging literature (e.g., cognitive apprenticeship, legitimate peripheral participation, embodiment, identity, motivation, self-efficacy, goals, and sense of belonging) as sensitizing concepts (Charmaz, 2002, p. 259) that alerted us to the important aspects of the data. We did not impose them onto our data because we wanted to have an authentic account of the students' perspectives and to contrast them with the key elements in the theoretical literature (Glaser, 1978; Knekta & McCartney, 2021; Patton, 2002). This round of coding focused on explicit meanings of the data.

Both authors coded all data. Each author individually organized the codes into groups of similar codes, which were then organized into subthemes and themes in the subsequent rounds of coding. The themes were discussed and compared, and a common thematization was agreed upon. Before the consensus was reached, the inter-coder agreement was about 80%. Based on the common thematization, the second author re-coded all interviews to refine the themes further. Finally, both authors reviewed and debriefed again to validate the final themes.

RESULTS

The inductive coding resulted in six main themes. The first three themes focus on answering the first research question. The last three themes address the second research question. Each of these themes will be described and supported with quotations. Each interviewee is represented by at least two quotes except for Student 12, who is represented by one quote because the student hardly spoke up during that focus group interview.

Theme 1: Enrichment activities helped students learn the content of the course.

All the students shared with us that they enjoyed the enrichment activities and believed that the activities helped them understand the concepts they had learned from the course. When asked why the enrichment activities were helpful, students gave various reasons. The first main reason was that the enrichment activities were carefully aligned and connected with the course content. For example, one student explained the connectedness below:

They're relevant to the topic that we're doing during the week. So, if we're looking at *for loops*, we looked at how some of the robots use *for loops* to have the robots do certain things. The last thing we did was, well, we're doing *arrays*, and we're able to create or make a program that uses the same concept to light up and do some other stuff so that it helps. (Student 10)

The loop concept appeared to be challenging to most students. Therefore, during the interviews, students showed a lot of appreciation regarding how the demonstrations improved their understanding of loops. Here is another example: "That's so helpful. It gives us some new information ... I don't have any idea how to move on the robotic. But after that day, I know something for *loop*, using *for loop*" (Student 13).

The second main reason for the helpfulness of the enrichment activities was that these activities enabled the students to see how concepts could be used in real-life situations. Many students felt that using the concepts they learned from the course or seeing how they could be used in real life reinforced the concepts and helped them grasp the concepts more, especially when some of the concepts could be complicated at first. For example, one student reflected: "It shows how to actually act as a user of it" (Student 8). Several other students shared similar thoughts: "I think it helps us apply what we learned in class rather than just constantly reading it, how it's like, it helps us be able to apply it in real life" (Student 4), and, "I thought it was hard. But you know, when I see everything, it's not that hard" (Student 12). Some students were also able to relate the demonstrations they saw with another real-life example that was familiar to them.

The third main reason given by the students was due to the hands-on and embodied nature of these activities. For example,

one student preferred “actually physically” doing the activities themselves “compared to watching a video, or just on a virtual lab” (Student 4). They elaborated further:

We’ve seen pictures of it, but we haven’t physically seen it in person and anything hands-on. So, I feel like that’s not beneficial for me because when it’s time for me to apply this in real life, I’m gonna be lost compared to if I was doing a lab while I’m learning this subject. I’ll be able to have more confidence in what I’m doing and be able to apply it much better. (Student 4)

The hands-on activity that seemed to be the most well-received by the students was the computer take-apart activity. During their interviews, many students described this activity very positively. For example, one student said: “I learned a lot from that experience. So, I think that’s the hands-on learning ... will be more of a help to me than just actually sitting in a lab or lecture” (Student 8). Another student concluded: “We’re able to physically do it hands-on. It’ll be better for us to understand better, and I feel like that will help students gain confidence overall” (Student 4). This student went further to express the desire for more lab classes and more in-person class offerings. Other students also shared their perceived benefits of hands-on experiences in a computer science class, for example: “I feel like one being able to see things hands-on and do things hands-on makes it a lot more tangible. It makes it a lot less intimidating for you, like to do on our own or in the future” (Student 11), and “I was intimidated when the class started. I’m afraid ... for the beginning. But right now, I’m feeling so excited. And I’m learning so many things” (Student 13).

