Linking First-year Computing Courses to Engage Commuter Students

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Abstract

Commuter students face unique challenges in integrating into college learning communities. Engaging with first-year commuter students became incredibly challenging after the pandemic forced learning communities to transform into virtual or hybrid environments. To address this challenge, we developed an approach to engage first-year commuter students in our departmental learning community. We linked two introductory courses, Computer Science I (CS I) and Foundations of Computing, with joint-curricular and extracurricular activities offered by sophomores, juniors, and seniors from student clubs and a service-learning program. Informed by the situated learning theory, our approach creates the context for the first-year students, the novice, to interact with the more experienced non-first-year students and develop their sense of community and belonging. Our surveys and interviews showed that the linked activities increased the students' sense of community, enjoyment of computing, and confidence in computing. Some first-year students established meaningful relationships with non-first-year students, joined student organizations, or became volunteer presenters.

Background and Motivation

A particularly challenging point in the path to careers in computer science comes in the first year of college. Nationwide, the retention rates for part-time first-year Black and Latinx students are 38.2% and 46.6%, respectively[13]. Engaging and strengthening first-year students' scientific identities and sense of belonging is crucial to retaining them, according to the literature [3] [8] [6]. Literature also shows that first-year college students with positive changes in university belonging have corresponding positive changes in self-perceptions (e.g., academic competence and self-worth) [15]. College students' sense of community has been directly linked to their persistence [8], satisfaction with the university, motivation, and perception of course value [6].

Commuter students face unique challenges in integrating into college learning communities. Engaging with first-year commuter students became incredibly challenging after the pandemic forced learning communities to transform into virtual or hybrid environments. There is an urgent need to investigate methods and activities that build communities on post-pandemic urban commuter campuses. However, there is limited literature on post-pandemic community building, particularly on urban commuter campuses of minority-serving institutions.

In this work, we developed an approach to engaging first-year commuter students in our departmental learning community on an urban commuter campus. We linked two introductory courses, Computer Science I (CS I) and Computing Foundations, with joint-curricular and extracurricular activities offered by sophomore, junior, and senior students from student clubs and a service-learning program. Informed by the situated learning theory [18], our approach creates the context for the first-year students, the novice, to interact with the more experienced non-first-year students and develop their sense of community and belonging. We developed hands-on activities tailored to the class syllabi to provide opportunities for the first-year students to meet each other and to observe and interact with non-first-year students, addressing the needs

of our commuter students, primarily underrepresented minority students, who are often first-generation college students and thus lack social capital in computing.

In the next section, we review the related works. We then explain our approach and evaluation methods. After that, we present our data collection and analysis, discuss our results, and draw conclusions. We end the paper with our future plan.

Theoretical Framework and Background Literature

As communities of practice, college learning communities facilitate the development of collaborative and academic support relationships through ongoing peer interaction [5]. Sense of community is the feeling that one is part of a larger, dependable, stable structure [16]. It is comprised of the following sub-factors: membership, influence, needs fulfillment, and emotional connection [11], [12], [14].

The authors of [17] presented a linked-course learning community in computer science majors for men of color and women (of any ethnicity) with "a variety of activities planned to facilitate the forming of an academic support group." They reported that "learning community students were more likely to indicate both pre- and post-quarter that they were a part of a community of programmers (as compared to students who did not belong to the learning community)," and "the change from pre- to post-quarter was both positive and statistically significant."

Situated Learning Theory (SLT) [18] defines learning as a process that takes place when learners participate in a community of practice, which includes participants of the community (i.e., the novices and the experts), the relationships between these participants, their identities, all activities, and artifacts. New learners reach the expert level as they have more opportunities to practice within the learning context. The learners move from the periphery of the community to the center as they gain expertise and engage and participate actively in the sociocultural practices of the community[7].

Figure 1. [7] shows the following components in the situated learning theory: 1) context, the environment within which the learning occurs; 2) novice, the learner and newcomer in the community of practice; and 3) experts, who know about the subject to be learned.

