AC 2008-1154: ENHANCING PEER-LED TEAM LEARNING THROUGH COOPERATIVE LEARNING

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Enhancing Peer-Led Team Learning in Computer Science through Cooperative Learning

Abstract

Peer teaching and peer mentoring is in use at many colleges and universities in the United States in an effort to improve undergraduate education. At the University of Texas at El Paso (UTEP), peer-led team learning (PLTL) is being used in the Departments of Chemistry, Mathematics, and Computer Science (CS). In CS, we have enhanced the traditional PLTL sessions by incorporating active learning and cooperative learning in the PLTL sessions. Early evaluation of the data suggests that this approach is effective in improving the competency of students and reducing the failure rate in the early CS sequence.

Introduction

According to the U.S. Department of Labor, computer sciences are expected to be among the fastest growing occupations in the next decade[1]. The U.S. economy added 150,000 technology-related jobs in 2006 alone. However, according to the Computing Research Association[2], between Fall 2000 and Fall 2005, newly declared Computer Science (CS) majors have declined nearly 70 percent. Furthermore, Cohoon and Chen[3] reported that the attrition rate among computer science majors is on the rise at a rate of 16 percent. "Not surprisingly, attrition was highest among first- and second-year students. Freshmen and sophomores migrated out of the computer science major each year at an average rate of 19 percent." (p. 2). This strongly suggests that the critical juncture for computer science majors is early in the program.

This notion supports the identification of the first three semester-long courses in the computer science program as critical by faculty at UTEP. These courses are CS1: Introduction to Computer Science; CS2: Programming and Algorithms; and CS3: Data Structures. From entry into CS1 to progression through CS3, the average passing rates has been less than 70 percent. To counter this barrier, we began a program to apply effective, research-based retention strategies that actively engage CS students in their learning. The long-term goal is to increase the number of highly qualified students who graduate with degrees in CS from UTEP.

The overall strategy is to foster a culture of scholarship among students at all levels through effective teaching and learning approaches in the introductory CS sequence where students must acquire deep understanding of the key fundamental concepts in CS for success later in the program. Specifically, Peer-Led Team Learning (PLTL)[4, 5] is the mechanism we have adopted and adapted to foster this culture of scholarship. It is a proven model for involving and retaining students through the creation of an active learning experience for students and leadership roles for peer facilitators. PLTL workshops in CS1, CS2, and CS3 provide timely assistance to students in learning the key course concepts that the students and instructors have identified as essential.

PLTL was originally developed at the City University of New York and has been used at over 90 colleges and universities[6]. In PLTL, peer leaders conduct weekly workshop sessions to engage

students in problem solving exercises and discussions. Peer leaders are typically students who have recently done well in the course for which they conduct workshops. Peer leaders attempt to facilitate learning not by answering questions, but by guiding students to actively engage with the material and with other students. PLTL is based on the idea that peers, i.e., other students who have recently completed the course, can assist students in learning.

While PLTL has been suggested as an alternative to cooperative learning [7], our adaptive approach is to combine PLTL with cooperative learning techniques to establish and nurture learning communities.[8] We recruit students with an interest in helping other students. These are not necessarily the students with the highest grades in the courses, but are instead students recruited based on their willingness and ability to work in teams dedicated to problem solving. Our view is that as peers, the students leading the sessions are not domain experts: they are not responsible for providing answers. Their job is to create the environment necessary for students to learn through inquiry and discourse.

Learning Communities

At UTEP a group of faculty members have implemented and refined an approach using the Affinity Research Group Model (ARG)[9] in the research setting. In this model a set of fundamental principles and effective practices using the essential elements of cooperative learning[8] emphasize the conscious development of students' disciplinary knowledge, research, and skills. The ARG model helps a faculty member to create a learning community. Learning communities in education has recently gained popularity due to its potential to transform learners in ways that are meaningful and enduring[10-16]. This notion holds for engineering education as well as classrooms, laboratories, and research groups are shifting from teacher-centered to student-centered approaches as illustrated, for example, by several authors [17-20]. These studies demonstrate how communities of learners can improve student learning and enhance interdisciplinary teams.