Although all the students we interviewed found the enrichment activities enjoyable and helpful, we also received some feedback regarding how to improve the student experience. For example, the lack of organization undermined the effectiveness of one of the enrichment activities for the Fall 2023 class. One student said, “If it had been more organized, then it probably would’ve been a little bit different. It would’ve probably made sense” (Student 14).

Theme 2: Enrichment activities motivated students to learn computer science.

Students found the enrichment activities motivating and inspiring, making them want to know more about computer science and keep going. The activities motivated these students in two ways. First, some students told us that the activities made them see the relevance or importance of computer science in real life and were eye-opening to them. For example, one student shared with us that the enrichment activities exposed them to so many applications of computer science and described the ubiquity of computer science in everyday life as: “I realized that everything in this world has something to do with a computer like clearly, even though you might not know what to do, and I just find it really intriguing. And I would like to learn more about it” (Student 7). Another student, impressed by the microbit activity, shared some similar thoughts; they reflected: “I grew because I was able to learn there are more aspects of computing that I didn’t think about,” and then added: “It gives me more understanding of the different paths that having a computer degree can offer So, it increases my choices that I can go to after college” (Student 9). Even a student who had more previous experience with computer science appreciated how the

enrichment activities broadened their horizon: “I would say my interest or excitement level slightly grew just because of the fact that even though the Edison robot was, you know, a fairly basic thing, also the A.I. and Dance app that we looked at, it just shows you kind of a glimpse into real-world applications” (Student 5).

The second way the enrichment activities influenced student motivation to learn was by generating excitement and enjoyment. These positive emotional responses often piqued students’ interests and curiosities in computer science. For example, a couple of students described their first-time experience with excitement and joy: “I had never seen anything like that before, and it made me kinda get interested in wanting to learn more about it” (Student 2). Another student elaborated on a specific experience:

Like the takedown of a computer, that was my first time ever doing, actually seeing the inside of what a desktop looks like, or like the motherboard. I’ve never physically seen that in person. So, I found that to be very exciting. So, yes, I feel more engaged in what I’m learning. (Student 4)

Theme 3: The instructor’s support is part of the situated-learning pedagogy.

This is a somewhat unexpected theme because none of our interview questions directly asked about the course instructor. Students volunteered their opinions about their course instructor. The reflections on the various activities were often interwoven with descriptions of their instructor.

For example, one student shared that the students in the class once suggested that their course instructor modify how she taught the course. Then, the student expressed deep gratitude by saying, “She actually did take our criticism, and she applied it. And I think she found it beneficial. And I know I found a bit of patience ... We have a professor that listens. It makes you feel more welcome in the class” (Student 4). Another student confessed that they were sometimes uncomfortable asking questions during classes and especially felt scared if another student had already asked a question. But they emphasized: “I am okay asking her a question, even if I ask the same question” (Student 7).

Students considered an instructor’s effort to tailor a course to their needs as a sign of caring and high expectations. They obviously noticed their course instructor’s effort to enrich their educational experience and often related this effort with the general caring attitudes demonstrated by their instructor.

Theme 4: The situated-learning pedagogy helped students build meaningful relationships and a sense of belonging both inside and outside the classroom.

Some students were able to build meaningful relationships beyond this course after the presentations by the ACM and ACM-W members. For example, one student got to know another student from the ACM club after a presentation and later was able to receive help from the ACM student:

So, now that he came, and he introduced himself, and he was a part of the workshop. Like this one time, I had an issue. And I went to him ... And he did help me. So, I say it’s really good to know people in your field. Yes. Because you can always reach out for help. (Student 15)

Later, this student volunteered to give a presentation themselves, and the ACM student helped them prepare their presentation on robotics and with their resume.

A non-traditional-aged student expressed gratitude about receiving help from ACM members: “It made me feel like I had a big challenge that I needed to overcome. And after I got into it and got meeting younger people ... had helped me a lot along the way, and I really appreciate them” (Student 2).

Another student concluded:

I think it's very important that we have a community like that within the department. You know, for students, even if you're having problems in class, there's always someone above you that can explain or be hands-on with you about something that you don't understand. (Student 3).

Some students joined ACM and ACM-W after watching and participating in a few presentations and found their volunteer experience very rewarding. For example, one student shared:

I've learned more about my department; I've learned how different aspects of it, like different categories that computer science can lead me to ... Since I'm a freshman, it gives me more connection to my upperclassmen. So, I can ask them various different questions about the department and any classes” (Student 9).

