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Utilizing Peer Tutors in Introductory Programming Education: An Exploratory Investigation

John Crabtree, Xihui Zhang, and Daniel Ray
University of North Alabama

Learning how to solve problems using computer programming is very challenging for beginners. Supplemental instructors (SIs), who lead tutoring sessions outside of normally scheduled class time and are usually peers of the students they tutor, can be of great assistance. However, since these tutors are also taking classes themselves, it can be difficult for them to juggle the demands that are placed on their time. This research investigates the impact and pedagogical efficacy of the presence of SIs in the classroom during the normal lecture. We present a detailed comparative examination of academic outcomes and student experiences for two sections of an introductory programming course that uses Python as the programming language: one with SIs in attendance and one without. Our counter-intuitive findings suggest that these mentors can have the same positive impact on their mentees without attending lectures along with their mentees. The results can inform future expenditures in time and resources when considering how best to provide supplemental assistance, particularly as related to introductory computer programming courses but with implications for other courses as well.

Learning how to write computer programs to solve problems is a challenge for beginners (Robins et al., 2003). For a variety of reasons, students fail to fully utilize the out-of-classroom assistance that is often available in the form of online discussion boards, the professor's posted office hours, and tutoring sessions. Tutors are usually student peers who have recently passed the course that they are helping to tutor. These tutors more easily relate to the students they are helping, and the students receiving the help may feel more comfortable revealing knowledge gaps that they may not want to acknowledge in the presence of their professors (Golding et al., 2006).

As such, peer tutors can positively impact students who may be struggling to learn their first programming language. One option with the potential to maximize that impact is to make the tutors available to assist students both outside of class as well as in the classroom. In the role of a supplemental instructor (SI), a tutor leads study sessions outside of the normally scheduled class time (Martin, 1977). The SI may or may not be present in the classroom during the normally scheduled lectures. This research addresses three questions: (a) What impact, if any, does the presence of the SI in the classroom have on tutoring session attendance? (b) What impact, if any, does the presence of the SI in the classroom have on learning as reflected by course grades? (c) How do the students who attend these SI-led sessions rate the impact of the sessions on the learning process and how do attitudes differ between those who have the SI in the classroom and those who do not?

In the fall 2019 semester, our introductory programming course (CIS 225) was offered in two different sections: Tuesday and Thursday mornings (Section 01) with 19 students and Tuesday and Thursday afternoons (Section 02) with 11 students. This is a standard introductory CS1 course with a Computer Information Systems (CIS) designation that is required of students who plan to major in computer information systems, geographic information systems, and information technology. However, students with majors in other areas commonly enroll in this course as well. Our tutors attended the afternoon lectures (Section 02), while no tutors were present during the morning lectures (Section 01). One SI attended the Tuesday afternoon classes and the other SI attended the Thursday afternoon class on a regular basis. Outside of class, the same two SIs held open tutoring sessions twice weekly in the evenings (Wednesday 5:30 pm to 8:00 pm and Thursday 5:30 pm to 8:00 pm; five hours total per week). Both sessions were advertised and made available to all students from both sections.

At the University of North Alabama, SIs are given access to the course's materials (including assignments) via the Canvas learning management system (LMS). The SIs are also encouraged to meet with the instructor of the course, as needed, for clarification of assignments and expectations. As stewards of the university's scarce resources, it is important to understand the benefits attained, if any, by requiring SI attendance in lectures. As a regional university, our students experience many demands on their time. In addition to time spent in class and time spent studying, many hold off-campus jobs. Therefore, evaluating the impact of required SI attendance in classroom lectures is important. The SIs may benefit from listening to a lecture they have heard before as a student which may help refresh their memories; however, if they have access to the course material via the LMS, attendance may not be strictly necessary to function effectively in their role as an SI. The question then becomes, do current students benefit from SI attendance in the classroom?

In the study semester, our SIs gathered attendance statistics on exactly who attended each session. We also administered a survey, completed by all students in both sections of the class, that asked for student attitudes and

opinions related to the SIs, their presence in the classroom, and their experiences in the SI-led sessions. The students in the afternoon section were also asked about their experiences and opinions related to the SIs who were present during the lecture.

This paper will present a literature review and discuss our methodology in detail. We will then discuss our analysis of the data and present our results. Finally, we will conclude with a discussion of the implications of this research.

Literature Review

In recent years budgets have tightened across higher education, and extrinsic pressure to achieve higher performance in directly measurable outcomes like graduation and retention rates have simultaneously mounted. Add to that increased scrutiny concerning the value proposition on higher education from parents and politicians alike, and it is no wonder that there has been an emphasis on research that seeks to identify best-practice pedagogy for maximizing successful educational outcomes. Special emphasis has been focused on those that do not require additional faculty or staff. Peer tutoring, a student-mediated learning strategy between two or more students where a more senior student acts as a tutor for the other students, all of whom are at or near the same knowledge level, is one such widely studied pedagogical tool.

This paper does not purport to test the well-established benefits of peer tutoring, nor do we broach the subject of learning models or methodology for supporting beginning programmers in general. Rather we maintain a narrower scope focusing on the efficacy of spending resources to have peer tutors be present during class lecture periods.

Below we identify past research that falls into two categories: (a) peer tutoring in general higher education and (b) peer tutoring in beginning programming courses specifically. In the first, research cements peer-tutoring as an important and well-understood technique. It also reports on the expected benefits from peer-tutoring across higher education and makes central the need for meaningful interaction between students and peers. In the second, the expected benefits and best practices in the narrower scope are shown to mirror those in the wider case.

Though our study is constrained to only beginning programming courses, the fact that the use of peer tutors is supported across multiple domains, and that meaningful student-tutor interaction is consistently identified as a critical aspect of the successful use of peer tutoring suggests that our findings may be applicable outside beginning programming courses.

The selected literature constitutes a broad, representative (but certainly not comprehensive) survey of the field that establishes, first, the need for and expected benefits of peer tutoring in both general education as well as the narrower scope of early programming courses. They also collectively motivate our study in attempting to determine if the use of in-class peer tutors is, by itself, a way to foment interaction between students and tutors. Table 1 summarizes the findings of our literature review, and the findings are expounded upon in the following sections.

Research has shown that peer tutoring programs improve students' performance in higher education courses. Arco-Tirado et al. (2019), for instance, studied a cohort of first-year students and found that the experimental group which attended peer tutoring experienced statistically significant improvements in grade performance over the control group. Other studies have identified specific positive impacts from peer tutoring for students including benefits in achievement, motivation, and attitude (Chen & Liu, 2011) as well as improved student satisfaction with both the course and the instructor (Clarkson & Luca, 2002). Additionally, research shows that experience with peer tutoring has a positive impact on student-tutors themselves (Song et al., 2018). Clarkson and Luca (2002) found that peer tutoring helped tutors assimilate and frame course content and develop better communication and interpersonal skills.