Learning communities can be characterized by several features: members are positively interdependent [13, 16, 21]; they exercise collective decision making and share a common vision that all members value and internalize; and they are democratic empowering academic cultures [22-25]. Positive interdependence occurs when members give and receive "considerable social support, both personally and academically" as they help each other achieve their and the group's goals [16, p. 3:12]. The group's actions and behaviors reflect their common values as they accomplish their goals together through reflection and discourse [16, 23-25].

The faculty members at UTEP have transferred key features of the ARG model to the PLTL model and are using it to support students who are in their first three semesters of the computer science course sequence. This enhanced model maintains attributes of the traditional PLTL model; however, cooperative learning elements are embedded throughout all aspects of the enhanced model to include both the staff development activities and the PLTL sessions.

Cooperative Learning

Five basic elements must be present for a group to function cooperatively: positive interdependence, face-to-face promotive interaction, individual and group accountability, professional skills, and group processing[8]. Positive interdependence ensures that each member of the group has a personal stake in the success of the group. Promotive interaction is the result of students sharing ideas and resources with each other and working together to bring out the best in each other. Individual and group accountability holds each student responsible for making tangible contributions to the team effort and each team responsible for delivering the required work. The professional skills component of cooperative learning attempts to teach students how to work together in teams. Faculty mentors should not assume that students come with these skills. It is not sufficient to simply put students together in a group setting and assume that they will learn to work effectively together any more than it is sufficient to give elementary school students a set of mathematics problems and assume that they will learn to add and subtract. Group processing encourages students to reflect on how well they are achieving their goals and how well each group is functioning. This reflection will guide the group members to determine how individual and group behaviors must change.

Adaptive PLTL

While the original PLTL workshops have been successful, they can be improved through the use of cooperative learning. Original PLTL workshops have six essential components[26]: (1) The PLTL workshop is integral to the course; (2) faculty and peer leaders work together to prepare workshops and train peer leaders; (3) peer leaders are well trained; (4) workshop materials are challenging and at an appropriate level; (5) organizational arrangements promote learning; and (6) the department administration encourages innovative teaching. In the standard setting, a peer leader works with six to eight students during weekly workshop sessions. The peer leader meets with the same students each week.

Our approach to PLTL is modeled after a successful HP-funded project in the UTEP Department of Electrical and Computer Engineering (ECE) that targeted a gatekeeper course in the program. This project employed these essential elements of PLTL with one defining difference: the intentional and deliberate integration of cooperative learning techniques. Research has shown that these techniques (a) enhance achievement through development of higher-level reasoning skills; (b) facilitate closer relationships among students; (c) promote greater acceptance of differences; and, (d) develop higher self-esteem[16]. Many features of UTEP PLTL workshops in CS are similar to the original PLTL sessions. They are weekly, mandatory, problem-based sessions where students meet with trained peer facilitators who are undergraduates with demonstrated proficiency in targeted courses. The process requires the peer facilitators to develop and conduct workshop sessions to focus on key concepts that students are having difficulty understanding. Sessions are designed by the peer leaders in consultation with the faculty and graduate teaching assistants responsible for the course.

The adaptive PLTL differs from traditional PLTL. Peer leaders are responsible for working with faculty on a weekly basis to identify workshop topics with which students taking the course are having difficulty. These topics may be the newest material covered in lecture, remedial material

from previous semesters, or review material. The peer leaders then develop a workshop to address the issues related to the topic. Workshop sessions are not graded; thus, students are motivated to attend the workshops through the encouragement of faculty and peers as well as the recognition that the sessions are immediately relevant. To date, over ninety workshop sessions have been designed and written. The repository of workshop materials is being prepared for publication on the Department website[27].

