Peer-Led Team Learning in an Introductory Calculus Course

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Abstract

The Partnership for Retention Improvement in Mathematics, Engineering, and Science (PRIMES) is an NSF STEP program being implemented in three different schools: Engineering, Education, and Arts and Sciences, and across nine different departments at the University of Louisville. The cornerstone of this program is the development of Peer-Led-Team-Learning (PLTL) communities in several of the foundation courses for each of the participating departments. A fundamental concept of the communities approach is to utilize undergraduate teaching assistants (UTAs). When mentors/peer leaders (UTAs) are closer to their age and/or experience, students in the course are more comfortable and more likely to be engaged.

The exact implementation of PLTL model varies between schools, departments, and courses, but every implementation uses UTAs to present material and/or to provide help with homework problems. Within the departments and courses assessed at the J. B. Speed School of Engineering, implementation of the PLTL model has varied between using external volunteer attendance sessions versus mandatory in-class sessions. Each implementation style has advantages and disadvantages.

External volunteer attendance sessions allow for a better relationship between the peer leader and the student attendees. The disadvantage of a volunteer session is that participation by students is reduced unless attendance is heavily incentivized. The mandatory in-class peer led groups have the advantage of greater attendance, and instant feedback on lecture materials. However, depending on the implementation of the course, this method may reduce instructor led class time. The in-class method can also be chaotic in the classroom with multiple peer leaders simultaneously meeting in groups. Group work in general may also foster a false impression of understanding the topics, since students work the problems correctly in a group setting.

This paper will provide an introduction to the PRIMES program, and a description of one course created using a variation of the emporium model to deliver an Introductory Calculus course, using UTAs to foster learning in the class meetings. The modified emporium model has dedicated course meeting times where students are required to attend the assembly much like a traditional course. This past semester there were six sections of this course taught. All six sections were led by UTAs, with four sections utilizing three person groups. The other two sections used the same materials and were led by UTAs without the three person groups. The course also uses online interactive and educational software to deliver the material and automatically grade the students’ assignments.

1. Introduction

The Partnership for Retention Improvement in Mathematics, Engineering, and Science (PRIMES) is a University of Louisville cross-college collaboration aimed at reducing attrition among our STEM majors. This project unites faculty from the College of Arts & Sciences, the J. B. Speed School of Engineering, and the College of Education and Human Development in
tackling identified hurdles that contribute to poor retention (and thus low graduation rates) in our respective undergraduate STEM programs. PRIMES’ goals are quite straightforward:

1. A 25% increase of the number of Bachelor’s degrees awarded in biology, chemistry, geosciences, mathematics and physics in the College of Arts & Sciences by 2016.
2. A 25% increase of the number of Bachelor’s and Master’s degrees in Engineering awarded in the J. B. Speed School of Engineering by 2016.

The rationale underlying these two goals is substantial and compelling. The University of Louisville’s 2020 Strategic Plan, a business and growth blueprint for the current decade, states that we will “Implement STEM initiatives leading to more graduates with science, technology and mathematics majors; more students majoring in engineering; and an increased cohort of science teachers for K-12.”. The 2020 Strategic Plan Scorecard sets year-by-year targets using 2008 graduation statistics as baseline data. University of Louisville’s goal is to increase by 33% the number of degrees conferred in these disciplines by 2020. PRIMES goals intentionally mirror these Scorecard metrics for growth by mid-decade.

Evidence, both data-driven and anecdotal, indicates that we can meet our goals if the primary focus is on retention as opposed to recruitment. However, evidence also shows that differences in the academic and social cultures among the various STEM disciplines will undermine a ‘one size fits all’ retention plan. Based upon departmental needs analyses and published research on possible ‘fits’ from successful STEM initiatives at other institutions, we designed PRIMES to blend two general strands that would support these anticipated outcomes:

1. Transform Teaching and Learning: Improved retention as a result of expanding our undergraduate teaching assistance (UTA) programs and institutionalizing a formal UTA training pedagogy. A working knowledge in best practices will enable them to be both effective and engaging in the laboratory and/or classroom.
2. Increase Faculty and Student Interactions: Improved retention as a result of implementing University-wide and discipline-specific (intentional) community building activities that foster STEM students’ sense of identification with STEM departments.

This project’s conceptual framework is built around three intersecting groups: STEM faculty, STEM undergraduates, and STEM Undergraduate Teaching Assistants (UTAs). In order to strengthen retention of STEM majors, the mutually reinforcing benefits of a simultaneous focus on these key groups will guide this project. At the heart of this triad are the UTAs, which will be the primary focus of this project’s work.

