Using Peer Led Team Learning (PLTL) approach to improve retention in ECE gateway courses

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Abstract

Peer-Led Team Learning (PLTL) has proven to be a very effective technique for improving student outcomes with respect to several metrics[1,2]. Studies have also demonstrated that PLTL methods are not only beneficial to the students involved in the learning process but also the students who are leading the teams. In this study, we aim to take advantage of this mutual benefit to organize PLTL sessions for circuits 1 and circuits 2 courses taught as part of the electrical and computer engineering curriculum for undergraduates. Students in circuits 2 lead workshops for students in circuits 1. Students' participation in these sessions was for credit, and qualitative feedback was gathered immediately after the sessions. To assess the efficacy of this approach, results were compared to previous semesters when no such PLTL sessions were organized. Our results show that applying PLTL sessions increased the ABC% by 18.6%. To our knowledge, this is a unique customization of the PLTL technique, and it is also a first study of using PLTL in circuits 1 and 2 courses, which are gateway courses that usually have relatively low passing rates.

Keywords

Peer led team learning, PLTL, leadership, circuits, student-engagement.

Introduction

As part of a continuing effort to improve student success and engagement in introductory circuits courses, the authors piloted and explored the effects of implementing an evidence-based teaching strategy, peer-led team learning (PLTL). In PLTL,[1,2] students work in groups on problems that are an integral part of their course. Student peer leaders who have already completed the course lead and facilitate the groups during the PLTL session. This type of student-led activity gives students supplemental learning opportunities, increases motivation, and increases learning assistance as students may be more comfortable asking fellow peers for help[3]. PLTL has been successfully applied in several fields, including chemistry[4], physics[5], biology[6], and computer science[7].

While our implementation of PLTL followed the six essential components of PLTL[8], this research study has several unique aspects. First, to the best of our knowledge, we found no previous studies of implementing PLTL in a circuits course. Second, we specifically recruited circuits 2 students to serve as peer leaders for the circuits 1 students in the PLTL sessions, and we explored the impact of this experience on the circuits 2 peer leaders. Finally, we incorporated the use of an online homework system, Pearson Mastering Engineering[9], during the PLTL workshops.

This program was conducted in a small STEM-focused public University, and as such, students who are struggling in gateway courses such as circuits do not have many fallback options.

Furthermore, these gateway courses are the foundation required by most of the advanced courses as students' progress in their program of study. Both of these concerns served as a strong motivation for the authors to initiate and pursue this PLTL program.

Studies have shown that serving as peer leaders helps leaders reinforce their own breadth and depth of learning and develop personal qualities such as confidence and perseverance[10]. There is also evidence that peer leaders earn higher grades and are more successful at progressing through the curriculum[11], suggesting that PLTL is a very appropriate practice especially in introductory gateway courses such as circuits 1 and 2.

As is the case with most institutions, we had to first show the effectiveness of this program in our context before our department committed significant resources towards it. As such, the program described in this article is a small pilot program. We hope our results can be used to jump start programs like these in ECE programs at other institutions.

In our pilot study of implementing PLTL in Circuits 1, we explored these research questions:

1. What are the perceptions of the usefulness of PLTL by Circuits 1 students and Circuits 2 peer leaders?
2. What is the impact of PLTL on Circuits 1 exam scores?
3. What are the perceptions of using an online homework system during PLTL workshops?
4. What are important considerations for further optimizing the positive effects of PLTL in ECE courses?

Method and Implementation

Perhaps one of the most helpful features of the PLTL program is the availability of guide books[3,12] that specify six critical components[8] that are important for the successful implementation of PLTL.

1. *Workshops are integral to the course and are coordinated with other elements (Fully implemented):* Workshops were organized as group quizzes during lecture times.
2. *Faculty are closely involved with PLTL workshops and with peer leaders (Partially implemented):* Faculty selected the questions and were present during the workshops.
3. *Peer-leaders are closely supervised, review material and strategies for facilitating discussion (Partially implemented):* Peer-leaders were shared the questions and solutions in advance and were requested to solve them before the workshop.
4. *Workshop materials are challenging at an appropriate level, aligned with learning objectives, and encourage collaborative learning (Fully implemented):* The workshop questions were administered using Mastering Engineering, based on the material being covered at the time, and the results were used in evaluating course learning outcomes.
5. *Organizational arrangements including size of group, space, time, noise level are conducive to group learning (Fully implemented):* The workshops were conducted during the lecture, inside the classroom, with group sizes of 4 or 5.
6. *The institution places student success and retention as a high priority and encourages innovative teaching to reach that goal (Fully implemented):* Although this is not strictly an implementation component, the support from the department and cooperation between faculty members were crucial in successful implementation of the pilot program.