Colvin (2007) studied the social dynamics between peer tutors and students in a higher education setting. Her research found that the role of the peer tutor was not well established or well understood amongst students and that expectations about what to expect from peer tutors varied widely. The study revealed that students' attitudes and expectations ranged from wanting tutors to do their work for them to wanting tutors to leave them alone. These widely varying degrees of confusion were identified as a major potential roadblock to establishing a good working relationship between peer tutor and student. Approximately 10% of students in the study wondered if the peer tutors were diminishing the rightful role of the instructor, and another 10% wondered if they were hindering student learning.

Colvin (2007) identified a "continual negotiation" between peer tutor and student surrounding the usefulness of the tutor to the student. She found that students often felt ill at ease with the peer tutors whom they identified as authority figures more than fellow students. She writes, "The peer tutors had to convince the other students in the classes that though they were students just like everyone else, they had additional insight and credibility that allowed them to function as a resource apart from the instructional staff" (Colvin, 2007, p. 174). Colvin (2007) ultimately found that it was quality interaction and the building of trust relationships between peer tutor and student that were key to a successful implementation of peer tutoring.

Table 1
Summary of Reviewed Literature Related to Peer Tutoring

Literature considering peer tutoring as a higher education pedagogy in general	
Research showing improved outcomes for students	Arco-Tirado et al., 2019 Chen & Liu, 2011 Clarkson & Luca, 2002
Research identifying positive impacts on peer tutors	Clarkson & Luca, 2002 Song et al., 2018
Studies strongly linking quality interaction and trust relationships between peer tutors and students to improved outcomes	Abbot et al., 2018 Colvin, 2007
Research identifying high tutor self-efficacy as a key contributor to maximized outcomes for students	Holt & Fifer, 2018
Literature examining peer tutoring strictly as applied to early programming courses	
Studies showing improved outcomes for early learners in programming courses	Arco-Tirado et al., 2011 Gerhardt & Olan, 2010 Munley et al., 2010
Investigations linking improved and/or increased interaction between peer tutors and students and improved outcomes for students	Feijóo-García & Ortíz-Buitrago, 2018 Weikle, 2016
Comparative research involving peer tutoring alongside other pedagogical techniques and analyzed as one component of a multi-faceted approach	Erdei et al., 2017 Han et al., 2010 Kentros et al., 2019 Liu et al., 2019 Porter & Simon, 2013

These are clearly elements that can only grow over time and require continued engagement between tutor and student to foment.

In much the same vein, Abbot et al. (2018) found that establishing and maintaining role clarity and realistic expectations were significant themes in peer tutors' understanding of, and satisfaction with, their tutoring experiences. Further, Holt and Fifer (2018) studied characteristics of peer mentors and identified self-efficacy as the key to positive self-reporting concerning mentoring to mentees. Further, they identified the frequency of mentor-mentee interactions as the only predictor of the mentees' ratings of mentor support.

Certainly, peer tutoring is a well-studied pedagogical tool and research covers many aspects of the practice. Fong (2016), for instance, recommends the use of appropriate tutoring material that matches students' abilities in peer tutoring. She also suggests that instructors should provide regular guidance for tutors in order to develop the tutors' confidence in playing their role. Though a full exploration of the literature is outside the scope of this research, the interested reader will find that Topping (1996) offers a detailed review of the relevant literature and Topping (2020) gives a thorough overview of key finding and highlights fertile areas for future research.

The focus of our research is specifically narrowed to the use of peer tutoring in introductory level programming classes. There has been significant prior research performed on the pedagogical application of peer tutoring in this area as well. Gerhardt and Olan (2010) described their experience with peer tutoring in introductory programming courses where they collected survey data of student perceptions on peer tutors and the peer tutoring services over a two-year period. Their results suggest that employing peer tutoring in a programming class was a success. Their students reported that the tutoring was useful, the tutors were knowledgeable, and they were satisfied with the tutoring service. The research results by Arco-Tirado et al. (2011) showed that even though not statistically significant, the peer tutoring program helped students overall with their GPA, performance rate, success rate, and learning strategies.

Peer tutoring studies have focused on a wide range of applications. Weikle (2016) reported on experiences with building a for-credit peer tutoring program for programming courses at a small private university. She exemplified an outlook common to researchers in the

area, where peer tutors hold office hours (1 hour a week in this case) in order to better facilitate in class outcomes. Erdei et al. (2017) performed a comparative analysis of the use of pair programming techniques vs. an undergraduate teaching assistant (effectively a peer tutor) in the context of a required laboratory component. They examined the effects of each strategy on students' programming procedural knowledge as well as their self-efficacy and found that results were similar with a slight, but statistically significant benefit to the use of a teaching assistant in the last four weeks of the semester. They also identified a theme of "immediacy of assistance" during student feedback.

Porter and Simon (2013) reported on results from incorporating media computation, pair programming, and peer instruction simultaneously in a reworking of an introductory program course. They found these changes resulted in a significant increase in student retention. Liu et al. (2019) found similar positive results to retention with the holistic application of peer assistance (including peer tutors) for programming courses. Kentros et al. (2019) found that interventions of peer tutoring in conjunction with group work - along with novel assignments that were based on Finch robots that have a peer-learning component - benefited pass rates in early programming courses. Each of these studied peer tutoring as only one component of a multi-faceted approach.

Feijóo-García and Ortíz-Buitrago (2018) studied a peer tutoring strategy that paired a single tutor with every student, offering a "personalized accompaniment" for each student. Han et al. (2010) developed a peer learning agent system to facilitate the learning of a programming language through the use of pair programming strategies. Such a system simulates the "tutor" and "tutee," and is demonstrated to have positive effects on knowledge retention and transfer in a programming course. Munley et al. (2010) examined the effect of participating in the peer tutoring program on a student's final course grade. Their findings indicate that peer tutoring does indeed produce a positive effect on student learning outcomes. "For this effect to translate into an increase in a student's letter grade in a particular course, though, the results suggest that it is necessary to engage in the activity for ten to 20 hours over the course of a 14 week semester, something akin to an hour per week" (Munley et al., 2010, pp. 281-282).

Overall, these findings show the significance of our study concerning the impact of peer tutors as supplemental instructors as it relates to increased contact with tutors in a more traditional extra-curricular setting. The body of literature on the subject suggests that trust relationships between peer tutors and students are a major impactor to successful outcomes. Additional contact hours with peer tutors during class seem likely to be able to underpin these trust relationships. We ask, in part, if we can observe these improved outcomes by making tutors available in class. Will said availability increase attendance at out-of-class tutoring sessions and more generally provide a better tutoring experience? Our research attempts to determine if in-class assistance helps reinforce learning outcomes outside of the classroom. Will we observe more frequent tutoring interactions and improved outcomes for students and tutors alike?

Additionally, our research seeks to fill a gap in the literature. Zhang et al. (2020) identified the use of in-class tutors as a beneficial "teaching tip" for introductory programming courses. They observe a correlation between increased tutoring attendance and the presence of tutors in class. Our study isolates and directly tests this correlation. Unlike prior studies, our research isolates and focuses on the impacts surrounding the peer tutoring pedagogy alone, and specifically the efficacy of employing peer tutors as supplementary instructors during class as it relates to the use of out-of-class tutoring, rather than obfuscating the results by measuring the effects of an ensemble of pedagogical tools.