The conceptual framework for the UTA implementation is based on the Colorado Learning Assistant model1,2. In this specific implementation, UTAs will head PLTL communities in the early core courses of the participating departments. To help foster the student to UTA mentorship, multiple UTAs are assigned to each class with a target of a 10-to-1 student to UTA ratio. UTAs are chosen by each of the departments and are typically only 1 to 2 years removed from taking their assigned course themselves. Research suggests that the learning of students in such groups benefits significantly from the mentoring of a competent peer2–4.

Substantial numbers of STEM-intending students choose to leave STEM degree programs5 after completing only the introductory coursework. The effective implementation of peer learning and
tutorials within the introductory coursework can play a significant role in preventing early departures from STEM programs\textsuperscript{6,7}. Therefore, to enhance retention of STEM-intending students at the University of Louisville, our project’s focus will be centered on select introductory courses for STEM majors.

Improving the teaching ability of the UTAs through direct pedagogical training will directly benefit the undergraduate students in the introductory STEM courses. Research demonstrates that undergraduate learning benefits from mentoring by more competent peers\textsuperscript{2–4}. Undergraduate students that had UTAs that underwent systematic and supported instruction in pedagogical issues regularly outscored their peers in non-UTA classes\textsuperscript{1}. Likewise, because the presence of the UTAs and their regular interaction between the STEM faculty will strengthen the pedagogical practices of both the faculty and the UTA, and the undergraduate students in these classes will also benefit from a richer classroom experience.

The next section of this paper will focus on the implementation of the PRIMES program within the J. B. Speed School of Engineering.

2. Implementation at the J. B. Speed School of Engineering

A very brief introduction of UTA training follows, since this paper is dedicated more to the implementation of the UTAs within the Department of XX in the J. B. Speed School of Engineering as opposed to the implementation of the UTA program. Every UTA position requires the undergraduate to apply for the position, and each application is reviewed by the faculty member involved in PRIMES as well as the faculty member that the UTA will be directly working. This application process allows for faculty members to fully review candidates based on their prior course performances as well as their desire to participate in the program. Each UTA regardless of school or department must attend mandatory workshops prior to the semester as well as monthly seminars during the semester. The workshops have been developed with the Education Department to help train the UTAs. The workshops cover educational principles and techniques used in education. The workshops are not designed to make the UTAs experts in education but to expose them to the concepts and related use of these key concepts. The workshops cover topics related to the following over a two day period:

\begin{itemize}
  \item Questioning (closed vs open questions, also referred to as convergent vs divergent questioning)
  \item Preconceptions
  \item Mental Models
  \item Metacognition
  \item Formative vs Summative Assessments
\end{itemize}

Each seminar is designed to bring the workshop topics back into focus for the UTAs and allow them to discuss their successes and failures to date with other UTAs while being led by PRIMES faculty members.

There have been three main methods of implementing the UTAs into courses at the J. B. Speed School of Engineering. The methods are (a) voluntary supplemental instruction, (b) mandatory supplemental instruction, and (c) mandatory in-class instruction. The method used has been left up to the instructor of record of the course that is utilizing UTAs.
The first method, voluntary supplemental instruction (SI) model, can further be broken into two sub categories. These categories are rewarded attendance and non-rewarded attendance. The SI model has been a successful model at the University of Louisville, so using undergraduate teaching assistants (UTAs) from PRIMES was a natural extension of the model. The non-rewarded attendance voluntary SI meetings have problems with poor attendance. However, the non-rewarded attendance voluntary SI meetings do not create grade inflation by solely attending the SI meeting. The rewarded attendance voluntary SI meeting helps solve poor attendance, but does reward students solely showing up to the session.

The mandatory SI follows a more traditional recitation model or lab setting. Students are required to attend sessions with penalties for not attending. In the recitation or lab, students are encouraged to work on homework or assignments with a UTA available to help them with material. The mandatory SI model counters the poor attendance problem; however it introduces scheduling challenges that must be accounted for in students’ schedules so that they can attend the recitation or lab.

The mandatory in-class instruction removes some lecture time from the faculty of record and allows the UTAs to meet with a smaller group of students to cover problems or more detailed aspects of a concept. This method combats requiring students to attend a session outside of class or having the option of attending. Faculty members must be aware of some of the best practices to use UTAs in the classroom, such as allowing them to meet with small groups and be more interactive, not just another lecture.

The next section focuses on the implementation of the modified emporium model used in the Department of Engineering Fundamentals’ Introductory Calculus course.