Workshops typically have one peer leader working with ten to twenty students. Students work in groups of two to five, and the peer leader must monitor and facilitate group activities for as many as ten groups. An essential component of the PLTL program, therefore, is the training of the peer leaders. This includes an intensive pre-semester training in cooperative learning by a certified cooperative learning trainer to provide the knowledge and skills to create an effective active learning environment in the PLTL sessions and the use of cooperative learning in the workshops. The training includes techniques of both formal and informal cooperative learning groups, monitoring and intervention, and facilitation.

Training continues in weekly sessions throughout the semester, peer leaders are taught the theory and practice of cooperative learning. Our experience has been that in order for peer leaders to become proficient at using the key elements of cooperative learning, it is necessary to revisit these elements regularly and to evaluate workshop sessions for the inclusion of positive interdependence, individual accountability, promotive interaction, group processing, and social and professional skills. It is also necessary for peer leaders to practice techniques for dealing with questions without providing direct answers.

An essential component of the ongoing training is peer leader reflection. Regularly throughout the semester peer leaders discuss their peer sessions, identify the elements of cooperative learning incorporated in their sessions, discuss the effectiveness of each element and the session as a whole, and as a group discuss challenges and the approaches to improving workshops. The certified trainer and faculty leader are present at these meetings to ensure integrity of the effective integration of cooperative learning techniques in the PLTL sessions. The PLTL meetings focus on leadership, organizational, interpersonal, communication, and teaming skills that are critical to the development of competencies leading to success in CS courses and beyond. Another defining difference between the original model and the adaptive one is the manner in which the weekly training meetings are conducted. The faculty leaders have set up a template whereby each PLTL leader rotates leading the weekly meeting while another takes detailed minutes of the meeting. This shared leadership model has transferred ownership of the peer leader training sessions from the faculty leads to the peer leaders. This has created more engagement in the process, and evidence strongly suggests an emerging community of learners among the peer leaders.

Assessment

Our assessments show that through repeated practice, peer leaders become more adept at handling larger numbers of students in group settings, and they become more confident and capable in leading workshops. Systematic assessments show that students who are engaged through PLTL have higher grades, faster time to graduation, and improved retention of

undergraduate students. Students and peer leaders report that students arrive early to PLTL sessions and more fully engage in the process of acquiring conceptual understanding. Ongoing assessments suggest that students exposed to and use cooperative learning early in their undergraduate careers more quickly form informal study groups, which leads to improved student performance throughout their undergraduate careers.

The UTEP CS PLTL project has similar components as the aforementioned HP-funded project in the ECE department. The cooperative learning trainer in the CS adaptive model of PLTL was a co-PI of the ECE project and led the integration of cooperative learning into the ECE project. Evaluation of the ECE project is briefly outlined below followed by preliminary findings of the CS PLTL project.

Evaluation of the 2002 HP-Funded Project

The basis of the adaptive model of PLTL is the HP-funded pilot project implemented in the ECE at UTEP in 2002. Students enrolled in a sophomore level course self-selected into weekly sessions designed to deepen their conceptual understanding of topics offered in the course. At the heart of the intervention were cooperative learning techniques with upper division electrical and computer engineering students as facilitators or peer leaders. The findings presented here included qualitative and quantitative data that was triangulated. The evidence suggests that there was impact in the ECE project, and initial evidence suggests similar impact in the current project. However, neither of these projects' data have received rigorous statistical analysis, and at this stage we make no claims as to their statistical significance.

In the ECE project, analyses found that students completed their academic studies in a shorter time than average; they formed study groups early on; and their grade point average was higher. The participants completed their degrees in an average of 5.24 years. This finding is noteworthy when compared with the Consortium for Student Retention Data Exchange[28] report indicating that 54 percent of STEM students graduate in six years[29]. The majority of the participants revealed that they established study groups early on and that these groups had stable membership throughout their undergraduate years. The intervention provided the opportunity for them to work with all the students in the weekly sessions in a cooperative fashion and provided them the opportunity to find their "affinity" group. One student stated that during one of the enrichment sessions the group vowed to come together during their senior year to do their capstone project together. Indeed two years later that vow came to fruition, and they successfully completed their two-semester senior project.