Method

The primary goal of this study is to investigate whether the tutors' presence in the classroom will make a difference in attendance at the tutoring sessions. There are two major reasons for SIs to attend the lectures: (a) to be aware of the current assignments, learning expectations, and lecture material; and (b) to develop a rapport with student peers in the classroom. Both of the SIs took this same course in the previous semester (spring 2019), had "TA-level" access to all of the course material via Canvas (i.e., the course LMS), and had ample access to the instructor of the course for questions. Therefore, requiring these SIs to attend lectures was of marginal benefit to the SIs themselves, although it is required by our institution's current rules governing SIs.

Three types of data were collected from the two sections of CIS 225 during the fall 2019 semester: (a) tutor logs, (b) student grades, and (c) student survey data. The tutor logs record each student's name and section number who shows up for a tutoring session and seeks help from the tutor. These data help determine whether the tutors' presence or absence in the classroom made a difference in attendance at the tutoring sessions.

The student grades include the student's final score for the course, as well as scores for each of the major grade components including assignments, quizzes, and exams. These data support our investigation into whether the tutors' presence in the classroom improves student learning.

The student survey includes questions regarding the students' backgrounds, their perceptions of the in-class tutors, and their perceptions of tutors and tutoring

services in general. The survey questionnaire is provided in the appendix. A total of 30 students completed the survey: all 19 students from the morning section, and all 11 students from the afternoon section (a 100% completion rate). The number of students who enrolled for the two sections, the number of students who completed the survey, and the number of students who used tutoring services are presented in Table 2.

Specifically, we carried out this research in four steps. Step one, we performed a comprehensive literature search and a critical literature review of tutors and tutoring services in higher education, focusing specifically on utilizing peer tutors in introductory programming education. Step two, we described our research methods and the three types of data we collected. Step three, we presented the data analysis results. Step four, we discussed pedagogical implications of the research, as well as limitations and future research directions.

Table 2
Student Enrollment, Survey Participation, and Tutoring Attendance

	Section 1	Section 2	Total
Enrollment	19	11	30
Completed the survey	19	11	30
Used tutoring services	14	5	19

Results

Tutor's Attendance Log

There were two tutors dedicated to the CIS 225 course in the fall 2019 semester. Tutor 1 provided tutoring on Thursdays from 5:30 pm to 8:00 pm; Tutor 2 provided tutoring on Wednesdays at the same time. Throughout the fall 2019 semester, the two tutors kept an attendance log of their tutoring sessions. For each session, each tutor recorded the student's name and their course section (i.e., Section 01 or Section 02). All in all, 153 student visits were recorded during the tutoring sessions (see Table 3). Within the 153 student visits, 100 student visits were from students of Section 01, and 53 student visits were from students of Section 02. As such, the average number of visits per student of Section 01 was 5.263 (i.e., 100/19), and the average number of visits per student of Section 02 was 4.818 (i.e., 53/11). Tutor 1 served 72 student visits, 47 from Section 01 and 25 from Section 02. Tutor 2 served 81 student visits, 53 from Section 01 and 28 from Section 02.

A closer look at the tutors' attendance logs indicates that 14 students (out of 19) of Section 01 and 5 students (out of 11) from Section 02 attended the tutoring sessions. Figure 1 shows the 19 students and their number of visits to tutoring sessions. Table 4 presents the

Table 3
Statistics on Total Student Attendance by Tutor and Section

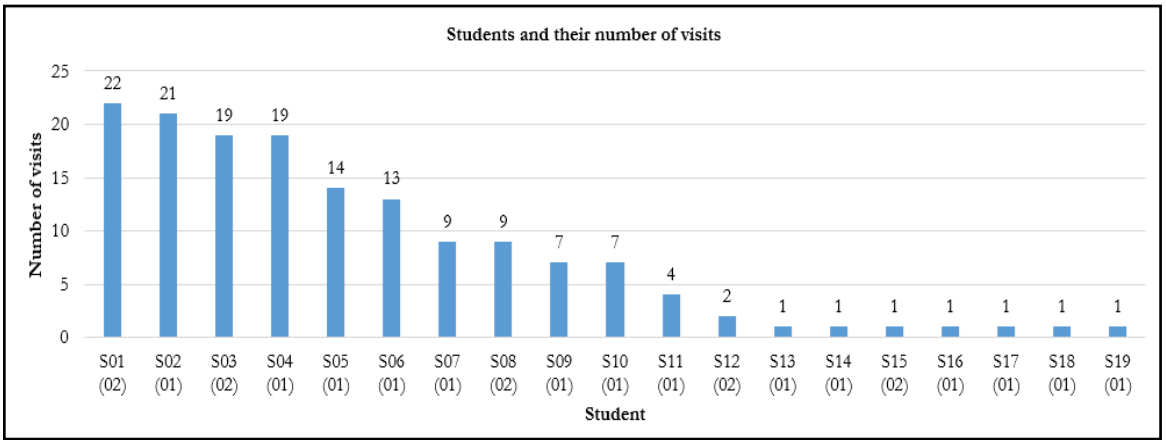
Tutor	Section 1	Section 2	Total
Tutor 1	47	25	72
Tutor 2	53	28	81
Total	100	53	153

descriptive statistics of the number of visits for Section 01, Section 02, and both sections combined, respectively. To investigate whether the tutors' presence in the classroom made a difference in attendance of tutoring sessions, we performed a t-test (two-sample assuming unequal variances) on the count of students from Section 01 (where no SI was present in class) and the count of students from Section 02 (where SIs were present in class) in each tutoring session. The p value (0.0016) is less than 0.01, indicating a significant difference in student attendance of tutoring sessions between the two sections. However, the numbers of students in Section 01 and Section 02 were different. The counts of students in each tutoring section are not comparable without normalizing the values. To normalize the values, we divided each count of Section 01 students showing up for a tutoring session by 19 (the total students in that section), and we divided each count of Section 02 students showing up for a tutoring session by 11 (the total students in that section). We then ran the same

Table 4
Descriptive Statistics of the Number of Visits

Statistic	Section 1	Section 2	Overall
Mean	07.14	10.6	8.05
Standard Error	1.89	4.27	1.76
Median	5.5	9	7
Mode	1	N/A	1
Standard Deviation	7.09	9.60	7.69
Sample Variance	50.28	92.3	59.27
Kurtosis	-0.51	-2.74	-1.02
Skewness	0.86	0.25	0.69
Range	20	21	21
Minimum	1	1	1
Maximum	21	22	22
Sum	100	53	153
Count	14	5	19
Confidence Level (95.0%)	4.09	11.92	3.71

Figure 1
Students and Number of Visits



t-test with the normalized values again, and obtained a p value that was about 0.690, indicating a non-significant difference in student attendance of tutoring sessions between the two sections. This indicates that the tutors' presence or absence in the classroom does not make an appreciable difference in attendance of tutoring sessions.

