

AC 2010-1659: IMPLEMENTING PEER LED TEAM LEARNING IN GATEWAY SCIENCE AND MATHEMATICS COURSES FOR ENGINEERING MAJORS

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Abstract

The large lecture format found in most introductory mathematics and science courses is generally not conducive to a teaching-learning process that would allow for the development of professional skills such as team work, oral and written communication, and time management. Motivated by a successful experience in a general chemistry course, we have implemented workshops based on the Peer Led Team Learning (PLTL) model that engages every engineering student enrolled in the introductory chemistry, mathematics, and physics courses through a guided-process and inquiry-based strategy utilizing small group settings. For this purpose we replaced one hour of lecture with a two-hour small-group workshop. Workshops are guided by an advanced undergraduate peer leader who has successfully completed the course with a grade of A or B. The courses included in this project are pre-calculus, general chemistry 1 and 2, mechanics, and fields and waves. We anticipate that the implementation of PLTL will result in improvements in learning that will positively impact second year retention and success in subsequent engineering courses. One of the key factors in this approach will be the performance of peer leaders as facilitators and role models for engineering students. Peer leaders are trained following a schedule that includes a pre-semester induction session, weekly preview sessions, and an end of semester debriefing session. The induction generally lasts three days and involves faculty engaging peer leaders in cooperative-style learning and knowledge constructivism activities that they can subsequently apply in the workshops. In this session peer leaders also learn tips for small classroom management. Weekly preview sessions with faculty cover course content and pedagogical approaches. Lessons learned and ongoing challenges are discussed during the end of semester debriefing sessions. The formative assessment of PLTL workshops includes a survey to obtain opinions of the peer leader experience, determine the actual time spent preparing for workshops, gauge amount of interaction between peer leaders and instructors, and identify additional training needs. On average, peer leaders agree or strongly agree that the workshops significantly aid students in developing problem solving skills and better preparing for examinations. The amount of time that peer leaders dedicate to preparing for workshop varies significantly even within discipline but they all felt that the amount of time dedicated to the endeavor was just right. Peer leaders also identified a number of valuable outcomes including improvements in teamwork, organization, communication, and goal setting. Nearly all of them indicated that the time spent coordinating with faculty was used efficiently and expressed an interest in continuing as workshop leaders in the immediate future. Although this effort is work in progress, the results from the peer leaders' perspective indicate that the workshops indeed add value to the education of engineering majors.

1. Introduction

Historically, the large lecture format found in most introductory mathematics and science courses is not conducive to a teaching-learning process that develops professional skills such as team work, oral and written communication, and time management. As noted by Felder¹, “learners do not learn much in situations that require them to be passive, and ... do not learn much in

situations that provide no opportunity to think about the information being presented.” Not only is the passive large lecture format counter to the intent of providing a well-rounded educational experience in the first years², it also has negative potential on initial passing and retention rates. These factors affect students’ decisions to stay in college. Since the probability for stopping out is particularly high at urban institutions with a large first-generation college-going student body³, it is essential to consider ways to engage students in the teaching and learning process.

A considerable body of knowledge exists regarding pedagogies of engagement at the freshman and sophomore level⁴. When thinking about adopting and adapting a best practice, a crucial question that often arises is to what extent the practice can be up-scaled so that it benefits a majority of students in a sustainable manner. Motivated by our experience in an introductory chemistry course where implementing peer led team learning (PLTL) has shown to improve understanding, passing rates, and retention⁵, we opted to expand the effort by including mathematics and science gateway courses that are part of five undergraduate engineering degree plans. This effort guarantees that most engineering students experience PLTL in at least one mathematics and one science course. The selected courses for this purpose are:

- Pre-Calculus. Topics include functions and their graphs, polynomial and rational functions, exponential and logarithmic functions, sequences and series, trigonometry and analytical geometry,.
- General Chemistry II. Topics include intermolecular forces, solutions, equilibrium, acid/base behavior, kinetics, thermodynamics, and electrochemistry
- Physics I: Mechanics. Topics include dynamics of particles and rigid bodies using vectors and calculus, Newton’s laws, conservation of energy and momentum, rotational motion and universal gravitation.
- Physics II: Fields and Waves. Topics include electric field and potential; current and magnetism; time varying fields and electromagnetic waves, interference and diffraction.