Qualitative data using phenomenological interviews[30] revealed that 58 percent of the students (N=28) showed compelling evidence that the study groups they formed early had the attributes of high-performance cooperative groups (HPCG). Johnson et al. [31] define cooperative groups as ones that believe the success of the group is dependent on each group member's effort. The characteristics are 1) common goal or purpose that motivates them to each work to achieve that goal; 2) accountability; 3) work together; 4) use social skills to accomplish goal; and 5) analyze effectiveness. If a cooperative group outperforms all reasonable expectations, it is called a high-performance cooperative group (HPCG) where the group is bound by emotion and mutual concern for each other's personal growth. "Most groups never achieve this level of

development" (p.4:6). The remaining 42 percent of the students had either formed ad hoc study groups or occasionally met with someone to do homework or study for a test. These groups showed compelling evidence that they had created strong bonds possibly as a result of encounters with such adversities as difficult coursework and faculty members that "failed" to teach. The students seemed to possess a strong sense of confidence, contentment, and happiness. All of them reported their interest in advanced degrees.

Emerging Findings of the Adaptive PLTL Model

Approximately 150 students have participated in the PLTL workshops in the introductory CS courses in each of the three semesters the program has been in place. Twenty peer facilitators have been trained. Collected data include a cross-sectional student survey of perceptions of the effectiveness of the workshops and both current and historic student course performance data.

Student surveys were administered the last week of class. The surveys included the following statements:

- The PLTL sessions helped me to understand the course material
- I was actively engaged in all the PLTL sessions
- I recommend that the Computer Science Department continue these PLTL sessions next semester
- My grade has improved because of these sessions
- The sessions helped me to learn how to solve problems
- I study with people from my PLTL session on my own time
- My PLTL leader was approachable and helpful

Students rated their agreement from 1 (strongly disagree) to 5 (strongly agree). The results of this survey are summarized in Table 1 below. While the results are strongly influenced by the effectiveness of individual peer facilitators and the maturity of the students, 82 percent of the students recommend continuing the PLTL workshops in the future. In addition, 86 percent believe the PLTL sessions helped them understand the fundamental material of the course, and 83 percent believe they helped improve their grades. More importantly, the survey indicates that PLTL sessions help students form student study groups and cohorts, the types of study groups that in previous work led to improved persistence and shorter times to graduation. The trend shown below indicates that as students mature, they are more likely to study together. Previous research findings suggest that the sooner these study groups form, the greater the positive effects.

In all three courses, a grade of “C” or better is required in order to take the next course in the sequence or to upper division courses in the curriculum. Figure 1 graphically shows the average progress rate for the three years prior to the start of the PLTL program compared to the progress rate for the first two semesters of the PLTL program in CS1, CS2, and CS3. This chart indicates that a modest improvement in the progress of students has occurred since the introduction of PLTL for two of the three courses. This is an 18 percent improvement in CS1, a 3.5 percent decrease in CS2, and a 29 percent improvement in CS3. Figure 2 shows the average grade for all students in the courses for the three years without PLTL compared to the average grade for the students in the courses using PLTL. This chart indicates that a modest increase in the grades of

students in the three introductory courses has occurred since the introduction of PLTL. The increase is between 3 percent and 18 percent.

