Promoting Students' Social Interactions Results in an Improvement in Performance, Class Attendance and Retention in First Year Computing Courses

Candido Cabo and Ashwin Satyanarayana
Department of Computer Systems
New York City College of Technology/CUNY
New York City, USA
{ccabo, asatyanarayana}@citytech.cuny.edu

Abstract— **This Innovative Practice Full Paper presents the impact of Learning Communities (LC) on student retention, class attendance and performance outcomes in first-year computing courses. LCs are a group of students who enroll in two or more courses, generally in different disciplines that are linked together by a common theme, in an academic semester. Our results show that when first-year students take computing courses as part of a LC, retention rates increase and students perform significantly better. We also found that LCs promote class attendance and that students' academic and social interactions with classmates may play a critical role in the improvement of student performance observed in LC students.**

Keywords— Learning Communities; Student Performance; Class Attendance; Student peer relationships; Study habits;

I. Introduction

1.1. Challenges of first-year computing courses

First-year computing courses, which typically include a wide range of topics such as problem-solving, pseudocode, algorithm development and programming, are more difficult to teach and learn than other courses [1]. Students are required to develop competence in several cognitive areas such as syntactic and conceptual knowledge to be able to develop a wide range of technical and practical skills. Students also need to develop problem-solving skills to creatively solve new problems with computer programming [2]. All in all, most novice programmers find introductory computing courses frustrating and difficult to learn [3] resulting in student attrition and transfers out of computer science degrees. The major challenges that students face in first-year computing courses has been reviewed elsewhere [4].

1.2. Learning Communities

A curricular Learning Community (LC) is a group of students who co-enroll in two or more courses, generally in different disciplines that are linked together by a common theme, in an academic semester [5], [6], [7]. LCs is one of the ten high-impact educational practices recognized nationally to improve student persistence using data from assessment to increase retention [5], [7]. First Year LCs provide an opportunity for students to begin their college experience with other students who share similar interests and career objectives. LCs consist of small groups of first-semester college students taking two to three linked courses as a group. Each LC is designed to ease the transition from high school to college by allowing first-year students to acquire educational and social skills crucial to their long-term academic success, through an integrated learning environment. This cluster of linked courses reserved just for first-semester students makes it easier for students to meet new friends and learn about many college resources. From the beginning of the semester, students who participate in First-year Learning Communities more easily form study groups, share notes, and prepare for exams. Students in first-year learning communities enjoy the benefits of sharing common courses while making new friends, exploring common interests and being a part of a close community of peers. We have implemented LCs at our institution for more than 10 years [8], [9], [10].

The goal of this study is to explore if teaching introductory computing courses in a learning community environment increases retention (course completion) and student academic performance as compared to teaching them as independent courses. A preliminary report of these study has been published in abstract form [11].

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II. Research Questions

The specific research questions were:

(RQ1) Do learning communities have any effect on student retention (i.e. class completion)?
(RQ2) What is the effect of a LC environment on students' academic performance in first-year computer courses as compared to the same courses outside of LC?
(RQ3) Which is the effect of a LC environment on class attendance?
(RQ4) Do student relationships and study habits have an effect on student performance?

III. Methods

3.1. Participants and setting

Our institution is one of the most racially, ethnically, and culturally diverse institutions of higher education in the northeast United States: 30% of our students are African American, 32% are Latino, 21% are Asian or Pacific Islanders, and 12% are Caucasian. The College's fall 2015 enrollment was 17,424. First-year students were recruited to the LC on a first-come first-served basis. Students assigned to the LC took the two first-year computer courses Introduction to Computer Systems (CS0) and Problem-Solving with Computer Programming (CS1) as well as English Composition I as a group (see [10] for a detailed description of the learning community organization and assignments). A total of 131 students enrolled in the CS0 course between Spring 2013 and Fall 2015: 67 in the LC group and 64 in the non-LC group. All CS0 courses were taught by the same professor (author AS).

A total of 258 students enrolled in different semesters in the CS1 course between Fall 2011 and Fall 2015: 112 in the LC and 146 in the non-LC group. All CS1 courses were taught by the same professor (author CC). Note that the 67 students in the CS0/LC group are also part of the 112 students in the CS1/LC group.