Although the overriding strategy was to promote PLTL as a teaching and learning process that is both dynamic and student centered, the reasons for choosing these courses are diverse. For instance, in physics the effort focused on increasing both the efficiency of class organization and students’ time on task, with the aim of improving grade distributions and increasing overall student satisfaction with the courses. In chemistry, the intent was to ingrain the philosophy of PLTL by significantly involving more faculty members and making them aware of the benefits of using peer leaders as teaching partners. And in mathematics, the effort aims at ensuring that science and engineering students not yet ready to take the Calculus sequence obtain a solid foundation in the topics of college algebra and trigonometry that enable them to succeed in their subsequent mathematics courses.

Figure 1 illustrates how PLTL can be implemented in a large section of a three-credit course. Students meet with their professor in a large lecture hall twice a week, and subsequently meet with a peer leader in a small two-hour workshop session. This scheme can be viewed as a compromise between the large, impersonal but resource-saving lecture and the small, inclusive but resource-intensive lecture. Consequently, it is appealing to an administration concerned with budget issues but committed to improving the quality of education, and expanding the pool of talented engineers⁶.

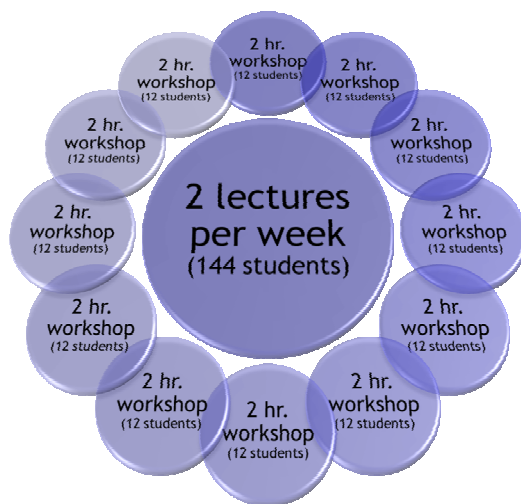


Figure 1. Breakdown of a large class into PLTL workshops

2. Peer Led Team Learning

PLTL is a recognized curriculum enhancement strategy adopted in various forms by many universities and colleges across the United States^{7, 8}. In the mid-1990's the National Science Foundation initially funded the "Workshop Project" which has blossomed into a national movement and is coordinated by the PLTL organization (www.pltl.org). PLTL engages an experienced student as the overseer of a small group of learners in the capacity of Vygotsky's "more capable peer"⁹. The idea builds on the pioneering observations of Treisman^{10, 11} from his studies as a graduate student at the University of California at Berkeley. From the beginning, the PLTL strategy has been recognized to reduce student anxiety and to build confidence¹².

Peer leaders are successful students who assist professors and serve as role models for freshman and sophomore students. Peer leaders help with course planning, modeling course objectives, and implementation of course goals. A good peer leader serves as mentor, a bridge between student and professor, and a friend. In our program, every peer leader receives training that includes a pre-semester introduction session, weekly preview sessions, and an end of semester debriefing session. The introduction generally lasts three days and involves faculty engaging peer leaders in cooperative-style learning and knowledge constructivism activities that are subsequently applied in the workshops. Peer leaders also learn tips for small classroom management. Weekly preview sessions with faculty cover course content and pedagogical approaches. Lessons learned and ongoing challenges are discussed during the end of semester debriefing sessions.

In our approach to PLTL, peer leaders have taken the initiative of incorporating games and other playful activities to drive points across. For instance, a chemistry peer leader conceived an

exercise she named “Body Geometry.” During her training to become a peer leader, she recalled, “I knew that a lot of students have a hard time discerning the difference between molecular and electronic geometry when they're studying the shapes that molecules make.” So, she had the idea that people themselves would make good models, particularly for hydrocarbons. “We have one belly button, which could be the central atom, and we have four limbs, and that's the same way that carbon bonds,” she explained. Then she expanded the concept to work with other types of compounds.