Table 1: Student Perception of Effectiveness of PLTL Workshops: percent in Agreement

Question	CS1	CS2	CS3	Overall
The PLTL sessions helped me to understand the course material	77	100	100	86
I was actively engaged in all the PLTL sessions	85	92	100	89
I recommend that the Computers Science Department continue these PLTL sessions next semester	74	92	94	82
My grade has improved because of these sessions	74	92	100	83
The sessions helped me to learn how to solve problems	73	91	94	81
I study with people from my PLTL session on my own time	58	73	82	66
My PLTL leader was approachable and helpful	84	91	100	89

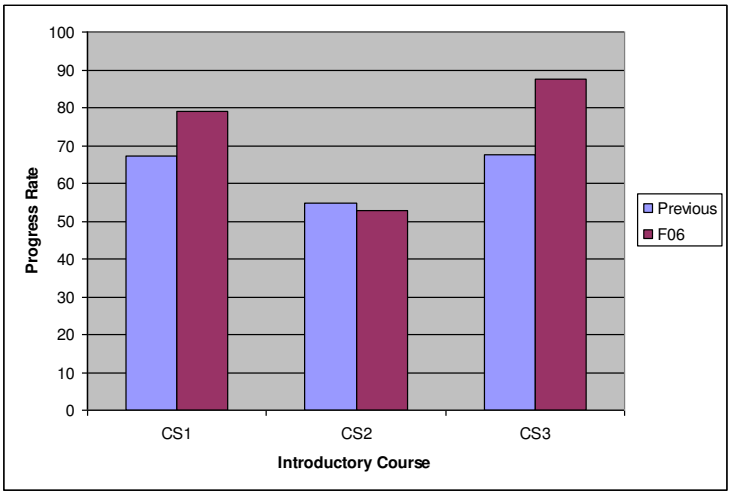

Figure 1: Student Progress Rate

Clearly, the progression of students and the improvement of the competency of students as measured by grades are important. In all three of these courses, the same members of the faculty have taught the courses for at least the past two and a half years.

The goal of the project is to increase the number of graduates in CS. To assess this, in addition to the progress rates for individual courses and the grades of students, we are also monitoring the average major GPA of students at graduation, the total persistence to graduation, the average number of years to graduation for a given year and for a given cohort, and the average number of courses taken as repeat each semester. Ultimately, we want to compare the time to graduation, courses repeated, and GPA for students who come through the program with PLTL and those who came through the program without it.

In addition, the PLTL program has provided opportunities for PLTL leaders to develop leadership and professional skills. Of the twenty PLTL leaders thus far, five graduated and three have been accepted to graduate programs. Six others have become active members of research

groups. Every one of peer facilitators has reported that the involvement in PLTL has improved their own understanding of the material and their technical competency.

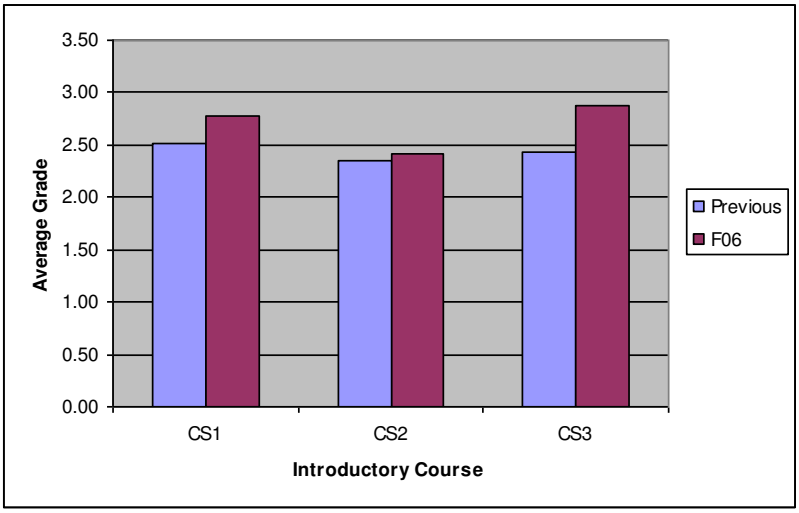

Figure 2: Average Student Grade

Conclusions

Other institutions may find PLTL more effective under this paradigm of integration of cooperative learning techniques and a shared leadership model for peer facilitator reflection and process improvement. We suggest that faculty advisors who desire to integrate these techniques should have a working knowledge of the theory and practice of cooperative learning.

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