Data from students who dropped the class or stopped attending the class were excluded from the performance data, but it was used to calculate retention (i.e. course completion).

3.2. Student performance

In the CS0 course we measured student performance in concepts related to introductory concepts in computing. The problems used to assess the skills were categorized in three groups: number system conversions (including binary arithmetic), logic gates and circuits design (including truth tables), and writing algorithms using pseudocode.

In the CS1 course we measured student performance in concepts related to problem-solving and computer programming and skills in solving problems using a flowchart interpreter (which allows the execution of the flowchart) with Visual Logic (www.visuallogic.com). The problems used to assess the skills were categorized in three groups: problems using only a sequence of computational steps (sequence), problems that needed the use of selection structures (if/else), and problem requiring the use of repetition loops (both for and while loops).

3.3. Student attendance

All sections of the CS0 course (LC and non-LC) were in-class, so attendance reflects student presence in the face-to-face class sessions. All sections of the CS1 course (LC and non-LC) had a hybrid format: 50% of the sessions were held in-class and 50% of the sessions were online. Attendance to in-class sessions reflects student presence in the face-to-face sessions. A student was considered present at an online session if the student completed all the required assignments and participated in the required online discussions.

3.4. Statistical methods

The effects LC on student performance and attendance were analyzed using analysis of variance. Results were considered statistically significant when $p < 0.05$. The effect size was quantified using the partial η^2. We used contingency tables and the chi-square statistic to compare percent rates. The effect size was quantified by phi. We used SPSS in all our statistical calculations.

IV. Results

4.1. Learning Communities increase student retention

Linking the first-year computing course in a LC increased student retention. When the CS1 course was part of a LC 5% of students withdraw (officially or unofficially) from the course; in contrast, 12% of students withdraw from the course when the course was not part of a LC. Dropout rates were similar for the CS0 course: 4% when students took the course as part of a LC and 10% when students took the course outside the LC.

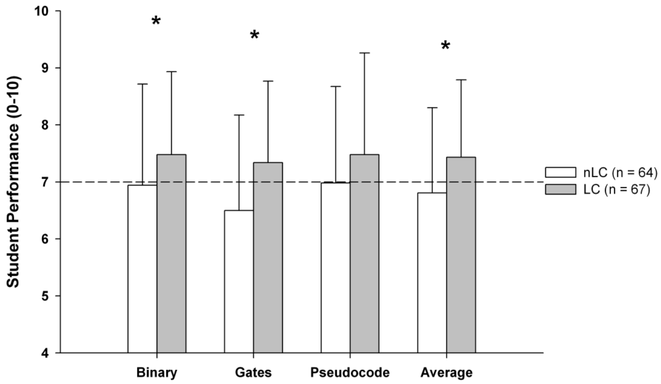

Fig 1. Student performance in three introductory computing skills (binary arithmetic, gates/circuit design and pseudocode / algorithm development)

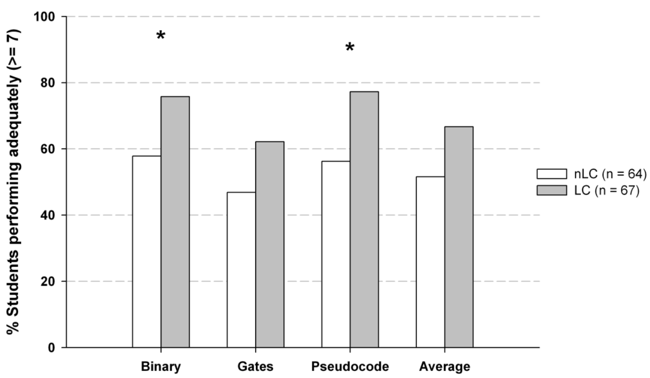

Fig 2. Percent of students who performed adequately (>=7) in three introductory computing skills (binary arithmetic, gates/circuit design and pseudocode/algorithm development)

4.2. Learning Communities increase student performance in Introduction to Computing (CS0)

In this foundational course for Computer Systems, students engage in an overview of machine architecture, algorithms, data organization, ethics, computer security, and the theory of computing, key concepts and skills that students will need in later computer systems courses. Thus, one of the main goals of this course is to enable students to develop critical thinking skills by designing solutions to given problems using pseudocodes and algorithms.