A few other students also expressed a sense of belonging after joining the clubs. For example, one student said: “I feel I belong because I joined the ACM-W club, that I feel like I somewhat have a place here in the department” (Student 4). Another student said they enjoyed all the presentations given by the ACM or ACM-W members, but their favorite one was the one they gave after volunteering to work for ACM-W: “For me, it's the robotics one ... So that's the best one for me. And the fact that I got to present too.” They also confessed that “when I started this semester, I would consider myself stupid ... but now I'm like super confident. I would say I like this class.” They went on to describe their experience in this course as “like a U-turn for me” and that they were thinking about leaving the department at the beginning of the semester because all of their friends dropped out and they were left alone, “I'm giving it one last shot,” and finally: “But this semester she [the course instructor] changed my mind completely. Now I know that this is where I belong and I'm just ready to be a part and active” (Student 15).

Some students appreciated the networks they were able to build after the presentations given by the ACM or ACM-W members. For example, one of them told us:

Upper-class students basically come interacting with us. It provides a bigger network for us, gives you an opportunity to interact with those students, and kind of find out that they love it because they wouldn't be back here helping us out if they didn't enjoy themselves ... give their time to help us incoming students to better grasp concepts ... it gives you a network, you can add them on LinkedIn, or you see them on campus, you can talk to them, and you know, get help from them. (Student 10)

Another student admitted that they needed such a network by sharing with us:

That's the only thing I feel like I've been missing out ... not having a network of people who are in tech or STEM. I feel like there's like one or two people kind of in distant places

that I know that like work in tech, work in like computing, but other than that, I want to be constantly meeting people that are like in this field (Student 11)

For some students, upper-class students from ACM and ACM-W served as role models to them. Their impact is more emotional than practical; however, it is equally important, especially in building a sense of belonging.

A student shared how watching the demonstrations given by the upper-class students encouraged them to persist in the field of computer science: “Sometimes I would be like, I was ready to give up, but when I get to see stuff like that, it makes me get engaged. It makes me feel like I can keep going and I need to do something to keep moving on” (Student 2). Other students reported being able to experience success vicariously, for example:

I feel like that whenever you see people who are upperclassmen demonstrating it, you feel like you could see ... yourself doing it. You see how tangible it is for someone your age who's so new to technology to understand and work with it. (Student 11)

Some students also could see themselves in the upper-class students. For example, one student described their reaction as “You have people who you look up to ... I want to be like this person. I want to take this later in future. I want to take the role this person is taking” (Student 1). And this student indeed joined ACM after this course and even took on a leadership role.

One student who could not actively participate in some of the enrichment activities expressed a desire to be more involved. They described themselves as a typical commuter student:

I just haven't been very active in my department. Like what I've done for the most part for the last two semesters is go to my class, like, do the best to get the grade, and then kind of go back, because like I was saying, I live in XX, so every time I do come out to YY, I feel like I'm really making a T-track. And this semester, I haven't had a car, so it's like an hour of metro each day. (Student 11)

However, unlike some of the other students who were not able to participate, they recognized the significance of active involvement in the department:

I've been trying to get more into computer clubs ... I know it would definitely make me feel a lot more involved within our computer technology department. So, I've been trying to get more exposure to that. ... it takes you from being just a student to someone who's actually working on a team of people to do something ... (Student 11)

Theme 5: Physical and virtual spaces extended classroom-based learning communities, but were underused.

We received mixed responses regarding the Discord server's helpfulness. Some students responded very positively about the server. For example, one student said they would highly recommend it because it is “pretty helpful not only inside of school but outside of school too” (Student 7). Most students considered the server a space for exchanging information instead of collaborating. For example, one student said, “I find it to be very organized as well because exactly what you're looking for, they have a channel for it. I find this to be very easy to exchange information and get a quicker response as well” (Student 4).

Only a few students used the Discord Server to collaborate. For example, one student reported: “I use Discord as a study group between me and my peers” (Student 8). Two other students reported receiving help on the server. One shared, “If you have a problem, you can put it there in the chat. Someone is always there to help. So, the Discord Server is top in my opinion” (Student 3).

Quite a few students stated that they never or hardly ever used the server or just used it for a specific purpose. For example, one of them told us: “The last time I used it was to check out some pictures or whatever was going on in the clubs” (Student 6). Another told us: “I was there just making A.I. art, and then I used it for the class just to check the announcements and things like that” (Student 5). Another student gave their reason for not using the server: “It’s a lot of people I don’t know. It’s just intimidating” (Student 14).