Student Grades

The student grades from CIS 225 in the fall 2019 semester were collected by the course instructor. In addition to the final scores, the major grade components for the course were also collected, including scores for assignments, quizzes, and exams. A student's final score for the course was calculated using the following formula: [Final Score] = 30% * [Assignment Score] + 10% * [Quiz Score] + 60% * [Exam Score].

Recall that the two peer-tutors only attended the afternoon section (i.e., Section 02) of the course. To investigate whether the tutors' presence in the classroom made a difference in improvements in student learning, we performed four t-tests (two-sample assuming unequal variances) on the assignment scores, quiz scores, exam scores, and final scores between students in Section 01 and students in Section 02. For each t-test, the input variables were the scores of each grade component from the two sections. However, none of the four t-tests generated significant results, indicating that there were no differences in improvements in student learning between the two sections. Table 5 shows the group statistics for assignment scores, quiz scores, exam scores, and final scores, as well as the t-test results (e.g., df, t, and p value) for equality of means of the two sections.

Student Survey

The "Peer-Tutor Project" survey contains six sections (see the survey in the appendix). The first section is the Introduction. It specified the purpose of the survey and assured students that their responses would be totally anonymous. The second section of the survey had only one question, which asked students to identify which CIS 225 section they were in. The results indicated that 19 students (63.33%) were in Section 01 (Tuesday & Thursday at 11 am – 12:15 pm, the morning section), and 11 students (36.67%) were in Section 02 (Tuesday & Thursday at 2 pm – 3:15 pm, the afternoon section).

The third section of the survey concerns student perceptions of the in-class tutors, and the fourth section is about student backgrounds. If a student chose Section 02 in the second section, the student was directed to the third section; otherwise, the student skipped the third section and passed directly to the fourth section of the survey. This means that only students who were in Section 02 took the third section, while all students participated in the fourth section. This is because the two in-class tutors only attended the afternoon section (i.e., Section 02).

There were three questions in the third section of the survey. Each question used a five-point Likert scale to determine the student's perception of the in-class tutors. The Likert scale ranged from 1, "strongly agree," to 5, "strongly disagree." For the statement "In-class tutors improved my learning experience," 8 students (72.73%) chose "strongly agree" or "agree." For the statement, "In-Class tutors provided timely assistance," 10 students (90.91%) chose "strongly agree" or "agree." For the statement "In-class tutors

Table 5
Group Statistics and T-Test Results

	Section	N	Mean	Std. Deviation	Std. Error Mean	df	t	p (2-Tailed)
Assignments	1	19	91.1	11.242	2.57	22	0.149	0.88
	2	11	90.5	10.682	3.22			
Quizzes	1	19	68.9	14.263	3.27	24	0.924	0.36
	2	11	64.4	11.824	3.56			
Exams	1	19	76.3	7.851	1.80	19	1.394	0.17
	2	11	71.8	8.816	2.65			
Final Scores	1	19	80.0	8.412	1.93	23	1.112	0.27
	2	11	76.7	7.548	2.27			

helped me better understand the class material," 9 students (81.82%) chose "strongly agree" or "agree." The student responses to these three statements indicated that on average 81.82% of the students thought in-class tutors provided timely assistance, helped them understand the class material, and improved their learning experience (see Figure 2).

The fourth section of the survey had nine questions, asking for information relating to student backgrounds. The entire survey results of this section are shown in Table 6. In regard to question one, 15 students (50.00%) identified their major as Computer Information Systems. The results to question two indicated that 22 students (73.33%) were male, and 8 (26.67%) were female. Question three indicated that 8 students (26.67%) were seniors and 19 (63.33%) were juniors. According to question four, 27 students (90.00%) were full-time students and 3 (10.00%) were part-time.