Figure 1 shows that student performance in three introductory computing skills (binary arithmetic, gates and circuits, pseudocode and algorithm development) increases significantly when students take the CS0 course as part of a LC (mixed model anova with repeated measures $F(1, 128) = 6.234$, $p < 0.05$, partial $\eta^2 = 0.046$, power = 69.8%). There were significant differences in performance for the different assessments for the nLC group (anova with repeated measures with a Greenhouse-Geisser correction $F(1.667, 133.652) = 4.343$, $p < 0.05$, partial $\eta^2 = 0.064$, power = 68.7%). Post-hoc tests with the Bonferroni correction showed that, for the nLC group, performance in gates and circuits was significantly lower ($p < 0.05$) than performance in binary arithmetic and pseudocode and algorithm development. There were no differences in performance for the different assessments in the LC group.

The average value of the assessments does not provide information on how many students perform adequately and how that is affected by LCs. Figure 2 shows the percent of students who performed adequately (i.e., students who obtained >= 7 in the assessments) in the three introductory computing skills assessments for the LC and nLC groups. The percent of students with an adequate performance was significantly higher for the LC group for the binary (chi-square = 4.975, $p < 0.05$, phi = 0.195) and pseudocode (chi-square = 6.774, $p < 0.01$, phi = 0.227) assessments. Even though the percent of students who performed well in the gates assessment and in the average of the three assessments was larger for the LC group, the difference was not statistically significant.

4.3. Learning Communities increase student performance in Problem-solving with Computer Programming (CS1)

The CS1 course is designed to introduce students to concepts of problem solving using constructs of logic inherent to computer programming languages, including procedural programming and object oriented programming. The student learns the nature of problems, common solution approaches, and analysis techniques. During the first two weeks of the fifteen-week semester, the emphasis is on solving problems in a context known to the students—for example, navigation of mazes or games such as tic-tac-toe. Several computer programming constructs such as sequencing, selection structures, and repetition loops are introduced to solve various problems using pseudocode. Later, students solve programming problems with flowchart interpreters (Visual Logic).

Figure 3 shows that student performance in three flowcharting skills (sequence, selection and repetition) increases significantly when students take the CS1 course as part of a LC (mixed model anova with repeated measures $F(1, 247) = 29.11$, $p < 0.001$, partial $\eta^2 = 0.105$, power = 100%). Anova with repeated measures with a Greenhouse-Geisser correction indicated that there were significant differences in performance for the different assessments for both LC ($F(1.753, 189.343) = 13.649$, $p < 0.001$, partial $\eta^2 = 0.11$, power = 100%) and nLC groups ($F(1.739, 241.688) = 39.314$, $p < 0.001$, partial $\eta^2 = 0.22$, power = 100%). Post-hoc tests with the Bonferroni correction showed that performance for both groups in repetition assessments were significantly lower

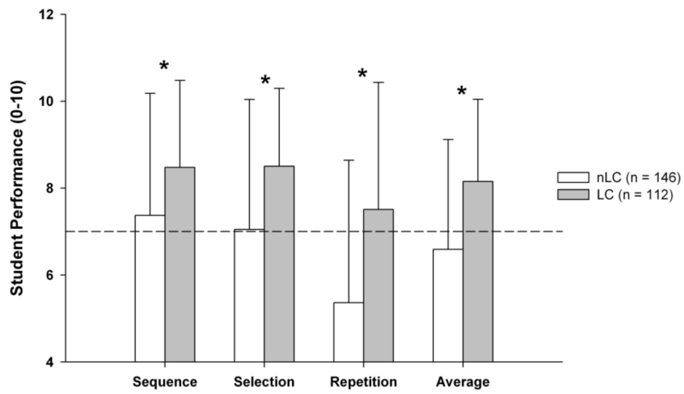

Fig 3. Student performance in three flowcharting skills (sequence, selection and repetition)