3. Assessment of PLTL Workshops

Peer Leader Perspective. The formative assessment of PLTL workshops included a survey to obtain opinions of the peer leader experience, determine the time actually spent preparing for workshops, gauge amount of interaction between peer leaders and instructors, and identify additional training needs and improvements. The amount of time peer leaders dedicated to prepare for workshop varied significantly even within discipline but they all felt that the amount of time dedicated to the endeavor was just right. Peer leaders also identified a number of valuable outcomes including improvements in teamwork, organization, communication, and goal setting. Nearly all of them indicated that the time spent coordinating with faculty was used efficiently and expressed an interest in continuing as workshop leaders in the immediate future. Although this effort is work in progress, the results from the peer leaders’ perspective indicate that the workshops indeed add value to the education of engineering majors. The majority of peer leaders agreed or strongly agreed that the workshops significantly aided students in developing problem solving skills and better preparing for examinations.

Students’ Perspective. Student surveys were administered at the end of the fall 2009 term. Students were asked if they felt the mandatory two-hour weekly small-group workshops were a better format to increase content understanding, whether the workshop peer leaders were knowledgeable and capable of presenting the material, and if the workshop materials and amount of time spent in workshops were meeting stated objectives. The objectives include reinforcing concepts initially presented in lecture through both individual and group work, including hands-on activities. Given a scale from 1 to 5 (strongly disagree to strongly agree), a mean 4.61 or 93% (n=644 of 693) of students felt the workshops were closely related to the lecture content. 84% felt the workshop activities better prepared them for tests while 88% believed workshop participation would improve their grade. While higher grades (increased passing rates) across disciplines do not mimic those found in the general chemistry class used as the base PLTL model for this current experiment, it is premature to comment as to the long-term effects that PLTL workshops will have on course success (grade) and graduation. Initial one year retention rates do appear to be on the rise.

Even with increasing contact hours by one hour, 81% of the students said “I would recommend courses with workshops to other students.” A mean 4.48 felt the workshop peer leader was well prepared and 93% (mean 4.56) said their peer leader was knowledgeable in the subject area. 85% agreed that the workshops “are a big help in learning to solve problems.”

A 5 point Likert scale (1-materials do not meet this objective at all to 5-materials are excellent meeting this objective) was used to address students’ perception of workshop materials. Table 1

shows the mean and percentage of students that regarded the workshop objectives as excellent or very good (4 or 5).

	Mean	% receiving 4 or 5
Workshop materials are: Well connected with the lecture	4.40	88%
Challenging	4.06	77%
Developed to review fundamentals	4.27	84%
Useful for group work	4.16	80%
Helpful for further study	4.31	85%
Useful for reinforcing concepts	4.39	88%

Table 1. Students' Perspective of Workshop Content

Comments about the peer leader/workshop structure varied from not liking workshops and peer leaders at all to "I really enjoy the workshops because it gives us (and other students as well) a chance to fully grasp concepts presented in previous lectures. Being in a smaller group with a peer leader also makes it easier to ask questions."

Faculty Perspective. Professors have provided valuable input about their experience with peer leaders. The following comment by a veteran professor in chemistry is representative of many. "I don't dictate to them: 'You will go over problems 17, 39, and 95 at the end of the chapter'. Instead I tell them that they need to make sure that their students understand the concept of limiting reagents or the concept of enthalpy change, and I let them decide how they're going to instruct their students. It puts them a bit ill at ease, but that's part of the confidence building. That's a very strong philosophical component in this program."

The perception from faculty involved in the project is there is an overall positive psychological effect on the leaders as they perceive that they can be successful and make a difference to the students they lead. In particular, a senior chemistry professor stated that "peer leaders gain stature and confidence of their worth by the experience this program provides."

To a large extent, give the significant number of students that have participated as peer leaders, they have become the focus of our assessment effort. Since spring 2008, 117 peer leaders have participated in the project. Of these, 31 percent have graduated and 66 percent are still pursuing degrees, for a combined 97 percent retention/graduation rate. This is in sharp contrast with the overall undergraduate student population six-year retention/graduation rate which stands at a combined 49 percent.

4. Decision Making via Internal Feedback and Dissemination

Internal feedback and dissemination of proposed activities and their outcomes have proven to be useful elements in decisions leading to effective curricular reform. We have sought guidance and advice from faculty at large and an internal advisory board.

