Peer learning assistants in undergraduate computer science courses

Inna Pivkina
Department of Computer Science
New Mexico State University
Las Cruces, NM, USA
inna@nmsu.edu

***Abstract* — The paper describes the experience of using undergraduate students as peer learning assistants (PLAs) in different undergraduate computer science courses which have graduate teaching assistants (TAs) as well. Depending on the course, PLAs have some of the following roles - holding office hours, helping with the labs and tutorials, facilitating student group work in class. The impact of PLAs on student learning outcomes is assessed by comparing student grades in the offerings of the course with and without PLAs and comparing the numbers of student visits outside of the class meeting times to the instructor, to the TAs, and to the PLAs. In addition to that, questionnaires are used to solicit feedback from students and PLAs about their experience. We find that the use of PLAs results in statistically significant increase in student course grades and decrease in the number of non-passing grades. Student experiences with PLAs are very positive. Many students prefer to seek help from the PLAs rather than from the TAs or instructor. PLAs report that the experience was beneficial to them, too. The paper discusses benefits of using PLAs, student preferences regarding PLAs and TAs, and what practices worked best.**

***Keywords* —** peer learning assistants; undergraduate education; computer science education

I. INTRODUCTION

Collaborative learning and peer tutoring has been known to be successful methods to improve student learning for quite a while [5][2]. Learning activities that involve peer discussions increase student engagement in the course and learning [6].

Peer facilitators have been successfully used in different ways in various disciplines. For instance, peer-facilitated workshops led to increased student learning in introductory biology courses [9][11]. Students in the workshop version of the course got higher scores on exams and higher overall course scores than students in semesters without the workshops [9][11]. Another successful model of using peers is peer-led team learning [4] that originated in a chemistry course. It uses peer facilitated group discussion as an integral course component [4]. A number of authors described benefits of undergraduate teaching assistants [3][7][10][12]. Different models for undergraduate student-assisted teaching are presented in [8].

Peer learning assistants (PLA) are undergraduate students who are helping students learn in the courses that PLAs recently took themselves. The paper describes a successful use of PLAs in computer science courses which have graduate teaching assistants (TAs), too. It also demonstrates that many students prefer peer learning assistants to the graduate teaching assistants.

II. PLA PROGRAM AT NEW MEXICO STATE UNIVERSITY

In 2014 the College of Arts & Sciences at New Mexico State University (NMSU) received President's Performance Funds to start a Peer Learning Assistants Program [1]. The program pays undergraduate students to work as peer learning assistants for courses that they recently took themselves. The role of PLAs is to help students learn in the course. A faculty member who wishes to participate in the program submits an application for PLAs in their course where they explain the need of having PLAs for the course, how PLAs will be used, how student learning will be assessed, etc. Once application is approved for a course, the faculty member selects PLA(s) from student applicants. One of the requirements of the program is that faculty members meet with their PLAs on a weekly basis.

The author has been participating in the program since it started in Fall 2014 semester. The following section describes in what computer sciences courses PLAs were employed and in what roles.

III. HOW PLAS WERE USED

The author had PLAs in three different courses: data structures and algorithms (CS 372), computer science I (CS 172), and discrete mathematics for computer science (CS 278). The structure of the courses and how exactly PLAs were used in each of them is explained below.

A. Data Structures and Algorithms Course

Data structures and algorithms (CS 372) is a 4 credit hour course with lectures and a 50-minute lab. It is mostly theoretical course. During lectures the material is presented in a typical lecture style. The lab meets in a regular classroom and it is a tutorial (a recitation session). In the labs students are practicing solving problems on paper in small groups. Enrollment is usually about 20 students per semester. One graduate teaching assistant (TA) is helping with the course. The duties of the TA are to conduct the labs, hold office hours, and do some grading.

The author taught the course in exactly the same manner, with very similar assignments and exams in the following five semesters: Spring 2013, Fall 2013, Spring 2014, Fall 2014, and Fall 2015. PLAs were used in the last two semesters (Fall 2014 and Fall 2015) only.

In Fall 2014 the duties of the PLA were to attend the labs and to hold office hours. In the labs PLA was helping students work on problems; however, all explanations in front of the whole class were done by the TA. As it turned out that was not the best way to use a PLA. Despite multiple announcements, some of the students did not realize that there was a PLA in the course until the middle or even the end of the semester.

In Fall 2015 PLA was more involved in student learning in the labs. The instructor prepared exercises for the labs while TA and PLA took turns explaining the exercises in front of the class. The TA or the PLA would tell the students what needs to be done, then both of them would walk around the classroom helping students solve the problem in groups, then the TA or the PLA would discuss solutions to the problem with the whole class. This was a better way of using the PLA and it resulted in a much lower rate of non-passing grades (6.7%) in the course comparing to Fall 2014 semester (23.5%). The PLA was also holding office hours for students to come and get help on the course.