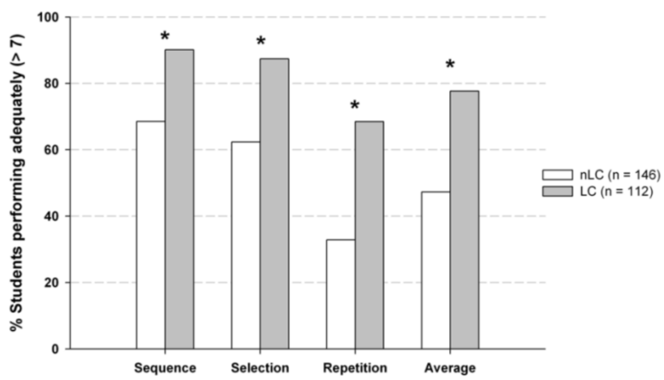

Fig 4. Percent of students who performed adequately (>=7) in the different flowcharting assessments (sequence, selection and repetition)

($p < 0.001$) than performance in sequence and selection assessments.

The average value of the assessments does not provide information on how many students perform adequately and how that is affected by LCs. Figure 4 shows the percent of students who performed adequately (i.e., students who obtained >= 7 in the assessments) in the different flowcharting assessments for the LC and nLC groups. The percent of students with an adequate performance was significantly higher for the LC group for the sequence (chi-square = 16.9, $p < 0.001$, phi = 0.258), selection (chi-square = 20.161, $p < 0.001$, phi = 0.28) and repetition (chi-square = 31.714, $p < 0.001$, phi = 0.353) assessments.

4.4. Learning Communities promote student attendance

Linking courses in a LC promotes student class attendance. Figure 5 (left) shows a histogram of students' attendance to CS0 courses when the course was linked to a LC and when it was not (nLC). The percent of students who attended >= 90% of the class sessions was significantly higher for the LC group (94%) than for the nLC group (77%) (chi-square = 6.457, $p < 0.05$, phi = 0.222). Figure 5 (right) shows a histogram of students' attendance to CS1 courses when the course was linked to a LC and when it was not (nLC). The percent of students who attended >= 80% of the class sessions was significantly higher for the LC group (77%) than for the nLC group (65%) (chi-square = 4.156, $p < 0.05$, phi = 0.127). Note that the attendance profile to CS0 and CS1 are different possibly reflecting the fact that CS0 had an in-class format and CS1 had a hybrid format (see Methods above), or a difference between the instructors.

4.5. Class attendance increases student performance

Class attendance results in increased student performance. Figure 6 (left) shows the average student performance in three introductory computing skills evaluated in the CS0 course for the LC and nLC groups. A mixed anova was conducted to examine the effect of LC (LC vs. nLC), attendance (>=90% vs. <90% attendance), and their interaction on average student performance (the average of the introductory computing skills). The interaction of the LC and attendance factors was not significant ($F(1,127) = 0.107$, $p < 0.744$, partial $\eta^2 = 0.001$, power = 6%). There was a significant effect of attendance on performance ($F(1,127) = 18.438$, $p < 0.0001$, partial $\eta^2 = 0.127$, power = 99%), indicating that students attending class >=90% of the time perform better than students attending <90% of the time.

Figure 6 (right) shows the average student performance in flowcharting assessments as a function of class attendance for the LC and nLC groups in the CS1 course. A mixed anova was conducted to examine the effect of LC, attendance, and their interaction on average student performance (the average of the flowcharting assessments). The interaction of the LC and attendance factors was not significant ($F(1,252) = 0.913$, $p < 0.403$, partial $\eta^2 = 0.007$, power = 21%). There was a significant effect of attendance on performance ($F(2,252) = 13.823$, $p < 0.001$, partial $\eta^2 = 0.099$, power = 100%) . Post-hoc multiple comparison tests showed that student performance with 40%-60% attendance rate was significantly lower than student performance with 60%-80% and 80%-100% attendance rates ($p < 0.01$). There was no statistical difference between performance of students with 60%-80% and 80%-100% attendance rates ($p = 0.079$). Simple main effects analysis also showed that for students with 80%-100% attendance rate average performance is higher for LC students (8.53+- 1.47) than for nLC students (6.89+-2.34)($p < 0.001$).