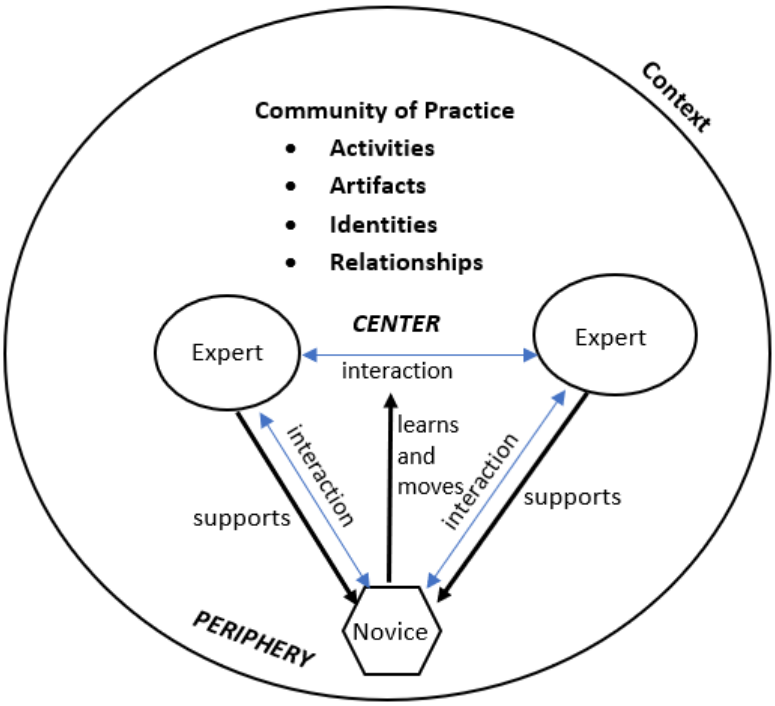

Figure 1. Model of Situated Learning Theory
(From "Situated Learning Theory" by Sandra P. Mina Herrera, used under CC BY 4.0)

In [2], the authors considered the traditional classroom to be decontextualized and discussed the applications of situated learning theory in computer science education and the challenges of doing so.

Approach

To increase the sense of community for underrepresented minority students, we designed and implemented a multipronged approach based on the situated learning theory. We linked two introductory computing courses, Computer Science I (CS I) and Computing Foundations, with joint-curricular and extracurricular activities offered by sophomore, junior, and senior students from student clubs and a service-learning program. We designed and implemented the following activities during Spring 2023 after analyzing the syllabi and schedules of both classes to expose the students to computing and engage them in our departmental learning community.

1) a joint seminar on AI & Dance presented by a junior student;
2) a joint seminar on women's role in cryptography history, hosted by the Department's student clubs, i.e., ACM (Association of Computing Machinery) and ACM-Women chapters, and presented remotely by the Cryptologic Museum; and
3) robotics workshops first presented by student participants of the ExCITE (Excellence in Computing and Information Technology Education) program, the Department's service-learning program.

To ensure the linked activities were relevant to the courses, the instructors met weekly to discuss the course content and learning outcomes of each course and to identify class time during the semester to have the activities.

Since activities outside class time are challenging to coordinate on a commuter campus to offer the joint events, we leveraged the overlapping class time between CS I and Foundations of Computing and the time immediately after CS I. The first two activities were offered during the Computing Foundations class time, which overlaps with the last twenty minutes of the CSI lab. The third activity was offered to these two classes separately during their respective meeting time. The CS I students were incentivized with extra credits to stay after their lab until the end of the seminars.

In our approach, ExCITE students and ACM officers serve as common contacts of students in these courses. A CS I student who was a new ExCITE volunteer presented at the foundation class.

- ***AI & Dance seminar***. Presented by a junior student using an off-the-shelf curriculum of AI4All Open Learning Curriculum [19], this seminar introduces how AI can be applied to dancing. During the seminar, students experimented with software that could detect, through a camera, their body movement and generate visual effects based on it. We chose this topic because AI is state-of-the-art computing and one of the hot topics these days. The interactive curriculum created a "wow" effect to spark students' curiosity. The workshop, including hands-on activities, discussions, questions, and answers, took about 45 minutes.