Although there was no intent to increase the number of credit hours associated with each course, implementing PLTL required replacing one hour of lecture with a two-hour small-group workshop that required approval from the curriculum committees. This procedure took a semester to process at the faculty senate level and another semester for approval at the state coordinating level. This paved the way for full implementation of PLTL in all five targeted courses by fall 2008.

Discussions with the university's ad hoc committee on undergraduate student success led to several recommendations, one of which was to study why the peer leaders in STEM gateway courses are having such a positive impact on their peers and on each other. As an example, the physics peer leaders were asked three specific questions:

- Why do you think that PLTL can be considered a student-success strategy?
- Why do you think you are having such a positive impact on the students in PLTL workshops?
- Why do you think you are having a positive impact on other peer leaders?

This exercise has not been fully assessed but the initial input from peer leaders reveals an awareness of the positive interdependence that PLTL helps to build. For instance one peer leader commented:

“PLTL can be considered a student-success strategy because it emphasizes several important aspects of the learning process, including the confidence of the students at the time of asking questions, the networking between them and the review of important material. Students are more likely to ask questions in a workshop than they are during lecture. This is probably due to the way peer-leaders explain the topic and the smaller size of the group. Furthermore, students can talk to each other and discuss their doubts efficiently, which is not possible during lecture because everybody is paying attention to a lecturer who is pressed to cover certain topics in a limited time, so he can't take discussion breaks to explain topics to each student separately. In contrast, a peer leader guides students through the review of concepts, derivation of important formulas, and discussion of problems solutions increases the analytical abilities of the student. As a peer-leader, I know I am having a positive impact on students mostly because I receive direct feedback from them. The fact that they continue to request review sessions makes me think they need this kind of activity to improve their performance. I am having a positive impact because of the type of environment and team work that I promote when working with my peers. I take their advice as well as give some to them in order to achieve common goals. We understand and support each other, which gives me confidence to say that I am having a positive of impact on them.”

We also recognize that advisory boards can serve as an important catalyst for decision making in curricular reform projects.¹⁴ Out of discussions with our internal advisory board, headed by the Provost, the use of official university evaluations was recommended for assessing the outcomes of PLTL activities. This exercise led to the development of general peer leader selection

standards and training activities. Selection standards required a minimum gpa of 2.9 and a course grade of an A or B in the course for which they would be a peer leader. Training recommendations resulted in the addition of a formalized pre-semester and post-semester workshop with all peer leaders meeting together, rather than in discipline-specific trainings. In physics, a decision was made to effect change in laboratory experiments to de-emphasize formulaic outcomes and produce better interconnection with lecture and workshop materials. One of the members of the advisory board worked with the chemistry faculty on a program outcome that promotes peer leading as part of the undergraduate experience of majoring in chemistry.

5. Summary

Upon implementing PLTL in General Chemistry I, the passing rate improved from the historic average of 50% to a rate of 75% in a period of three years. The rate of students who received undergraduate degrees within nine semesters subsequent to the first semester general chemistry course jumped from 33% to 45%. Based on this early success, we have set to perform a five year longitudinal study to determine retention, graduation rates, and years to graduation of undergraduate engineering students impacted by PLTL, and to track the success rate (measured by a C or better grade earned) in the five chosen courses.

The PLTL course delivery approach that employs undergraduate student peer leaders to guide small-group active-learning sessions will impact nearly every engineering undergraduate. By increasing the number of contact hours by one each week in selected lower division chemistry, physics, and mathematics courses, students are spending more time on task in an active learning environment. The National Survey of Student Engagement (NSSE) “consistently finds that across institutions the average first year student spends about 14 hours a week preparing for class”¹⁵ This number encompasses all of the time a student is reading, preparing assignments, and doing lab work. Faculty expect the student to spend more than twice that amount of time preparing, about six hours per week for a single class. By increasing the time spent in each PLTL workshop by one hour per week, active student engagement is mandatorily increased, with nearly half of our students reporting that they spend a minimum of four to six hours preparing per class. It appears that when combining this response, along with self-reported survey data from both peer leaders and students, the large majority of students feel that the Peer Led Team Learning workshop model improves student learning and professional development skills.

Acknowledgements

Funding for this project was provided by the National Science Foundation’s STEM Talent Search Expansion Program through grant DUE-0653270.

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