B. Discrete Mathematics for Computer Science Course

Discrete Mathematics for Computer Science course (CS 278) covers mathematical concepts that are used in computer science courses. The course has lectures and one two-hour lab (in a computer lab) a week. In the lectures students do a lot of collaborative work in groups where they apply concepts that are being taught. In the labs students write programs that implement some of the concepts from the course and use them to solve some practical problems. Enrollment in the course is about 30 students per semester.

The author taught the course in the same manner with very similar assignments and exams two times: in Spring 2014 (without PLA) and in Fall 2015 (with PLA). Both times there were two TAs in the course. The duties of the TAs were to conduct the labs, hold office hours, and do some grading.

When PLA was helping with the course (in Fall 2015), their duties were to help with student collaborative group work in the lectures, help students with programming in the labs, and hold office hours. All of these activities were successful and helped students learn in the course. The rate of passing grades increased in the course offering with a PLA as demonstrated in the next section. Students gave excellent evaluations to the PLA.

C. Computer Science I course

Computer Science I course (CS 172) is the first programming course for computer science majors where they start learning programming. Beginner programmers often need a lot of help as they get easily stuck on simple things like missing a ';' and they do not know yet how to find and fix errors. The course has lectures and one two-hour lab (in a computer lab) a week. In the labs students learn programming by actually writing programs. Each individual program is unique. Helping individual students takes time. While some students are being helped the other students who need help could be waiting for their turn to get help as they get stuck and cannot move on. Enrollment in the course is about 40 students per section of the course.

The author taught the course only two times, in Fall 2014 and in Spring 2015. Both times there were two TAs and one PLA in the course. The duties of the TA were to conduct the labs, hold office hours, and do some grading. The duties of the PLA were to help students in the labs and to hold office hours. The PLA's office hours were right after the labs with some additional hours throughout the week. Having PLA's office hours after the labs was very helpful for students because they were already in the groove of working on the assignment and could get extra help in case they ran out of time in the lab. Students used PLA's office hours after the labs much more than they used PLA's office hours at other times.

IV. Impact of PLAs on Student Learning

The impact of PLAs on student learning was assessed by comparing students' course scores and course passing rates in the semesters when PLAs were used and when PLAs were not used and by comparing the number of student office hours visits to PLAs versus TAs and instructor. Anonymous questionnaires were used to get feedback from students. PLAs were also asked to describe their experiences. Comparison of students' course scores and course passing rates were only done for courses which the author taught with and without PLAs, that is, data structures and algorithms course and discrete mathematics for computer science course.

A. Student scores in the course increase

Average student course scores increased when a PLA was helping with the course. Data from four semesters of data structures and algorithms course was used for comparison: two semesters without PLAs (Fall 2013, Spring 2014) and two semesters with PLA (Fall 2014 and Fall 2015). Data from Spring 2013 was not used because numeric scores were not available for that semester (only letter grades were saved). The average of student scores in the course in the two semesters when PLA was not helping was 71.38 (out of 100). The average of student scores in the course with PLA was 77.57 (out of 100). The difference is statistically significant at $p < .05$. It was evaluated using a one-tailed two-sample *t* test.

B. Number of non-passing grades(D/F/W) decrease

Students have to get a course grade of C- or better in order for the course to count towards their degree. Students who get grades D, F (fail), or W (when they withdraw the course) have to take the course again. Therefore, grades D/F/W are non-passing grades. Data shows that rates of non-passing grades in a course decrease when PLAs are helping with the course.

For discrete mathematics course, the rate of D/F/W grades decreased from 33% (in Spring 2014 without PLA) to 20.6% (in Fall 2015 with PLA).

For data structures and algorithms course, the rate of non-passing grades in the five semesters the course was taught is the following:

- 30.4% in Spring 2013 (no PLA),
- 31.8% in Fall 2013 (no PLA),
- 38.1% in Spring 2014 (no PLA),
- 23.5% in Fall 2014 (with PLA),
- 6.7% in Fall 2015 (with PLA).

The rates of D/F/W grades in data structures and algorithms course offerings with PLA is less than in the course offerings without PLA. The difference was evaluated using a one-tailed two-sample *t* test. It is statistically significant at $p < .05$.

C. Students use PLA's office hours more often than instructor's or TA's office hours

PLAs, TAs, and instructor had office hours and kept tally on how often it was used. Only student visits where students got help with course material or assignments were counted. Visits where students were discussing grading were not counted. Fig. 1 contains the data on office hours visits to PLAs, TAs, and instructor for all the courses where PLAs were used.