- ***Cryptologic Museum Presentation.*** In March 2023, the two classes jointly participated in an hour-long seminar on women's role in cryptography history, celebrating Women's History Month. This event was hosted by the Department's student clubs and presented remotely by the Cryptological Museum. It was open to not only CS I and Foundations students but also students in the ACM and ACM-W clubs. This extracurricular activity overlaps with the last twenty minutes of the CSI lab. Extra credits were given to students who chose to participate, either in person, on campus, or virtually. Twelve CSI and Foundations students participated, including one virtually.

- ***Robotics Workshops.*** We showed how a robot follows the torchlight of a cellphone, illustrating how loops and branches in programming can be used to make robot movement decisions. We chose the Edison robots to introduce programming concepts because 1) their simplified physical structure makes it easier for beginners to load software; 2) their website has quite a few interesting coding examples for students to explore; and 3) their coding examples are shown in both a block-based programming language and a language similar to python, which the CS I students had learned in a previous class. The first workshop was conducted in CS I by an ExCITE student. Nine CS I students participated; one became an ExCITE volunteer and led the second workshop in the Foundations of Computing class, where eight students participated.

Evaluation Methods

We chose the mixed-methods approach because it provides in-depth insight into the problem, i.e., the student needs we are trying to address. We conducted Pre-activities and Post-activities Surveys adapted from the College Sense of Community Scale survey [10] at the beginning before implementing our approach and at the end of Spring 2023 after implementation to collect quantitative and qualitative data. The surveys were created on Qualtrics and administered virtually. We also conducted group interviews to collect qualitative data at the end of Spring 2023. The qualitative data helped us understand the minority students' experiences and explore their perspectives.

1. **Adapted CSOC Survey.** We adapted the College Sense of Community Scale survey [10] to measure our participants' sense of belonging to the departmental learning community. The 14-item survey was derived from a 26-item instrument, and the survey designers conducted a factor analysis with a sample of 198 undergraduate students. The factor analysis yielded one large first-order factor (the only one with an eigenvalue greater than one) of 14 items [10]. Cronbach's alphas for the 14-item scale were 0.88 and 0.90 for two different samples of 98 undergraduate students [10]. When the 14-item survey was later given to a sample of 761 college students in another study, the reliability score was consistently high ($\alpha = 0.92$) [9].

   We kept all the survey items except for one but modified the questions to fit the departmental learning community instead of the entire campus. Before administering the survey, the research team, which consists of two computer science experts and one educational researcher, confirmed the face validity of the instrument. One item was considered irrelevant to the current study and, therefore, was removed from the instrument. A five-point Likert-style scale was used with choices ranging from "strongly disagree" to "strongly agree." The 13 items were summed to generate a single CSOC score ranging from 13 to 65. Survey questions can be found in Appendix A.

2. **Interviews.** The interviews were conducted 1) by the third author for the CS I class remotely in the presence of the first author and instructor of the course and 2) by the first author for the Foundations class in the presence of the second author and instructor of the course. Eight CSI students participated in two focus group interviews and one individual interview. Eight Foundations students participated in one group interview. All students were invited to the interviews, and participation was voluntary. The interview questions are listed in Appendix B.

Data Collection and Analysis

We collected both quantitative and qualitative data. Descriptive statistics and percentage increases were used to analyze the quantitative data. Thematic analysis [4] was used to make sense of the qualitative feedback. The qualitative data provides a sense of theoretical validation on the descriptive quantitative survey items, as it corroborated numeric results. Our project was designed as action research [1]; therefore, the result is not intended to generalize or be predictive. Additionally, our sample size is limited by the number of students enrolled in the classes. While the quantitative data indicates the effectiveness of our approach, inferential statistics were

deemed inappropriate due to the small sample size. Our results are summarized below.

1. **Quantitative Results.** Table 1 presents the sense of belonging survey result at the beginning of the semester before the linked-courses activities took place. At the time of the baseline survey, nineteen students were enrolled in CS I, and the response rate was 79%; eleven students were enrolled in the Foundations class, and the response rate was 55%.