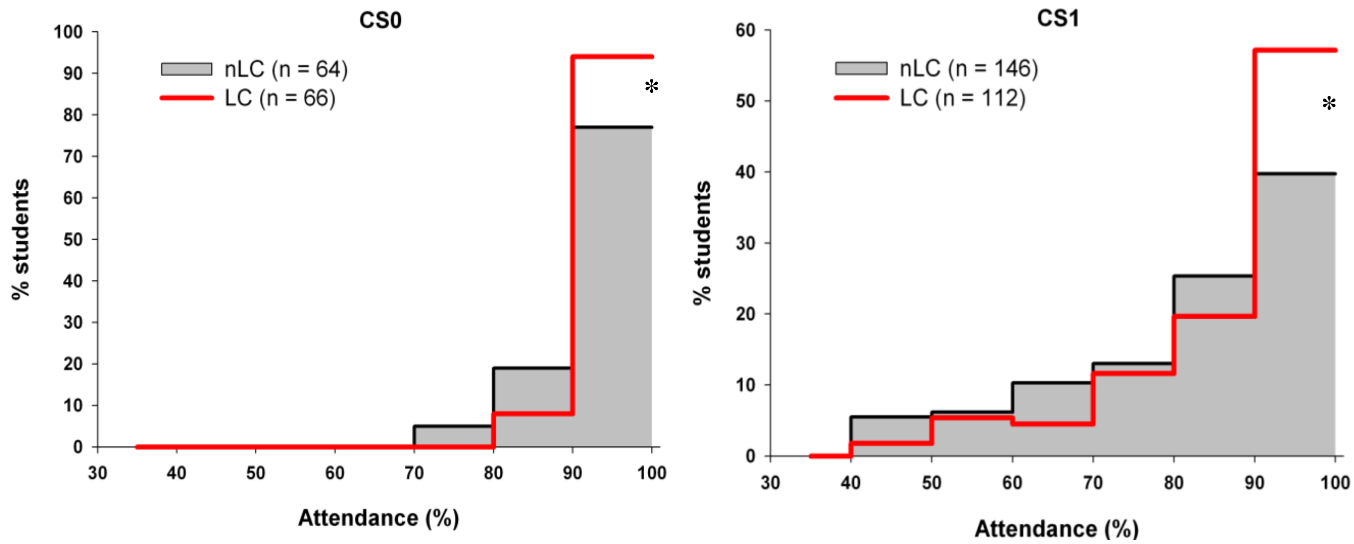

Fig 5. Histogram of student attendance in courses CS0 (left) and CS1 (right) for LC (red) and non-LC (gray)