Regarding using the computer labs as a physical space to work together, the responses from the students were also mixed. Those students who used the lab found it “quiet,” “safe,” and “spacious.” They loved the environment but mostly used it to study on their own. Only a few students, usually those who were actively involved in computer science clubs, used the lab for collaborative activities. One student also appreciated the lab as a common gathering place where they could always find help from different people: “I enjoyed being there. I get a lot of help from different people ... like doing the computer programming, and it’s very good” (Student 2).

Overall, although the lab and the Discord Server were intended to be used as a physical and a virtual space, respectively, to extend the classroom learning communities, they were underused by the students, especially for collaboration.

Theme 6: External factors beyond the instructor’s control influenced the level of participation.

Some students wished they could have participated in more activities, especially when an enrichment or co-curricular activity was offered outside of the classroom, for example, a computer science club meeting. However, the travel time and distance to the campus or their other work duties prevented them from participating. For example, one student who was already quite active in the school shared their desire to be more involved in the department: “The reason why I don’t participate as much is because I work. I’m part of student government, so I don’t really have a lot of free time to, I would love to, but I just, I’m kind of restricted” (Student 1). Another student told us their dilemma. While they found some of the activities were very beneficial, they were limited by the time it took them to get to the campus, which was usually over an hour. Finally, two students, even though felt the enrichment activities were interesting and relevant, did not consider the activities as very useful or important for them to learn the concepts. Both students emphasized that they were already self-motivated. For example, one student told us: “I think my enjoyment stayed the same. It was pretty high in the first place” (Student 6). One of them also suggested that learning with others was not their preference.

DISCUSSION

We redesigned a computer science introductory course based on SLT to create an environment that gives students more control of their learning and more opportunities for peer interactions. Our findings support SLT and contextualization because students reported better grasping of challenging concepts in computer programming when the concepts were embedded in authentic contexts that students would likely encounter in real-life experiences (Chiou, 2021; Rathburn, 2015). Our results also support the previous SoTL findings that situated learning provides effective guidelines for designing an instructional environment (Herrington & Oliver, 2000) and can close the gap between higher education and the real world (Green et al., 2018). Students also reported gaining more confidence in their learning after they were given opportunities to engage in hands-on activities during which physical robots and desktop computers were used as embodied pedagogical agents (Al Hakim et al., 2022). In addition, our results also support that when instructors show the relevance of the school curriculum to students’ future goals, academic activities become more enjoyable and exciting for students, encouraging them to exert more effort in learning (Pedler et al., 2022).

Our results show that SLT has intricate connections with students’ sense of belonging. Scholars in SLT and sense of belonging may benefit from each other by integrating their works. When our students noticed that their instructor was willing to modify the course curriculum and pedagogy to accommodate their needs and learning styles, they interpreted their instructor’s new strategies as a sign of caring (Freeman et al., 2007; Kirby & Thomas, 2022). Our situated learning pedagogy helped students build networks both inside and outside of their classrooms. Such networks benefited our students in multiple ways, such as receiving additional help beyond the classroom and being inspired by their peers to become presenters, mentors, and leaders. These results are consistent with Adler-Kassner et al.’s (2022) findings on the relationship between sense of belonging and connections with instructors and peers. Our situated learning pedagogy cultivated a collaborative culture that strengthened students’ sense of belonging to their program and their identities as future computer scientists.

Furthermore, our results support Tinto’s (1998) assessment that academic integration is probably more important than social integration, especially for commuter students. Consistent with those in previous literature (e.g., Holloway-Friesen, 2018; Whitten et al., 2020), most of the commuter students in our study did not consider social activities as a priority for them. Academic interactions in their classrooms were more critical for these commuter students to build learning communities. However, as suggested by Tinto (1998, 2006), academic interactions can drive social interactions and be extended beyond the classroom, and faculty often play a very important role in cultivating sense of belonging not only within their classrooms but also at the campus level. Our results are also consistent with that of Gravett and Ajjawi (2022). These authors found that some commuter students chose not to belong in a traditional way.