Table 1. Comparison of CSI and Foundations Baseline Survey Results

#	Field	CSI Avg. (15 entries)	CSI SD	Foundations Avg. (6 entries)	Foundations SD	CSI and foundations difference	difference percentage of the scale
1	I really feel like I belong here	4.20	0.77	2.33	1.03	1.87	37.3%
2	There is a sociable atmosphere in the department	4.27	0.80	2.00	0.89	2.27	45.3%
3	I wish I had gone to another department instead of this one (R)	2.87	1.36	2.83	1.17	0.03	0.7%
4	I feel I can get help if I am in trouble	4.20	0.68	2.33	1.21	1.87	37.3%
5	I would recommend this department to students in my high school	4.20	0.77	3.50	1.05	0.70	14.0%
6	There is a strong feeling of togetherness in the department	3.93	0.70	1.67	0.82	2.27	45.3%
7	I someday plan to give alums contributions to this department	3.67	0.90	3.33	1.21	0.33	6.7%
8	I really enjoy being in this department	4.13	0.52	3.17	0.98	0.97	19.3%
9	Students here really care about that happens to this department	3.87	0.52	2.50	1.05	1.37	27.3%

10	I feel very attached to this department	3.33	0.90	2.33	1.51	1.00	20.0%
11	Campus life offered by the department is very stimulating	3.00	1.00	1.83	0.98	1.17	23.3%
12	If I am/were going to college next year, I would continue with this department	4.20	0.77	4.17	0.98	0.03	0.7%
13	There is a sense of community here	3.67	0.62	1.67	1.03	2.00	40.0%
Total adapted CSOC		49.53	4.96	33.67	6.44	15.86	47.1%

We can see that there is a difference between the averages of the sense of community of these two classes. For CS I, the averages of all the items were above the mean of the scale (3.0). This finding indicates that the CS I students overall had a high sense of community at the beginning of the semester. For Foundations, nine out of the thirteen items were lower than the mean of the scale (3.0). The averages of all items in Foundations are lower than those in CS I. The most significant difference on average was for a) “I wish I had gone to another department instead of this one (Reversed), b) “I would recommend this department to students in my high school,’ and c) “There’s a real sense of community here.” However, due to the small number of responses from the Foundation students, we cannot safely conclude that the Foundations students overall had a lower sense of community at the beginning of the semester compared to CS I students. We do hypothesize that Foundations students, usually first-semester students, may have a lower sense of community compared to CS I students, who are usually second-semester students.

Figure 1 shows a visualization of the differences in Table 1.

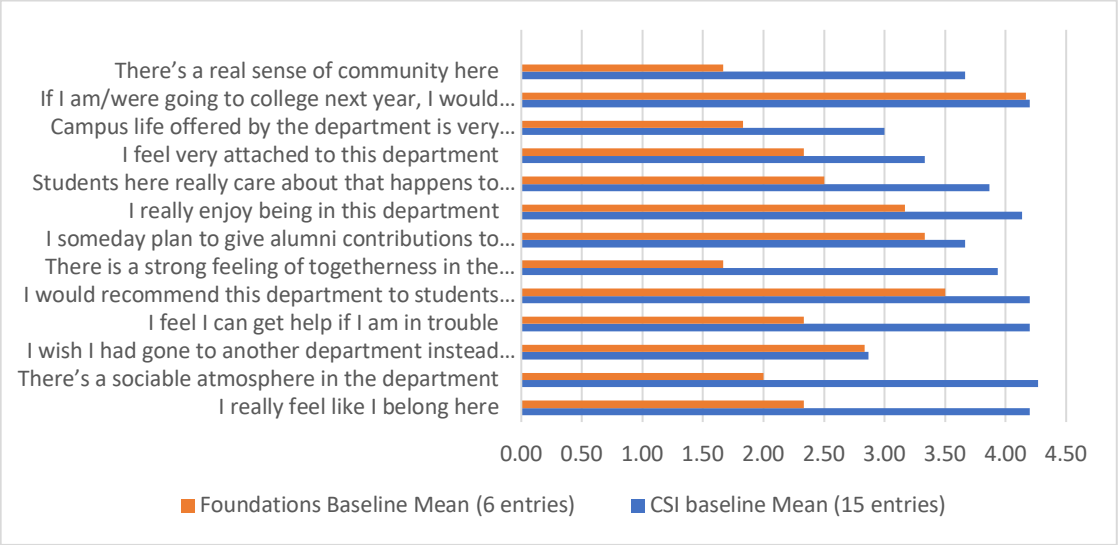

Figure 1. CSI vs. Foundations in the Adapted Collegiate Sense of Community

At the end of the semester, we only collected survey data from CSI students. Fifteen CS I students remained registered when the end-of-semester survey was conducted, and the response rate was 60%. The result is presented in Table 2.