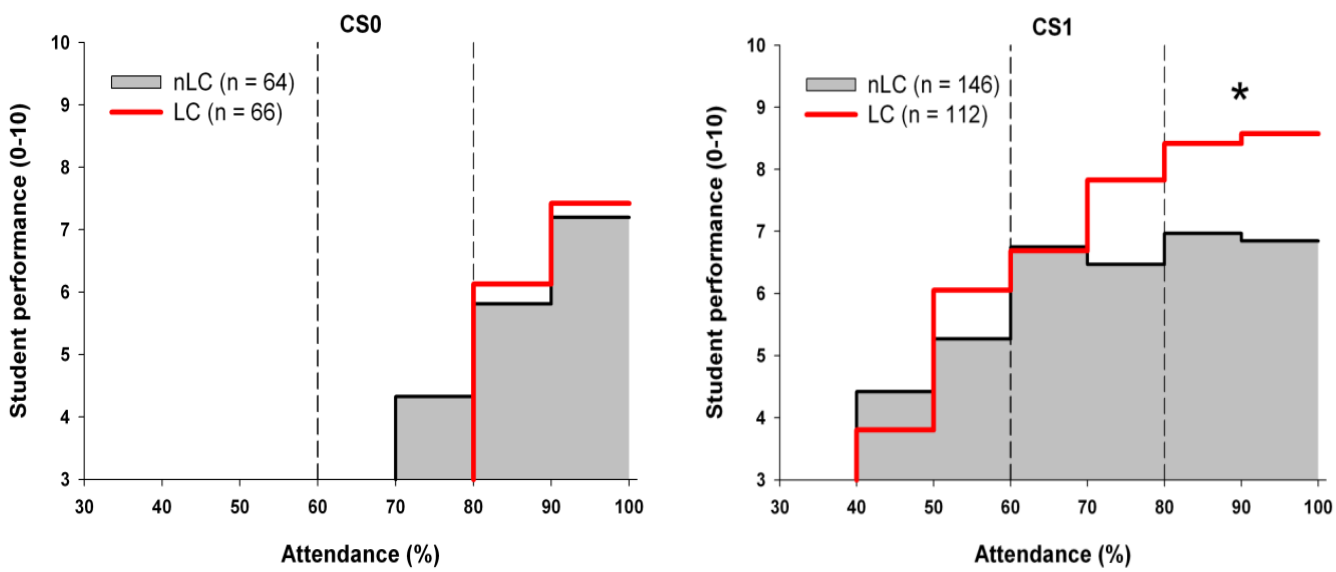

Fig 6. Student attendance and performance in courses CS0 (left) and CS1 (right) for LC (red) and non-LC (gray).

4.6. Students relationships and study habits

The results in the previous section show that class attendance contributes to student performance but class attendance alone may not be sufficient to explain the increase in student performance observed in the LC group. For example, the performance of nLC students who attend class >= 80% of the time in the CS1 course (Figure 6, right) is lower than that of LC students with a similar attendance rate.

A student survey conducted in Fall 2013, among 19 students belonging to the LC and 132 students taking the CS1 course outside the LC revealed the different relationships that develop among students when they are part of a LC and when they are not. LC students interact with more classmates than nLC students. About 62% of LC students interact with four of more classmates in contrast to 25% of nLC students (figure 7A). Most strikingly, about 16% of nLC students report that they do not interact with any other students in the class.