IMPLICATIONS FOR PRACTICE

We recommend our situated-learning pedagogical framework for computer science faculty. When using this framework, course instructors should carefully align and connect enrichment activities with the course curriculum ahead of time so that the activities

are truly co-curricular and support learning academic concepts. Furthermore, although some students may embrace academic clubs (e.g., ACM, ACM-W) and find additional physical and virtual spaces for communication helpful, instructors cannot assume that simply offering these opportunities will automatically extend the classroom learning communities. Notifications of events and activities may need to be posted in the building and online two or three days in advance. Instructors may also consider creating small and intimate virtual groups and ensure that students in their classes know this option. Students with opportunities to give a presentation or take on leadership roles in academic clubs are likely to feel a higher level of belonging to their major and campus. Therefore, instructors may consider involving more students in preparing and presenting enrichment activities.

Successful retention efforts are likely to start with the classroom (Tinto, 1998, 2006), and faculty's pedagogical choices significantly impact students' sense of belonging. Besides actively seeking professional development opportunities to diversify instructional strategies, faculty may also consider building learning communities to exchange ideas and create opportunities for meaningful conversations and collaborations.

LIMITATIONS AND FUTURE RESEARCH

The first limitation of this study is that our research was conducted at a single education institution and employed a small sample size. Although research based on interviews tends to offer in-depth information and unique insights into issues, it also limits our ability to generalize our results to other contexts.

Second, the participants of this study constituted a convenience and self-selected sample. Although we did not intentionally exclude any student, the four students who dropped the course and the one who failed the course in Spring 2023 did not respond to our invitation.

Third, not all students were interviewed after receiving their final grades. Only Fall 2022 students were. Spring and Fall 2023 CS I students were interviewed after 75% of their grades had been finalized but before their final grades were posted. In addition, the Fall 2023 CS I students were interviewed by the first author, who was also the course instructor. Although we did not detect any apparent bias in the interview responses from the students of Spring and Fall 2023, it was possible that some of them might have felt pressured to provide favorable responses due to concerns over their grades. To avoid possible coercion, future researchers should ask a colleague who is not the course instructor to conduct such interviews after all the grades are finalized.

Fourth, focus group interviews, although having some advantages, such as participants may "feed off each other" and generate richer data, often do not encourage equal participation among group members, despite the interviewer's sincere effort. In addition, some group members may not disclose certain information or true feelings due to peer pressure and concerns about social desirability. However, we believe this probably was not the case with the information we obtained in this study, as students were quite candid when offering both positive and negative reactions to their experiences related to the course. This could be attributed to the open, friendly, and caring relationship between the students and the course instructor. Nonetheless, we recommend that future researchers include multiple sources of data, especially individual interviews and quantitative data, to expand

our understanding of situated-learning pedagogy in computer science courses.

Fifth, it should be noted that it is widely accepted that the ideal size of a focus group is typically 6-8 people, and our focus groups included 3-4 students in each group. However, there is no set size for a focus group (Krueger & Casey, 2014). Larger and smaller groups each has its advantages and disadvantages. Larger groups sometimes do not give each speaker equal opportunities to contribute to the discussion. It is also possible that there is not enough time for speakers to provide detailed responses (Krueger & Casey, 2014). There are also logistic concerns when researchers form focus groups (Krueger & Casey, 2014). For example, in our study, we needed to keep the students in the same class together and students in the different classes apart due to their availability. However, smaller groups sometimes do not allow diverse opinions to emerge and may not give group members rich opportunities to feed off each other's responses (Krueger & Casey, 2014). Overall, we believe that our choice of using smaller focus groups gave us the advantage of respecting students' time while still allowing each student to participate equally and provide responses that were as detailed as possible. Future researchers may consider using larger focus groups and compare their results with ours.

We also want to point out that, despite the overall success observed in this study, the situated-learning pedagogy was not able to eliminate the influences of some of the external barriers that were beyond the instructor's control, such as travel distance or jobs as constraints that prevented students from more involvement. Additionally, more research is needed on how to involve students who are reluctant to join a learning community offered through SLT in computer science classrooms.

CONCLUSION

We redesigned a first-year introductory programming course based on SLT and offered students opportunities to engage in hands-on, minds-on activities embedded in authentic contexts. Students developed not only academic concepts and skills but also relationships that strengthened their sense of belonging to their department. Our computer science situated-learning class framework builds upon the current discourses within SoTL on sense of belonging and situated learning and expands them with a promising new way to increase commuter students' sense of belonging. We hope to provide computer science colleagues with a teaching and learning model that is replicable and adaptable in various educational settings and empower them to explore innovative practices that impact student learning and retention.

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