Table 2. Changes of Adapted Collegiate Sense of Community (CSI Only)

(R) indicates reversed scoring.

#	Field	Baseline Mean (15 entries)	Baseline *SD*	End-of-semester Mean (9 entries)	End of semester *SD*	End-of -semester Mean change	End-of-semester Mean change %
1	I really feel like I belong here	4.20	0.77	4.33	0.50	0.13	3.2%
2	There's a sociable atmosphere in the department	4.27	0.80	4.11	0.78	-0.16	-3.7%
3	I wish I had gone to another department instead of this one (R)	2.87	1.36	3.44	1.01	0.58	20.2%
4	I feel I can get help if I am in trouble	4.20	0.68	4.11	0.33	-0.09	-2.1%
5	I would recommend this department to students in my high school	4.20	0.77	4.33	1.00	0.13	3.1%
6	There is a strong feeling of togetherness in the department	3.93	0.70	3.89	0.78	-0.04	-1.1%

7	I someday plan to give alums contributions to this department	3.67	0.90	3.78	0.97	0.11	3.0%
8	I really enjoy being in this department	4.13	0.52	4.22	0.83	0.09	2.2%
9	Students here really care about that happens to this department	3.87	0.52	4.33	0.71	0.47	12.1%
10	I feel very attached to this department	3.33	0.90	3.78	0.83	0.44	13.3%
11	Campus life offered by the department is very stimulating	3.00	1.00	3.44	1.13	0.44	14.8%
12	If I am/were going to college next year, I would continue with this department	4.20	0.77	4.11	0.78	-0.09	-2.1%
13	There is a sense of community here	3.67	0.62	3.89	0.60	0.22	6.1%
Total adapted CSOC		49.53	4.96	51.78	5.89	2.24	4.5%

Table 2 shows that, for CSI, after our community-building activities, the total score of sense of community increased from 49.53 to 51.78, a 4.53% increase. The averages of nine out of the fourteen questions increased during the study. The four most significant positive changes on average were for a) “I wish I had gone to another department instead of this one (Reversed, 20.16%),” “Campus life offered by the department is very stimulating (14.81%),” “I feel very attached to this department (13.33%),” and “Students here really care about that happens to this department.”

The four that did not improve are “There is a real sense of community here,” “I feel I can get help if I am in trouble,” “There is a real sense of togetherness in the department,” “If I am/were going to college next year, I would continue with this department.” All four slightly decreased, by -3.65%, -2.12%, -1.13%, and -2.12%, respectively. Each decrease is far less than the respective standard deviation of their respective baseline data. The slight decline may be due to statistical error because baseline data for these items was already high.

At the end of the semester, “I really feel like I belong here,” “Students here really care about that happens to this department,” and “I would recommend this department to students in my high school” had the highest average (4.33). “I wish I had gone to another department instead of this one (Reversed)” and “Campus life offered by the department is very stimulating” had the lowest (3.44). Figure 2 visualizes the end-of-semester means versus the baseline means of Table 2.