Our PLTL sessions were mandatory for all circuits 1 students (32 students). We organized a total of 3 sessions which were held during class time and involved the use of graded group quizzes to incentivize student participation. The results were used towards the assessment of course learning outcomes. We sought out volunteer students from circuits 2 to serve as the peer leaders (6 students), with extra credit as an incentive. Since this was only a pilot program, we were not able to provide any stipends to the peer leaders.

Faculty were closely involved in the implementation of the program. All students were provided a background of the PLTL program along with evidence showing its success before implementation, in order to mitigate any potential student confusion or resistance[13]. Faculty selected all the questions and were present during the workshops to ensure proper execution. The questions were provided to the peer leaders ahead of time, and the leaders were requested to solve them before attending the workshop. The questions were administered through Pearson Mastering Engineering, which was linked to our learning management system (LMS). The students were divided into groups of 4 or 5, with one peer leader assigned to each group.

All students and the peer leaders were asked to fill out a short exit survey at the end of each PLTL session. A more elaborate survey was administered at the end of the program, along with a focus group discussion with the students. The results and inferences from these surveys are detailed in section.

Results

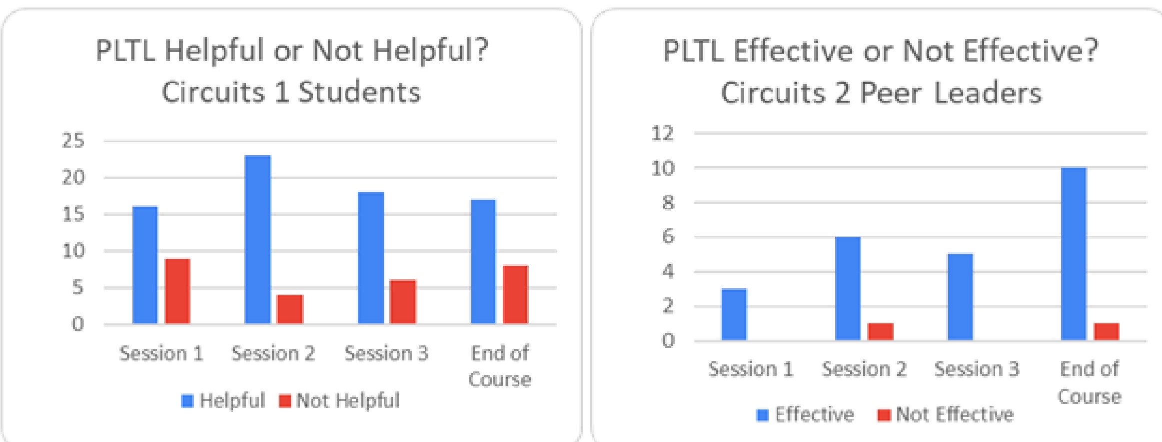
The results of the pilot program were quite promising, especially considering the small scale of implementation. The remainder of this section attempts to answer the research questions laid out in the introduction using data collected from surveys and exam scores.

Figure 1 shows the results from the surveys about student perceptions of the usefulness of the PLTL program. As shown, students in circuits 1 perceived the sessions to be helpful, and students in circuits 2 (peer-leaders) perceived the sessions to be effective. The perception of effectiveness of the program was much greater amongst the peer leaders as compared to that of helpfulness in circuits 1 students. Even though the peer-leaders were not trained, a significant majority of students felt that the peer-leaders were helpful, as seen in figure 2. Results from some more qualitative questions from surveys are shown in figures 3 and 4. As these figures show, students had favorable perception of PLTL in preparing for tests and understanding the material. A significant majority suggested they would like to see PLTL in other courses. In order to measure the impact of PLTL on exam scores, we compared the scores in the midterm exam conducted in two different semesters taught by the same instructor. The incoming GPA distribution was similar in both semesters. The material for the midterm exam has historically been where students struggle the most, and therefore it was an interesting measurement point to test the impact of PLTL. Figure 5 shows the comparison. As is evident in the difference between the histograms, students performed significantly better during the semester with the PLTL workshops. There were a total of 19 students in the semester without PLTL and a total of 32 students in the semester with PLTL. The percentage of students with grades A,B, or C increased by 18.6% when PLTL sessions were included. Using a z-test for statistical significance for difference in proportions, we can infer that the ABC rate of the students increased with the PLTL sessions with a p-value less than 0.00001.