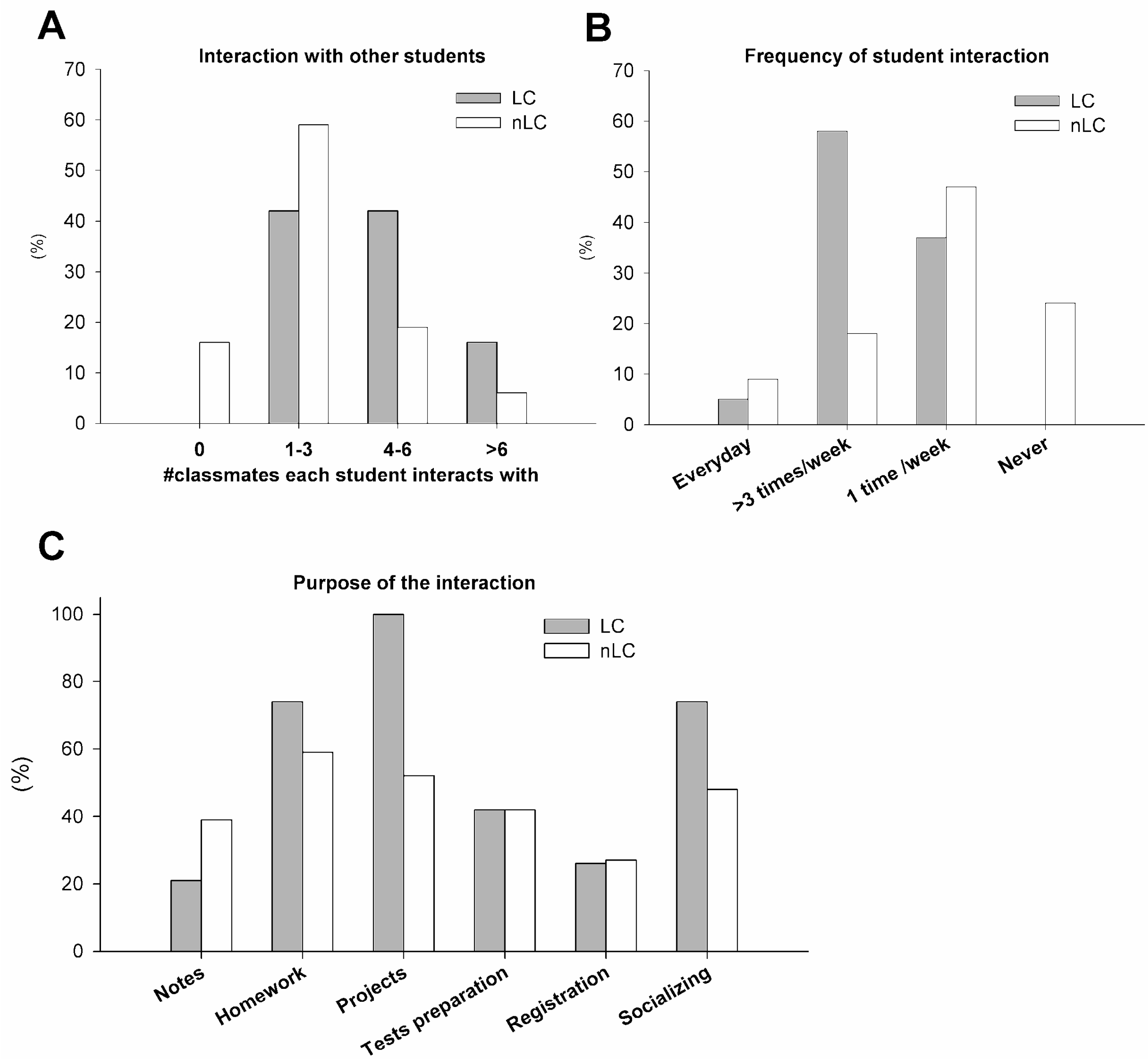

Fig 7. A student survey of student interactions with peers in the LC and nLC groups.

About 63% of LC students interact with their classmates more than 3 times per week; the same number for nLC students is 27% (Figure 7B). About 24% nLC students report that they never interact with classmates. The results indicate that LC students interact with classmates more often than nLC students.

The purpose of the student interaction reported by the majority of students in each group is to work together in homework assignments, projects and to socialize (figure 7C). All (100%) LC students report interacting with classmates to work on class projects in contrast with 52% in the nLC group. Likewise, more students interact with classmates to complete homework assignments in the LC group (74%) than in the nLC group (59%). Student interaction may occur not only for academic purposes but also to socialize: more students socialize in the LC group (74%) than in the nLC group (48%).

The results above suggest that the nature of students' relationships with classmates may play a critical role in the improvement of student performance observed in LC students.

V. DISCUSSION

We have shown that when first-year students take computational courses as part of the LC, retention rates increase and students perform significantly better. We also found that LCs promote class attendance and that the nature of students' relationships with classmates may play a critical role in the improvement of student performance observed in LC students.

5.1. Learning Communities and Retention (RQ1)

The transition from high school to college is difficult for most students as a result of the differences in academic expectations and the learning and social environments [12]. About 40% of college students drop out of college without completing a degree (National Center for Education Statistics) usually in the first two years of their college careers [13]. First-year retention rates vary by institution, with public institutions with students who are underrepresented minorities having the lowest retention rates. At our institution the retention for full-time first-time freshmen was 67% for the Fall 2014 cohort.

In this study, we examine the impact LC on student retention (i.e. course completion) in two gateway first-year computing courses. Our findings indicate that in both courses, the percentage of students who withdrew from courses linked in a LC was about one-half the percentage than in non-LC environments. The results are consistent with earlier published reports showing a beneficial effect of LC (and first-year experiences in general) on retention [14], [15]. Lenning et al. [16] summarize several variables found to influence retention including commitment to and satisfaction with the college and peer-group influence.