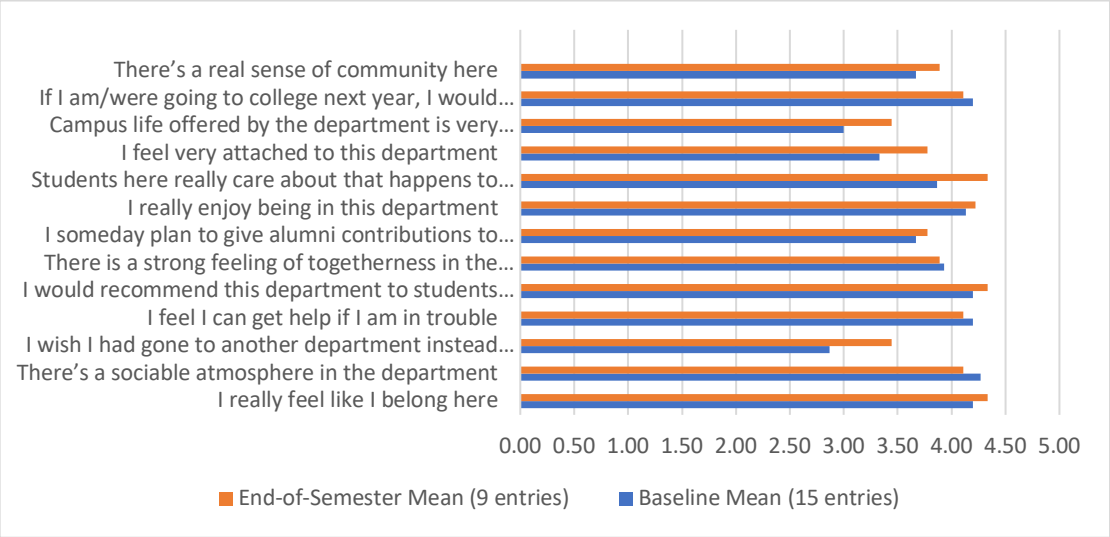

Figure 2. CSI Changes in the Adapted Collegiate Sense of Community

Other results indicated that students were finding belongingness. For example, one CS I student became an ExCITE volunteer early in the semester. One of the CS I students became ACM-W club officers during the semester.

2. **Qualitative Results.** At the end of the semester, we conducted group interviews of both classes. A total of fifteen students, eight of the fifteen CSI students and eight of eight Foundations students (who remained registered at that time) from the two linked courses participated. Our surveys and interviews showed that the linked activities increased the students' sense of community, enjoyment of computing, and confidence in computing. Some students established meaningful relationships with non-first-year students, joined student organizations, or became volunteer presenters.

- **Enjoyment in Computing**. Students used the following words to describe their experiences with the activities: "fun," "interesting," "cool," "amazing," great," "enjoyable," "helpful," "informative," "novel," "unique," "relatable," etc. One student said, "I feel more engaged in what I'm learning." Several students mentioned the hands-on aspect of the activities. Some students appreciated how the activities aligned with the course contents. One student noted, "I think it helps us apply what we learned in class, rather than just constantly reading it… helps us be able to apply it in real life and see how we'd be able to use this and physically do it ourselves compared to watching a video or just a virtual lab. And this will be my first class where we actually had people come in and show different things."

- **Sense of Community.** Students used the following words to describe their feelings regarding the departmental community: "belong," "welcomed," "pleasant," etc. One student commented, "It shows me that there are more women in the computer science field, so it doesn't make you feel like an outsider." Several students mentioned that they now have access to students they could ask for help. One student noted, "Participating in organizations and clubs like these, it helps you to be able to talk to someone who you feel

is more relatable. And as a student themselves, they understand the workload, they understand what it comes with being in an IT (information technology) or computer science major. And it makes you feel more at home or together…and they're able to relate with you and what you're going through throughout this."

- **Confidence in Computing.** Eight students reported their confidence increased compared to the semester's beginning. One student said, "Having a community definitely increased my confidence, having the upperclass students help us." Another student said, "I was having a really, really hard time and I thought I was the only one that was having this problem. But after everything, the workshops, I would now rate myself an eight (out of 10 for confidence) … it really came from talking to (upperclass) students."

Overall, these responses indicate an increased sense of community, interests, understanding, motivation, appreciation of computing, and confidence in computing. Several students indicated that they need more of such activities. We also discovered that students would like to have more of the following: 1) project-based learning experiences, 2) group activities, and 3) hands-on experience.

Conclusions

Our approach can be summarized into the following activity design strategies to link courses:

1. Host joint events between the linked courses presented by student volunteers or student organizations,
2. Utilize hybrid events to engage off-campus professionals and
3. Recruiting students from one class to offer hands-on activities for the other class.