One of the critical component of PLTL is selecting the right set of questions. The questions should be at the right difficulty level, and should be conducive of group discussions. The experience of the faculty organizing the pilot program and the feedback received from students both point to the fact that, while Mastering Engineering is a very useful tool for assigning homework, it is probably not the most appropriate tool for PLTL. The questions, apparently intended to provide students with much needed practice, are rather long and are not engaging in a way to incite group discussions. As seen in figure 2, most of the peer leaders thought the questions in Mastering Engineering were not very helpful, as the students spent all their time performing the extensive calculation instead of engaging with one another. In the conclusion section we discuss strategies for addressing this issue in the future.

Conclusion and Next Steps

The results of the pilot program were very promising, adding to the already substantive evidence of effectiveness of PLTL in other fields. The pilot program described here demonstrated that students in circuits perceive PLTL workshops favorably in several aspects. The results also indicate that peer-leaders perceive leading the discussions helps them better understand the material in circuits 2. The feedback from the students also provided valuable insights into types of questions that must used in future PLTL workshops in order to improve student engagement. The remainder of this section provides a description of the lessons learned from the program, with a focus on important considerations for successfully implementing PLTL in circuits 1.



(a) Circuits 1 students

(b) Circuits 2 students (peer-leaders)

Figure 1: Student perceptions of helpfulness and effectiveness of the PLTL sessions.

Lessons Learned

The pilot program described here was relatively short, but revealed several areas which a more organized program with financial and administrative support can greatly improve. Some of these improvements are common to the PLTL structure itself, and some are very specific to circuits. In what follows, we detail these lessons learned.

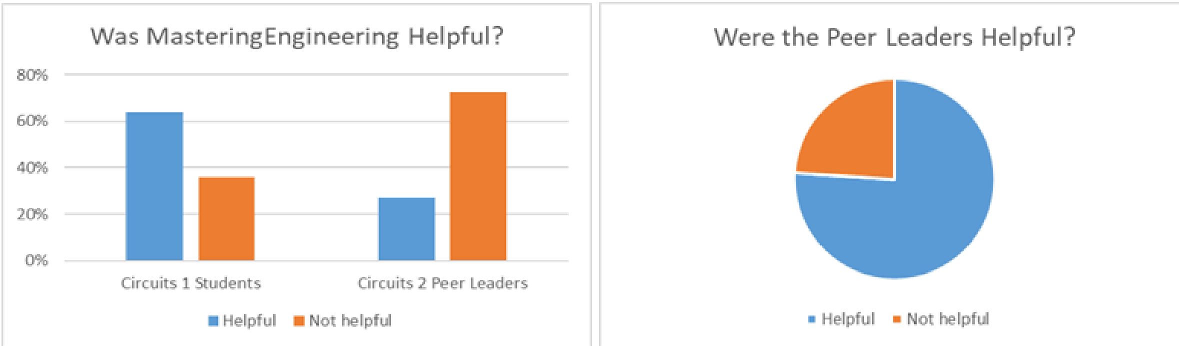
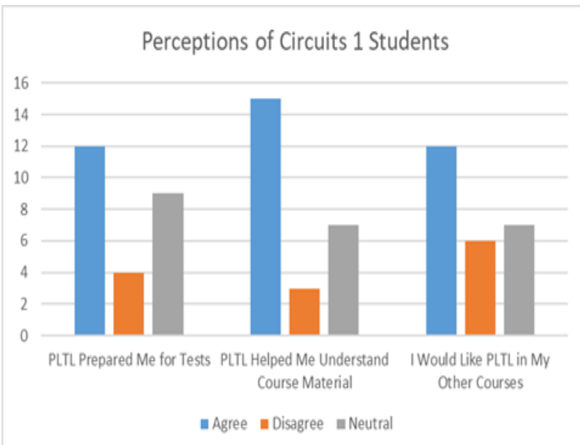


Figure 2: Student perceptions of Mastering Engineering and helpfulness of leaders.