Figure 2
Student Perceptions of In-Class Tutors

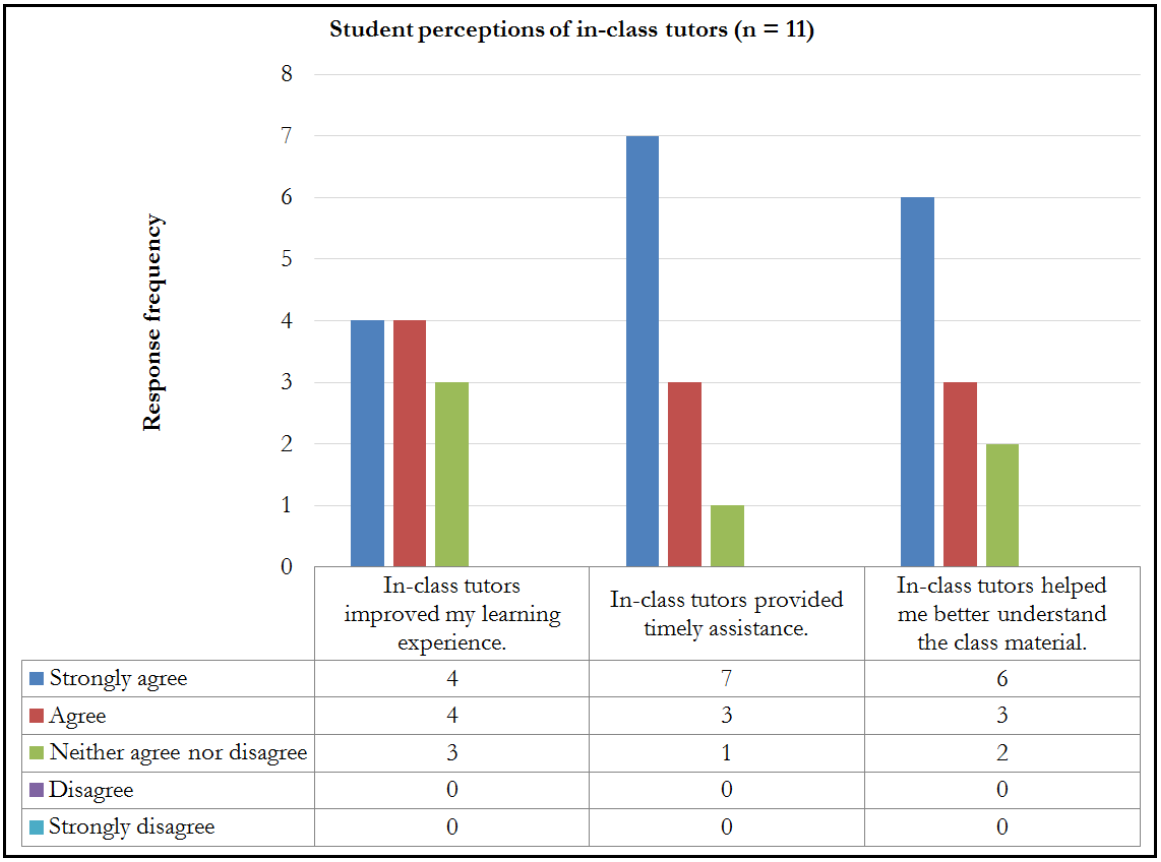


Table 6
Student Backgrounds

Question	Choice	Count	Percentage
Q1. What is your major?	Computer Information Systems (CIS)	15	50.0%
	Computer Science (CS)	1	3.3%
	Information Technology (IT)	4	13.3%
	Other (please specify)	10	33.3%
Q2. What is your gender?	Female	8	26.6%
	Male	22	73.3%
Q3. What is your current classification?	Freshman	0	0.0%
	Sophomore	2	6.6%
	Junior	19	63.3%
	Senior	8	26.6%
	Don't know	1	3.3%
	Other (please specify)	0	0.0%
Q4. Are you currently a full-time or part-time student?	Full-time	27	90.0%
	Part-time	3	10.0%
Q5. What is your age?	18 or younger	0	0.0%
	19-22	25	83.3%
	23-25	2	6.6%
	26 or older	3	10.0%
Q6. What is your current overall GPA?	1.49 or less	0	0.0%
	1.50 - 1.99	0	0.0%
	2.00 - 2.49	7	23.3%
	2.50 - 2.99	6	20.0%
	3.00 - 3.49	11	36.6%
	3.50 - 4.00	6	20.0%
Q7. Prior to this CIS 225 class, what was your programming experience?	None	11	36.6%
	Some	15	50.0%
	A fair amount	4	13.3%
	A lot	0	0.0%
	Expert	0	0.0%
Q8. What grade do you expect to get for this course?	A	4	13.3%
	B	15	50.0%
	C	10	33.3%
	D	1	3.3%
	F	0	0.0%
Q9. How often did you use the CIS 225 tutoring service this semester?	More than once a week	8	26.6%
	Once a week	4	13.3%
	Once every two weeks	4	13.3%
	Once a month	1	3.3%
	Once every two months	2	6.6%
	Never	11	36.6%

The results to question five showed that 25 students (83.33%) had an age of 19-22. Question six asked for the student's current overall GPA: 6 students (20.00%) replied with 3.50 – 4.00, and 11 (36.67%) responded with 3.00 – 3.49. Question seven asked for the student's programming experience prior to this CIS 225 class: 11 students (36.67%) said "none," and 15 (50.00%) said "some." Question eight asked for the student's grade expectation for the course using standard letter grades: 4 students (13.33%) expected an A, 15 (50.00%) expected a B, and 10 (33.33%) expected a C. Question nine - the last question in this section of the survey - asked how often the student used the CIS 225 tutoring service this semester: 8

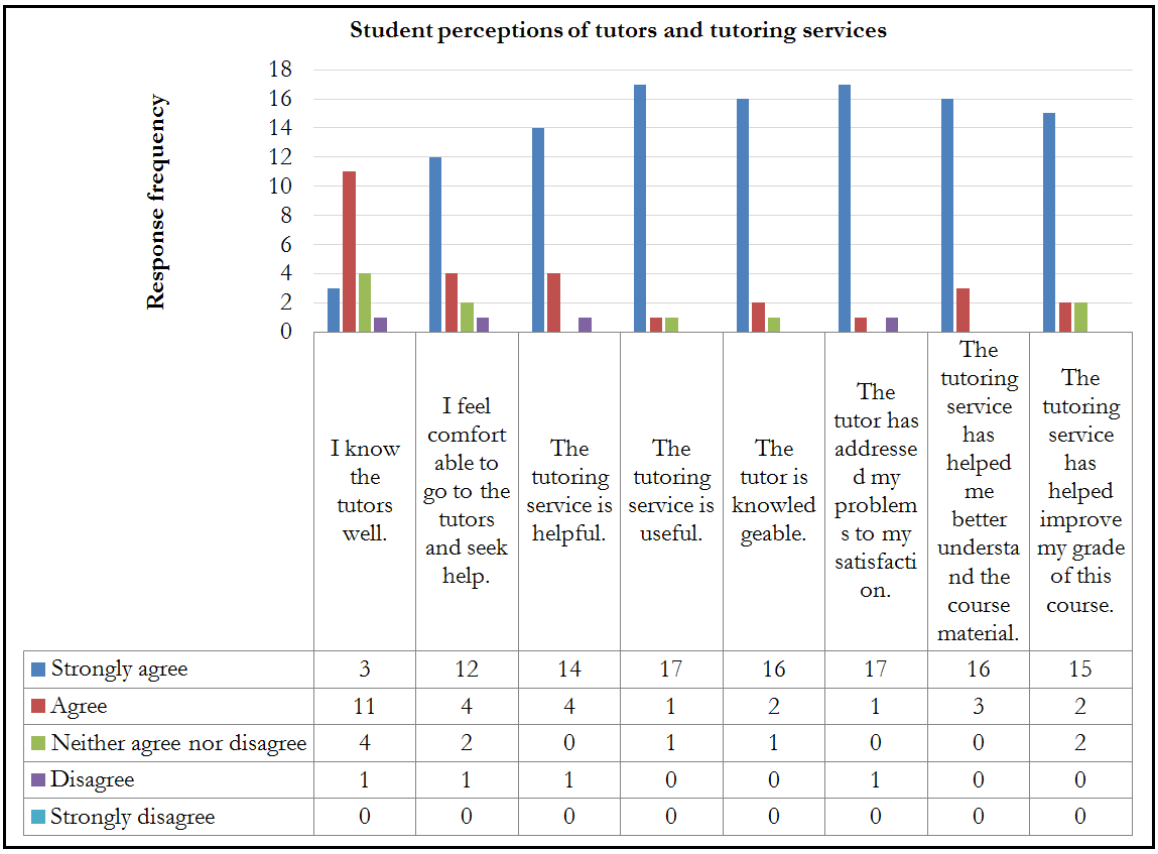
students (26.67%) said "more than once a week," and 11 (36.67%) said "never."

The fifth section of the survey concerns student perceptions of the tutors and tutoring services. If a student chose "Never" for the ninth question in the fourth section, the student skipped this section and was directed to the sixth section; otherwise, the student completed the fifth section and the survey ended there. This means that only students who had used tutoring services took the fifth section of the survey, while those who had never used tutoring services took the sixth section of the survey.

There were 11 questions in the fifth section of the survey, including two multiple-choice questions, eight Likert scale questions, and one essay question. The first question asked how many times the student used the CIS 225 tutoring service this semester: 4 students (21.05%) said "1-3" times, 4 (21.05%) said "4-6," 2 (10.53%) said "7-9," 2 (10.53%) said "10-12," and 7 (36.84%) said "13 or more." These responses aligned well with the tutor logs of actual visits. The second question asked when using the tutor service, on average, how many hours the student spent working on the homework independently, outside of the tutor session(s): 1 student (5.26%) said "0 hours," 4 (21.05%) said "1 hour," 9 (47.37%) said "2 hours," 2 (10.53%) said "3 hours," and 3 (15.79%) said "4 hours or more." The next eight questions (i.e., questions 3-10) used a five-point Likert scale to determine the student's perception of the tutors and tutoring services. The Likert scale ranged from 1, "strongly agree," to 5, "strongly disagree." The survey results of student perceptions of tutors and tutoring services are shown in Figure 3.