5.2. Learning Communities and Student Performance (RQ2)

In this study we also demonstrate that there is a significant improvement in academic performance in first-year computing courses when courses are taken in a LC environment compared to performance in those courses without the benefit of a LC environment. Our results are consistent with national trends showing the benefits of linking courses in LCs on student performance and engagement [5], [6], [7]. One of the reasons for the improved academic performance could be that LCs treat the classroom as the locus of community-building by featuring cooperative learning techniques and group process learning activities as integrating pedagogical approaches [17] leading to a strengthening of social and intellectual connections among students. Moreover, the LC environment influences student development as it provides a fertile environment for student growth through engagement with peers. Interacting with faculty members and cooperating with peers on learning tasks, may encourage them to continue these activities throughout college. In addition, students who actively participate in various out-of-class activities are more likely to connect with an affinity group of peers, which is important for academic performance. In this way, LCs make possible a constructivist approach to knowledge, whereby knowledge is not simply "discovered" but it is socially constructed [18]. This is in agreement with published reports showing that social support is a significant predictor of academic achievement [19], [20].

Interdisciplinary LCs also allow the use of domains (areas where students can apply and practice what they learn in assignments and projects) which students understand well and feel comfortable with (like games and narratives). The use of domains which are meaningful to students also lead to an increased in student success in first-year computing courses [8], [9].

5.3. Learning Communities, Class Attendance, and Students Relationships (RQ3 and RQ4)

Our results demonstrate that a LC environment promotes class attendance: students taking first-year computing courses as part of a LC are more likely to attend class more often than students taking those courses outside a LC (Figure 5). It is possible that the improved academic and social environment and the satisfaction with the institution resulting from LC environments naturally leads to increased rates of class attendance [6], [21].

It is well-established that there is a strong correlation between class attendance and student performance in a wide range of disciplines and institutions (see for example [22] for a meta-analysis of over fifty published papers over a period of eighty years). In agreement with those studies, our results show that in first-year computing courses class attendance correlate with improved student performance (Figure 6). Therefore, it is possible that the increasing in class attendance by students belonging to LCs is at least in part responsible for their improved performance.

Our data also illustrates the complexity of the relationship between class attendance and student performance [22]. Class attendance correlates with but does not completely explain the better student performance observed in the LC group. For example, the performance of LC students who attended class >= 80% of the time in the CS1 course (Figure 6, right) is higher than that of non-LC students with a similar attendance rate. It is possible that the students' relationships with classmates are also important in determining the relationship between class attendance and performance. About 16%-25% of non-LC students never develop a relationship or interact with classmates (Figure 7). This lack of social and academic interaction with classmates may result in students who attend class but do not participate in class activities resulting in a diminished effect of attendance on performance. This may also explain why some studies have found no correlation between class attendance and student performance [23], [24].

The quality of the attendance (i.e. class participation, the development of a community of learners) may be an important modulator of the relationship between class attendance on performance. Therefore, our results suggest that the nature of students' relationships with classmates may play a critical role in the improvement of student performance observed in LC students.

VI. LIMITATIONS

Several considerations should be taken into account when interpreting the findings of this study. First, sections of first-year computer courses linked in a LC were populated on a first-come-first-serve basis. It is possible that students who register earlier, and who consequently find a seat in a section belonging to a LC, are more academically motivated and that this motivation contributes to the increase in performance observed in the LC group.

Second, in this study we quantified student retention in two first-year computing courses (i.e. course completion). Even though we expect that academic success in the first-year computing courses will result in an increase in first-year retention, we have not studied the effect of LCs on actual first-year retention rates (i.e. the percent of students returning the following fall). Moreover, there are multiple factors that may influence retention (like financial and other societal factors) [16] that were not considered in this study.

VII. CONCLUSIONS

1) Student retention (i.e. course completion) in first-year computing courses increases when students take those courses as part of a LC.
2) Performance of LC students in first-year computing courses is higher than performance of nLC students.
3) The percentage of students performing adequately is higher for the LC group than for the nLC group.
4) LC encourages class attendance. For students attending class >= 80% of the time, performance is still higher for LC students than for nLC students.
5) LC students interact with more classmates and more often than nLC students. The nature of students' relationships with classmates may play a critical role in the improvement of student performance observed in LC students.

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