3. Department of Engineering Fundamentals’ Introductory Calculus Course

The Department of Engineering Fundamentals modified the Introductory Calculus course to accommodate the use of an online interactive educational software, Pearson’s MyMathLab product, and UTAs. The Introductory Calculus course is for students that are not prepared for the Engineering Analysis I course, which is a traditional Engineering Calculus course. The Introductory Calculus course has been designed to help prepare the students for the Engineering Analysis I course by helping the students increase their basic mathematics and algebra understanding as well as introducing some basic calculus concepts.

The course has become a modified emporium model. The course has dedicated course meeting times where students are required to attend the assembly much like a traditional course. These course meetings have been planned to promote students working on problems designed to implement the topics learned in their reading assignments and to promote the interactions with the UTAs. The reading assignments and worksheets have been designed by faculty members of the Department of Engineering Fundamentals. The UTAs have access to these assignments before the scheduled meeting times to allow them to prepare and review the material. The faculty member in charge of the course is also available to the UTAs to clarify any questions that
they have regarding the material as well as helping them prepare for typical student problem areas.

A typical class meeting involves the students arriving to class and administered a reading assignment worksheet. These worksheets have questions that the students should be able to answer based on the prior reading that was due that day. This requirement is to help encourage the students to be prepared for class interaction. If the students have not come prepared, it becomes immediately obvious to the faculty, UTAs, and their classmates. These reading assignment worksheets are not summative assessments, but may be used as a formative assessment to help the UTAs determine what topics need more focus. After approximately 10 minutes, a problem worksheet is passed out. These worksheets may be worked on by individuals or groups depending on the implementation used.

The UTAs are responsible for leading the class meetings and are encouraged to use what has been learned in the PRIMES’ workshops and seminars. The UTAs have access to the material before the class meetings to allow preparation of solutions, questions, and development of the plan for the class. The class meetings typically have approximately a 10 to 1 ratio of students to UTAs, so if the class has 33 students there would be 3 UTAs assigned to that course.

This past semester there were six sections of the Introductory Calculus course. Four of the sections always used three person groups while working on the problem worksheets, and the other two sections did the problem worksheets individually.

Based on self-reported comments from the students, the students in the sections that worked on the problem worksheets in groups reported feeling more engaged in the class and a better connection to the UTAs. A sampling of comments from students in the group sections follows:

- The UTA's were very helpful.
- The group work became the best way to learn in the class.
- The TAs did a good job answering any questions I had.
- This class was a success due to the TA that taught us.
- MyMathLab was a viable resource, and the TA's were eager to help.
- The TAs did a good job checking our group work answers and explaining how to do ones we got wrong.

As you can see the students felt more engaged and had a better connection to their classmates and the school. Part of the PRIMES program is increasing retention, and by helping these first year students make better connections, retention should increase. These connections should also help them as they progress through their undergraduate engineering courses by providing study partners and better group dynamics.

4. Conclusions and Future Directions of PRIMES

Based on the early results of the PRIMES program in the Introductory Calculus course and across the other schools and departments, it can be concluded that UTAs are have a positive impact on their students. These benefits are not only in the form of improved student performance in the course, but also through the development of a mentor-mentee relationship. Many of the UTAs have expressed that students from their sections have asked them about future
courses, co-ops, etc. This relationship also helps promote to the students that they can make it through the courses as the UTAs did. The key aspect lies in assuring that the UTAs and the students have regular contact. The Introductory Calculus course provides this regular contact and is being continued in the current form. The students from the fall Introductory Calculus course are now in the Engineering Analysis I course, which is an engineering based calculus course. The students who were in the group sections versus the individual sections will be compared based on their Engineering Analysis I grades to determine if one type of instruction produced better results than the other.

PRIMES is very early in its implementation, and there are a large number of research initiatives that have yet to be started. Several of these initiatives focus on the students of the courses. Specifically, attempts will be made to normalize students based on their performance in prerequisite courses, grade point averages, and other standardized measures to gain a better assessment of the students that attended courses similar to the Introductory Calculus course. Students will also be tracked as they matriculate through their degree program to determine if the UTA exposure early in their curriculum has a lasting impact on retention and performance. It is anticipated that repeated exposure to UTAs in the classroom environment will help better engage the students throughout their curriculum. The students’ first exposure to UTAs is typically in the Department of Engineering Fundamentals’ courses.

The UTAs are also an important study group within this program as one of the aims of the project is to increase UTAs’ depth of content knowledge and determine the impact of the UTA experience as they matriculate through their degree program. The UTAs will be tracked through their curriculum to determine if this has an impact in their advanced courses and their future career paths. It is anticipated that the deeper understanding of the materials gained by being a UTA will entice them to enroll in more rigorous courses as they matriculate. It is possible that the teaching experience may influence them to pursue an academic career at either the primary, secondary or collegiate levels.

5. Acknowledgements


Bibliography

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