Figure 3

Student Perceptions of Tutors and Tutoring Services



	I know the tutors well.	I feel comfortable to go to the tutors and seek help.	The tutoring service is helpful.	The tutoring service is useful.	The tutor is knowledgeable.	The tutor has addressed my problems to my satisfaction.	The tutoring service has helped me better understand the course material.	The tutoring service has helped improve my grade of this course.
Strongly agree	3	12	14	17	16	17	16	15
Agree	11	4	4	1	2	1	3	2
Neither agree nor disagree	4	2	0	1	1	0	0	2
Disagree	1	1	1	0	0	1	0	0
Strongly disagree	0	0	0	0	0	0	0	0

All in all, the student responses to these eight statements indicated that on average about 90.79% of the students were satisfied with the tutors and tutoring services. The last question in this section of the survey asked the student to provide suggestions for tutors to make the tutoring sessions more effective. Some of the suggestions are as follows: (a) do more example problems, (b) go over course content, (c) increase tutoring hours during the week, (d) provide tutoring at different times on the same day if possible, and (e) offer weekend tutoring

To compare the differences in perception between students in Section 01 and students in Section 02 on the tutors and tutoring services, we performed eight t-tests (two-sample assuming unequal variances) on the student responses to the eight statements in the fifth section of the survey. For each t-test, the input variables were the mean of the responses from each of the two sections. However, none of the eight t-tests generated significant results, indicating that there were no perception differences between students in the two sections. Figure 4 shows the two group means and the p value for each of the eight t-tests, corresponding to each of the eight statements, respectively. One reason why no significant differences were present might be that the sample sizes were not large enough. There were 14 students (out of 19) in Section 01 that used the tutoring services, but only 5 students (out of 11) in Section 02.

Section six of the survey had one multiple-choice question, which asked those students who never used the tutoring service to choose a reason: 4 students (36.36%) chose "I don't need tutoring service for this course," none chose "I don't know there is a tutoring service for this course," 7 students (63.64%) chose "The available CIS 225 tutoring times don't fit my schedule," and none chose "Other (please specify)."

Discussion

In this paper, we attempted to address three questions. First, we wanted to know if the presence of a supplemental instructor (SI) in the classroom would have any impact on tutoring session attendance. Second, we endeavored to discover whether the presence of the SIs had an impact on student grades. Finally, we wanted to know how students rated their experience with peer tutors and the impact of supplemental instruction on their learning process and if there was any difference in attitudes between the section that included embedded SIs and the section that did not.

In an effort to answer research question number one, we collected attendance data at tutoring sessions throughout the semester. By way of statistical analysis, we found no significant difference in attendance of tutoring sessions between students who had an in-class tutor and those who did not. To address question number two, we analyzed all graded materials including assignments, quizzes, and exams. We also compared students' final scores for the course. There was no appreciable difference in the scores of the two sections. This may be due to our small sample size, but the performance of the two sections of students appears to be balanced. To address the final question, we collected survey data at the end of the semester. The survey data measured students' perception of peer tutor effectiveness. We found convincing results that suggest that students were overwhelmingly satisfied with their tutors and tutoring experience and that they perceived their tutoring experience as having been beneficial to their learning outcomes. However, statistical analysis indicated that there were no differences in perception between students in the two sections. As noted above, this may be due to our small sample size. However, unsolicited and anecdotal comments made to the professor corroborated the survey results which concluded that the overall attitudes toward the tutors and tutoring experience were positive.

Pedagogical Implications

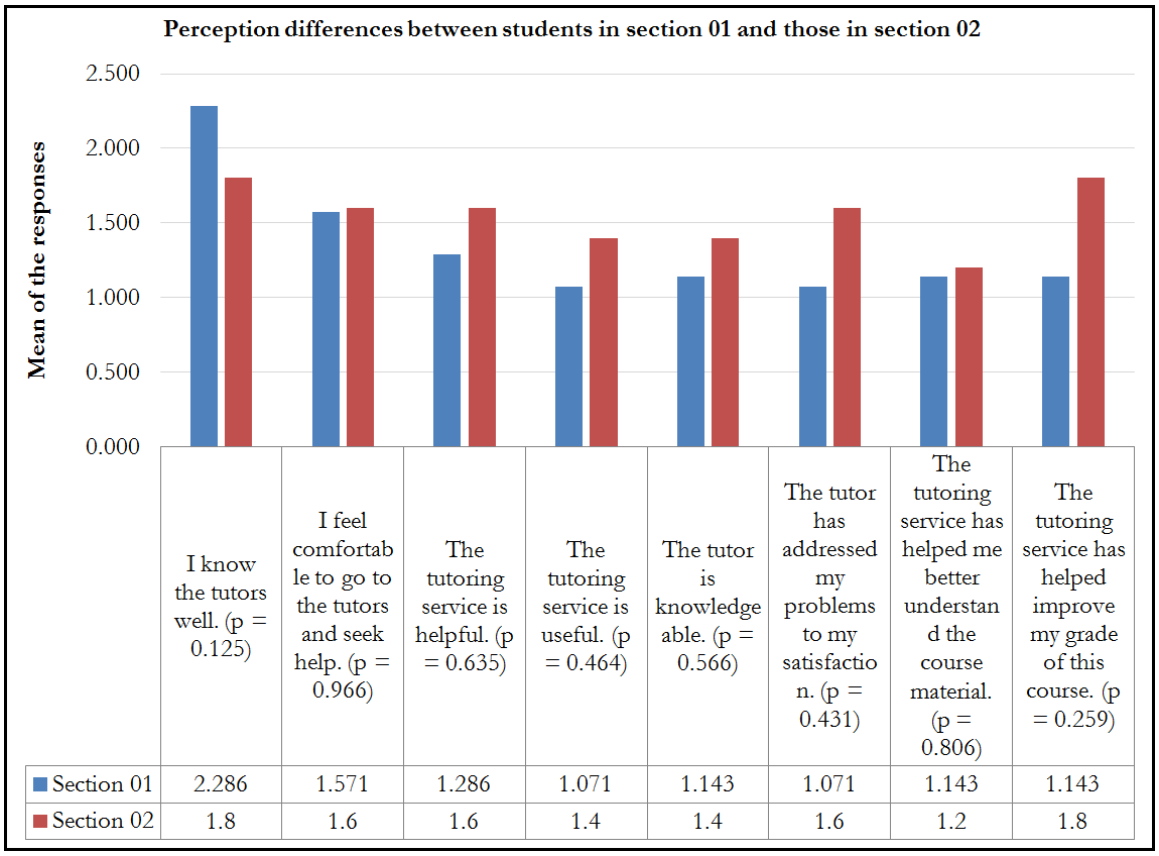
Since the in-class presence of tutors produced no observable impact on student grades, SI-led tutoring session attendance, or student perception of tutors, our research suggests that SI presence in the classroom could be made optional with no impact on these outcomes.