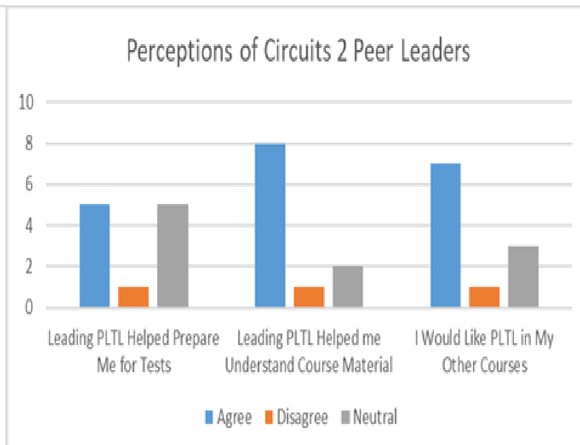


Figure 3: Student perceptions of PLTL sessions. Figure 4: Peer-leader perceptions

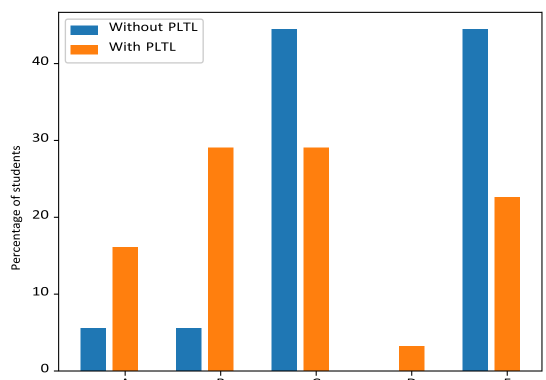
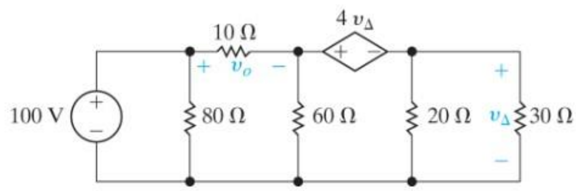


Figure 5: (a) Comparison of exam grades with and without PLTL sessions. Results show that PLTL sessions had a significant impact.

Training Leaders

There were a few instances where the lack of training the peer leaders was apparent. The most common problem in these instances were that the leaders were not able to engage all the students in a team into a discussion, and the students would either work by themselves or further divide into sub groups. Engaging all group members into a discussion is a complex skill, and leaders must have equipped with appropriate tactics during the training phase. In the future, we will be offering training to peer leaders using guidance from previous PLTL research[14].



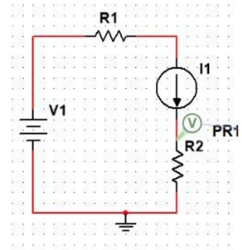


Figure 6: (a) shows an example problem from Mastering Engineering where students make a conceptual mistake. (b) Example conceptual question.

Selection of Questions

While Mastering Engineering is a nice tool for assigning homework problems, many of the problems in there are designed for students to work individually on solving them. Rather, there is a need for preparing questions which focus on common conceptual mistakes noticed by instructors, and those that induce discussions and debates.

Figure 6a shows an example problem in the book chapter (also included in Mastering Engineering). The question in the figure does incur a common mistake. At the center-top node, many students write the following KCL equation: $\frac{V-100}{10}+\frac{V}{60}+4v_\Delta=0$, the mistake being that they are adding voltages and currents, which is not allowed. But, once that is resolved, the students have to go through a lengthy calculation to solve the problem. It would rather be advantageous to include a shorter question such as “write the KCL equation at node x”, but more of them. During the semester, we also organized shorter format, two-stage quizzes.15 Owing to time restrictions, there was a necessity for designing shorter conceptual questions. Figure 2 shows one such example.

The student feedback at the end of the program overwhelmingly stated that the longer PLTL sessions should include more problems like these. We are developing new circuits questions in the future that are more suited to group discussion, inspired by circuits concept inventories[16] and tips from practitioners of the peer instruction technique[17].

Randomization

Randomization of the variables in problems had an apparently significant impact on the participation of the students in group discussions. We randomized the values of the variables in the problem, with the intention that students within the same group will be incentivized to participate. But in many cases, this had the effect of students working by themselves instead of participating in a discussion. Having common values to all students within a group should resolve this issue, while having different values for different groups can minimize cheating.

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