At the beginning of the semester, quantitative results suggest that second-semester students in the CS I course may had a greater sense of community than first-semester students in the Foundations course. However, this finding is inconclusive due to the limited responses from the Foundation students. Yet, given that second-semester students have had more time to acclimate to the campus environment and have developed relationships with fellow students, the first-semester students may benefit more from our approach. End-of-semester quantitative and qualitative results suggest that students had increased their sense of community compared to the beginning of the semester. Overall, results demonstrate a greater sense of community for students participating in the linked-courses activities.

It is important to note that the results are based on a small pool of students. This limitation is attributed to our small class size at the University. However, the small sample size of students has less impact on qualitative results than quantitative, and the qualitative results support the quantitative findings. Furthermore, other researchers could conduct the same study on a larger sample of students. We were not able to interview the students who dropped out on what could have been done to make them feel more belonging.

In conclusion, our linked-courses approach is effective in engaging first-year computing students. Other commuter campuses or schools with commuter students can adopt this

innovative, low-cost approach to increase student engagement and retention. Successful implementation of this linked-courses approach for community building requires 1) identifying common activities relevant to the courses, 2) recruiting and training available and capable presenters, and 3) scheduling activities to maximize student participation from both classes. Given the diverse schedule of commuter students, coordinating convenient times for activities outside of class can be challenging.

Future Work

We plan to 1) continue this study in the next few semesters to collect more data and investigate its impact on student relationships across these two courses; 2) explore emerging topics in computer science to introduce new topics and activities; 3) identify ways to involve more student participants by highlighting the activities' educational benefits and the potential for personal growth; and 4) further develop strategies to recruit student presenters, e.g., by offering presentation training sessions. We anticipate as students develop a greater sense of belonging and community, they will feel more connected to their peers and more motivated to present and participate.

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Appendix I. Adapted CSOC Survey Questions

Survey Directions: Using the scale below, please circle the number that best describes how you feel about the community of the Computer Science and Information Technology Department. (1) Strongly Disagree; (2) Disagree; (3) Neither Agree nor Disagree; (4) Agree; (5) Strongly Agree.

- I really feel like I belong here.
- There's a sociable atmosphere in the department.
- I wish I had gone to another department instead of this one.
- I feel I can get help if I am in trouble.
- I would recommend this department to students in my high school.
- There is a strong feeling of togetherness in the department.
- I someday plan to give alumni contributions to this department.
- I really enjoy being in this department.
- Students here really care about that happens to this department.
- I feel very attached to this department.
- Campus life offered by the department is very stimulating.
- If I am/were going to college next year, I would continue with this department.
- There's a real sense of community here.

Appendix II. Interview Questions

1. Do you find the presentations/workshops conducted by the ExCITE Program students (presenter names) helpful? Why or why not? If helpful, in what ways? If not, please explain why.
2. How did participating (or not participating) in the ACM and ACM-W club meetings/activities (including the take-apart event and the robotics workshop) impact your sense of belonging to the department community?
3. How did using (or not using) the CCIE Discord Server (where the ACM, ACM-W, and CSI channels) impact your integration into the department community?
4. Did you use C03A Lab (Center for Computing Innovation and Education)? Why or why not? If you used the C03A Lab, did you find it helpful or not? If helpful, in what ways? If not, please explain why.
5. Did your enjoyment in computing change this semester? If so, tell me more about it. What do you think led to this change? Do you think the ExCITE-Clubs-Community Center approach contributed to the change? If yes, how much?
6. Tell me about an event in the ExCITE-Clubs-Community Center approach this semester that you enjoyed the most and why.
7. Did your motivation to study computing change this semester? If so, tell me more about it. What do you think led to this change? Do you think the ExCITE-Clubs-Community Center approach contributed to the change? If yes, how much?
8. Would you please tell me about your confidence in computing at the beginning of this semester? What about now? If there's a change in your self-confidence, any key events/activities led to this change? Do you think the ExCITE-Clubs-Community Center approach contributed to the change? If yes, how much?
9. What are some frequent feelings when you come to the department for classes or extracurricular activities?
10. Do you expect to complete your degree? Have you considered graduate school? If yes, at the MS or PhD level?
11. What would you like to see more in the CSIT department community?