These results are especially important given their counter-intuitive nature. Specifically, an idea directly supported by the literature on SIs and peer tutoring is that trust relationships between tutors and students provide critical scaffolding for any possible successful outcome from peer tutoring (Colvin, 2007). It seems reasonable to assume that the presence of SIs in class would serve to familiarize students with their respective SIs. We would not have been surprised to identify that the in-class interaction between students and SIs would have constituted a quality interaction that put students more at ease with the SIs and helped better clarify the SIs' status as fellow students and learners instead of strictly as authority figures. These, again, were all concerns identified by the literature (e.g., Colvin, 2007). It also seems reasonable to assume that such an arrangement would serve to establish the "role clarity" that Abbot et al. (2018) identified as significant. However, our results subvert these expectations.

It is not our contention that prior findings in the literature are in any way in error or flawed. Testing these findings was never the objective of our research. However, what we can say is that the expected benefits from solving these issues could not be identified when we compared classes with embedded SIs against those

Figure 4

Perception Differences between Students in Section 01 and those in Section 02



	I know the tutors well. (p = 0.125)	I feel comfortable to go to the tutors and seek help. (p = 0.966)	The tutoring service is helpful. (p = 0.635)	The tutoring service is useful. (p = 0.464)	The tutor is knowledgeable. (p = 0.566)	The tutor has addressed my problems to my satisfaction. (p = 0.431)	The tutoring service has helped me better understand the course material. (p = 0.806)	The tutoring service has helped improve my grade of this course. (p = 0.259)
Section 01	2.286	1.571	1.286	1.071	1.143	1.071	1.143	1.143
Section 02	1.8	1.6	1.6	1.4	1.4	1.6	1.2	1.8

without. In other words, our results support the idea that merely having the SI present in class is not sufficient to address these issues. This is not a novel result in and of itself, but it is significant as it gives us a clearer idea of what constitutes the kind of quality interaction that could address these issues.

Still, based on our results strictly in comparing increased student engagement, student satisfaction, and academic outcomes, each SI could decide for themselves (along with input from the professor) if they would benefit from the lecture or not. As stewards of the university's scarce resources, we would argue that time spent by the SI in the classroom may not be of any value, assuming that the SI has indeed mastered the material.

The positive perceptions of the students in the morning section, who never had an SI in the classroom, further reinforces our conclusion that students in the role of an SI can have a positive impact on their mentees without attending each lecture.

Limitations and Future Research

Our study was confined to a single class, composed of two sections, within the same, single semester. A similar longitudinal study involving more students may produce different results. However, we did our best to keep as many other variables as possible (e.g., the instructor, lecture agendas, and course content) constant.

By design, the SIs were not used to their full potential as tutors in the classroom. Since the two sections did not both have tutors, the course was designed to not bias the results by having two separate lecture agendas, as mentioned above. The research (Colvin, 2007) suggests that one of the main success factors for using SIs is a strong relationship between students and their peer-tutors. One could easily imagine a class arrangement different from ours that was more conducive to fostering such relationships. This notion suggests a prime area for future investigation.

As is typical at a regional university, a significant number of students claimed scheduling issues that prevented them from attending the tutoring sessions. A significant number of our students hold part-time or full-time jobs during the school year. These are variables that are difficult to control for.

Additionally, this course is an introductory programming course (using Python) that is primarily designed for information systems, information

technology, and geographic information systems majors who typically enroll in the course during their sophomore year. It is occasionally chosen as an elective by students from other departments including, but not limited to, computer science, engineering technology, management, marketing, English, and education. Consequently, the age of the students is skewed older and the average student's interest in and motivation surrounding technology are shifted compared to typical CS1 courses.

Concluding Remarks

Although we did not discover a significant difference between the two sections in terms of improved student outcome, we did find that our students were very satisfied with their interactions with the peer tutors and they perceived those interactions as very beneficial. As stewards of the university's scarce resources and in opposition to conventional wisdom, it is valuable to know that our students may be able to enjoy the benefits that peer tutors can provide without requiring SI attendance in the classroom.

References

Abbot, S., Graf, A. J., & Chatfield, B. (2018). Listening to undergraduate peer tutors: Roles, relationships, and challenges. *International Journal of Teaching and Learning in Higher Education*, *30*(2), 245-261.

Arco-Tirado, J. L., Fernández-Martín, F. D., & Fernández-Balboa, J.-M. (2011). The impact of a peer-tutoring program on quality standards in higher education. *Higher Education*, *62*(6), 773-788. https://doi.org/10.1007/s10734-011-9419-x

Arco-Tirado, J. L., Fernández-Martín, F. D., & Hervás-Torres, M. (2019). Evidence-based peer-tutoring program to improve students' performance at the university. *Studies in Higher Education*, *45*(11), 2190-2202. https://doi.org/10.1080/03075079.2019.1597038

Chen, C., & Liu, C.-C. (2011). A case study of peer tutoring program in higher education. *Research in Higher Education Journal*, *11*, 1-10. https://doi.org/10.1080/03075079.2019.1597038

Clarkson, B., & Luca, J. (2002). Promoting student learning through peer tutoring – A case study. In P. Barker & S. Rebelsky (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications 2002* (pp. 1176-1181). AACE.

Colvin, J. W. (2007). Peer tutoring and social dynamics in higher education. *Mentoring & Tutoring: Partnership in Learning*, *15*(2), 165-181. https://doi.org/10.1080/13611260601086345

Erdei, R., Springer, J. A., & Whittinghill, D. M. (2017). An impact comparison of two instructional scaffolding strategies employed in our programming laboratories: Employment of a supplemental teaching assistant versus employment of the pair programming methodology. *Proceedings of the 2017 IEEE Frontiers in Education Conference* (pp. 1-6). IEEE. https://doi.org/10.1109/FIE.2017.8190650

Feijóo-García, P. G., & Ortíz-Buitrago, C. H. (2018). The godparent plan: A pedagogical strategy for CS1 accompaniment and CS2 pedagogical enhancement. *International Journal of Engineering Pedagogy*, *8*(1), 43-55.

Fong, L. S. (2016). Facilitating group analysis of two case studies utilising peer tutoring: Comparison of tasks and outcomes. *Journal of Educational Issues*, *2*(2), 90-99.

Gerhardt, J., & Olan, M. (2010). Peer tutoring in programming: Lessons learned. *Information Systems Education Journal*, *8*(39), 3-9.

Golding, P., Facey-Shaw, L., & Tennant, V. (2006). Effects of peer tutoring, attitude and personality on academic performance of first year introductory programming students. *Proceedings of the 36th Annual Conference of Frontiers in Education* (pp. 7-12). IEEE. https://doi.org/10.1109/FIE.2006.322662

Han, K.-W., Lee, E., & Lee, Y. (2010). The impact of a peer-learning agent based on pair programming in a programming course. *IEEE Transactions on Education*, *53*(2), 318-327. https://doi.org/10.1109/TE.2009.2019121

Holt, L. J., & Fifer, J. E. (2018). Peer mentor characteristics that predict supportive relationships with first-year students: Implications for peer mentor programming and first-year student retention. *Journal of College Student Retention: Research, Theory & Practice*, *20*(1), 67-91. https://doi.org/10.1177/1521025116650685

Kentros, S., Wadhwa, M., Sreeramareddy, L., Kaur, K., Ebenfield, M., & Shwedel, A. (2019). Course redesign to improve retention: Finding the optimal mix of instructional approaches. *Journal of Computing Sciences in Colleges*, *34*(6), 97-106.