Semester and course	Number of office hours visits by students		
	to the PLA(S)	*to the TA(s)*	*to the instructor*
CS278 Fall 15	13	0	4
CS372 Fall 14	24	15	n/a
CS372 Fall 15	8	12	31
CS172 Fall 14	52	18	5
CS172 Spr 15	78	3	0

Fig. 1. Number of office hours visits by students

The only time when there were fewer student visits to PLA comparing to student visits to TA and instructor was in CS 372 in Fall 2015. This was because the times of PLA's office hours were not convenient for students. Due to scheduling restrictions, the PLA was not able to have office hours a day before assignments were due; while the instructor and the TA had office hours a day before assignments were due. That was the main reason why PLA got fewer visits.

For all other courses, PLAs got much more visits than TAs and instructor. The most number of visits to PLAs was in 100-level course (CS 172). It may be reflecting the fact that younger students tend to feel intimidated by TAs and professors and feel more comfortable getting help from peers.

The data demonstrates that when given a choice, most students prefer to seek help from PLAs rather than from TAs or the instructor.

D. Student Reactions

Anonymous questionnaires were used to solicit student reactions to PLAs. Students' responses were very positive. A small percentage of students stated that they did not use PLAs; everybody else said that PLAs were helpful. A number of students wrote that they preferred PLAs to the instructor and the TAs. The following are some representative quotes from students on the benefits for having a PLA:

- "offered alternative ways of thinking about and approaching problems",
- "The greatest benefit of having a PLA is the fact that they have recently completed the class we are taking. … I feel that the TAs and professor both have much more experience in the CS field and have more difficulty in understanding the difficulties the students have. The PLAs seem to be much better at solving problems because it is something they struggled with as well",
- "They provide explanations easier to comprehend since they understand better our position as students",
- "There is less stress for professor, and there is more help for students",
- "Having a peer help you understand the material is less intimidating than having an instructor in a one on one meet",
- "… I found him to be less intimidating than the TA".

When asked about suggestions on the use of PLAs, students responses mostly included having more PLAs, PLAs having more office hours, and having PLAs in other courses. Some students wrote that they would like to have PLAs help instructor with lectures, so that PLAs present some of the lecture material.

E. PLAs benefit, too

All PLAs reported that they had a very rewarding experience. They enjoyed helping students learn. They reinforced their own knowledge of the material. They gained experience working with people and presenting material in front of the classroom (in some courses). Some of them said that they felt better integrated into the department. All of them mentioned that they would like to do it again in the future.

On several occasions students taking courses with PLAs asked me if they could work as PLAs in future offerings of the course. This indicates that students see the benefits of being a PLA. When the author first started using PLAs there were just a few student applicants for PLA positions. As more and more students became familiar with PLAs and took courses with PLAs, the number of applications for PLA positions significantly increased.

F. Benefits to TAs and instructors

Having PLAs is definitely beneficial for TAs and instructor. PLAs help students learn by answering their questions, providing them with alternative explanations of the material, helping with assignments. That makes it easier for the

instructor and the TAs to teach. Another benefit is that instructor and TAs spend less time answering students' questions and helping students as many students prefer to get help from the PLAs. PLAs can also provide input on assignments (whether or not assignments are too hard or too easy, whether some parts of assignment are unclear) before they are posted for students. Some PLAs made suggestions on how to improve the course they were helping with.

LESSONS LEARNED

After the first semester of using PLAs the author learned from student evaluations that some of the students in the courses did not know that there was a PLA for the course or learned about it late in the semester. This is despite the fact that the PLA program was explained in the first lectures and the PLA information was listed on the course web page. It is important to mention PLAs much more often and let them be more involved in student learning so all of the students know who they are and work with them.

A student does not have to excel academically to be a great PLA. One of the PLAs the author used was not an A student and got B in the course they were helping with when they took it themselves. He did an excellent job as a PLA and students loved him.

It is very important to choose PLA office hours at times that are convenient for students. Having office hours a day before assignments are due works well. For programming courses with labs, having PLA office hours right after the lab is very good. This allows students to stay in the lab longer to finish assignments. Having office hours right before the lab works well, too.

Some students wrote in the evaluations that they would like to have PLAs explain some of the material during the lectures, too. That would presumably allow students to understand what they missed from instructor's presentation. This is something that the author may try to incorporate in the future.

CONCLUSION

Having PLAs for computer science courses has proved to be very beneficial for student learning. It resulted in statistically significant increase in student course scores and reduction of the number of non-passing course grades. Many students prefer to get help from PLAs rather than from the TAs or instructor. The use of PLAs is beneficial for all parties involved – students, PLAs, TAs, and instructor.

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