Liu, Y., Phelps, G., & Yan, F. (2019). Developing a guided peer-assisted learning community for CS students. *Journal of Computing Sciences in Colleges*, *34*(7), 72-80.

Martin, D. C. (1977). *The learning center: A comprehensive model for colleges and universities*. Aquinas College. ERIC ED 162294.

Munley, V. G., Garvey, E., & McConnell, M. J. (2010). The effectiveness of peer tutoring on student achievement at the university level. *The American Economic Review*, *100*(2), 277-282.

Porter, L., & Simon, B. (2013). Retaining nearly one-third more majors with a trio of instructional best practices in CS1. *Proceeding of the 44th ACM Technical Symposium on Computer Science Education* (pp. 165-170). ACM. https://doi.org/10.1145/2445196.2445248

Robins, A., Rountree, J., & Rountree, N. (2003). Learning and teaching programming: A review and discussion. *Computer Science Education*, *13*(2), 137-172. https://doi.org/10.1076/csed.13.2.137.14200

Song, Y., Loewenstein, G., & Shi, Y. (2018). Heterogeneous effects of peer tutoring: Evidence from rural Chinese middle school. *Research in Economics*, *72*, 33-48. https://doi.org/10.1016/j.rie.2017.05.002

Topping, K. J. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. *Higher Education*, *32*(3), 321-345. https://doi.org/10.1007/BF00138870

Topping, K. J. (2020). Peer tutoring and cooperative learning. *Oxford Research Encyclopedia of Education*. https://doi.org/10.1093/acreforce/9780190264093.013.1432

Weikle, D. A. B. (2016). More insights on a peer tutoring model for small schools with limited funding and resources. *Journal of Computing Sciences in Colleges*, *31*(3), 101-109.

Zhang, X., Crabtree, J. D., Terwilliger, M. G., & Jenkins, J. T. (2020). Teaching introductory programming from A to Z: Twenty-six tips from the trenches. *Journal of Information Systems Education*, *31*(2), 106-118.

JOHN D. CRABTREE is a Professor in the Department of Computer Science & Information Systems at the University of North Alabama. He graduated with a Ph.D. in Mathematical and Computer Sciences from the Colorado School of Mines. His areas of instruction include programming, algorithms, architecture, and software engineering. In addition to computing-related pedagogy, he has published research related to data structures and algorithm development in cheminformatics.

XIHUI "PAUL" ZHANG is Professor of Computer Information Systems in the College of Business and Technology at the University of North Alabama in Florence, AL. He received his B.S. and M.S. degrees in Earth Sciences from Nanjing University (1993, 1996), Nanjing, China, and his M.S. and Ph.D. degrees in Management Information Systems from the University of Memphis (2004, 2009), Memphis, TN. His work has appeared in journals such as the *Journal of Strategic Information Systems*, *Information & Management*, *Journal of Database Management*, and *ACM Transactions on Software Engineering and Methodology*, among others. He is currently the Editor-in-Chief of the *Journal of Information Systems Education*.

DANIEL A. RAY is an Associate Professor in the Department of Computer Science & Information Systems at the University of North Alabama. He graduated with a Ph.D. in Computer Science from the University of Alabama. He teaches classes on a broad spectrum of computer science areas with special focus on early programming, algorithms, and digital forensics and information security. He researches in these area as well as public computer science education and outreach. He has been active in the areas of computer science research, teaching, and outreach since 2007.

Appendix

Peer-Tutor Project Survey

Section 1. Introduction

This survey is about your perceptions of the CIS 225 tutors and the tutoring service. Please answer all the questions as accurately as possible. Note that your responses will be totally anonymous. We appreciate your time and effort. Thank you.

Section 2. Two sections

Q1: Which CIS 225 section are you in?

- Section 01: Tuesday & Thursday at 11 am - 12:15 pm
- Section 02: Tuesday & Thursday at 2 pm - 3:15 pm

(Note: If a student chooses Section 02, the survey will take the student to Section 3; otherwise, the student will go on to Section 4.)

Section 3. In-class tutors

Q1: In-class tutors improved my learning experience.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q2: In-class tutors provided timely assistance.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q3: In-class tutors helped me better understand the class material.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Section 4. Your background

Q1: What is your major?

- Computer Information Systems (CIS)
- Computer Science (CS)
- Information Technology (IT)
- Other (please specify)

Q2: What is your gender?

- Female
- Male

Q3: What is your current classification?
- Freshman
- Sophomore
- Junior
- Senior
- Don't know
- Other (please specify)

Q4: Are you currently a full-time or part-time student?
- Full-time
- Part-time

Q5: What is your age?
- 18 or younger
- 19-22
- 23-25
- 26 or older

Q6: What is your current overall GPA?
- 1.49 or less
- 1.50 - 1.99
- 2.00 - 2.49
- 2.50 - 2.99
- 3.00 - 3.49
- 3.50 - 4.00

Q7: Prior to this CIS 225 class, what was your programming experience?
- None
- Some
- A fair amount
- A lot
- Expert

Q8: What grade do you expect to get for this course?
- A
- B
- C
- D
- F

Q9: How often did you use the CIS 225 tutoring service this semester?
- More than once a week
- Once a week
- Once every two weeks
- Once a month
- Once every two months
- Never

(Note: If a student chooses Never, the survey will take the student to Section 6 and then ends; otherwise, the student will go on to Section 5 and then the survey ends there.)

Section 5. Perceptions of the tutors and tutoring services

Q1: How many times did you use the CIS 225 tutoring service this semester?

- 1-3
- 4-6
- 7-9
- 10-12
- 13 or more

Q2: When I used the tutor service, I spent _____, on average, working on the homework independently, outside of the tutor session(s).

- 0 hours
- 1 hour
- 2 hours
- 3 hours
- 4 hours or more

Q3: I know the tutors well.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q4: I feel comfortable to go to the tutors and seek help.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q5: The tutoring service is helpful.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q6: The tutoring service is useful.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q7: The tutor is knowledgeable.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q8: The tutor has addressed my problems to my satisfaction.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q9: The tutoring service has helped me better understand the course material.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q10: The tutoring service has helped improve my grade of this course.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

Q11: Please provide some suggestions for the tutors that can make their tutoring sessions more effective.

Section 6. Reasons for never using the tutoring service

Q1: I have NEVER used the CIS 225 tutoring service this semester. This is because:

- I don’t need tutoring service for this course
- I don’t know there is a tutoring service for this course
- The available CIS 225 tutoring times don’t fit my schedule
- Other (please specify)