Peer-Led-Team-Learning in a Mechanics I: Statics Course

Dr. James E. Lewis, University of Louisville

James E. Lewis, Ph.D. is an Assistant Professor in the Department of Engineering Fundamentals in the J. B. Speed School of Engineering at the University of Louisville. His research interests include parallel and distributed computer systems, cryptography, engineering education, undergraduate retention and technology (Tablet PCs) used in the classroom.

Dr. Thomas D. Rockaway, University of Louisville

Thomas D. Rockaway, Ph.D., P.E., is an Associate Professor in the Civil and Environmental Engineering Department, and Director for the Center for Infrastructure Research at the University of Louisville. His research work has focused on identifying methods to extend the life and improve the performance of urban infrastructure. Much of his worked has included water and wastewater initiatives and incorporating green concepts into existing systems.

Prior to his work at the University, he has served as a geotechnical engineer for a large power corporation, a regional consultant and the United States Army Corps of Engineers. He has provided foundation and subsurface recommendations for structures ranging from single story dwellings to multi-story buildings.

He has doctorate from the Georgia Institute of Technology, a Masters and Bachelors degree in Civil Engineering from Purdue University, and a Bachelor of Arts degree from DePauw University.

Dr. Gerold Willing, University of Louisville

Gerold (Jerry) A. Willing is an Associate Professor in the Chemical Engineering Department at the University of Louisville. He received a Bachelor of Science Degree in Chemical Engineering from the University of Wisconsin-Madison and a Ph.D. degree in Chemical Engineering from Auburn University. Dr. Willing's expertise lies in the development of complex fluid systems for practical applications and characterization of their properties and stability. He has additional interests in water utility infrastructure materials and their impact on water quality, electroactive hydrogels, soft-lithography techniques, Peer-Led-Team-Learning, and development of a students engineering identity.

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Abstract

The PRIMES program (Partnership for Retention Improvement in Mathematics, Engineering, and Science) is an NSF STEP program implemented in three different schools: Engineering, Education, and Arts and Sciences, and across nine different departments at the University of Louisville. This program is designed to develop Peer-Led-Team-Learning (PLTL) communities in courses from the participating departments by utilizing undergraduate teaching assistants (UTAs) as mentors/peer leaders. UTAs are typically closer to the age/experience of the students in the courses, therefore the students are likely more comfortable and more engaged.

The PRIMES implementation of the PLTL model has varied between schools, departments and the courses in which UTAs have been involved. In each implementation, UTAs present material and/or provide help with homework problems. To promote the PLTL between the students and the UTAs a variety of implementation techniques were adapted by the departments at the J.B. Speed School of Engineering. These techniques include UTAs hosting voluntary help sessions outside of class hours, and utilizing UTAs during regular class periods with mandatory in class sessions.

There are advantages and disadvantages of each of the PLTL implementation techniques. The external volunteer attendance sessions allow for closer relationships between peer leaders and students. One disadvantage is students' participation is reduced unless attendance is incentivized. The mandatory in-class peer led groups nullify the disadvantage of reduced attendance since it occurs during class meeting times. Having the groups meet during class times allows the UTAs time to provide more instant feedback on lecture materials as well as clarifying information for the students. Some disadvantages to in-class groups is a reduction of instructor led class time, and also has the potential to be chaotic depending on the number of UTAs and groups that are meeting simultaneously.

This paper will introduce the PRIMES program, and a description regarding the use of UTAs and peer led groups of students in a Mechanics I: Statics course. This course used the mandatory in-class peer led group implementation. The Statics' UTAs attended each class meeting, and during the final 30 minutes, they worked with groups of students on graded assignments. The students generally self-selected into small study groups and interacted with the same UTAs throughout the semester. In this manner, the students built relationships with the UTAs and the students received immediate feedback regarding current topic materials.

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 STEM majors. Faculty from the College of Arts & Sciences, the J.B. Speed School of Engineering, and the College of Education and Human Development, work together in tackling identified hurdles that contribute to poor retention and thus lower graduation rates in our respective undergraduate STEM programs.

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 sets year-by-year targets using 2008 graduation statistics as the baseline data. University of Louisville's goal is to increase by 33% the number of degrees conferred in these disciplines by 2020. PRIMES goals mirror these metrics for growth.

Data-driven and anecdotal evidence indicates that the university can meet its goals if a concentrated effort is placed 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, analysis, and published research on possible 'fits' from successful STEM initiatives at other institutions, the PRIMES faculty designed PRIMES to blend two general concepts to support retention and increase graduations:

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 UTAs 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.

PRIMES conceptual framework was designed around three groups that intersect: STEM faculty, STEM undergraduates, and STEM Undergraduate Teaching Assistants (UTAs). In order to strengthen retention of STEM majors, the mutually reinforcing benefits of focusing on these three groups simultaneously guide this project. The UTAs are a primary focus of this project's work.

Substantial numbers of STEM-intending students choose to leave STEM degree programs[1] after completing only the introductory coursework. The effective implementation of peer learning and other tutorials within the introductory coursework can play a significant role in preventing early departures from STEM programs[2,3]. To enhance retention of STEM-intending students at the University of Louisville, PRIMES' focus is centered on select introductory courses for STEM majors in order to help retain students in the programs.

The Colorado Learning Assistant model[4,5] provides the conceptual framework for the UTA implementation. In the PRIMES implementation, UTAs will head PLTL communities in the early core courses of the participating departments. Multiple UTAs are assigned to each class to help foster the student to UTA mentorship. Each department chooses their own UTAs, and UTAs are typically 1 to 2 years removed from taking the assigned course. Research suggests that the learning of students in such groups benefits significantly from the mentoring of a competent peer[5-8].

The UTAs receive direct pedagogical training to improve their teaching abilities. The training directly benefits the undergraduate students in these introductory STEM courses. Undergraduate students that had UTAs that underwent systematic and supported instruction in pedagogical issues regularly outscored their peers in non-UTA classes[3]. 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 Civil and Environmental Engineering in the J.B. Speed School of Engineering as opposed to the implementation of the UTA program. Each UTA position requires the undergraduate to apply for the position, and the department's faculty member involved in PRIMES, as well as the faculty member of record for the course being taught, review each application. The application process allows faculty members to fully review candidates based on their prior course performances as well as their desire to participate in the program. Every UTA, regardless of school or department, must attend mandatory workshops prior to the semester as well as monthly UTA seminars during the semester. The workshops were developed with the Education Department to train the UTAs. The workshops cover educational principles and techniques that are commonly used in education. The workshops were not created nor designed to make the UTAs experts in education but to expose them to educational concepts and their use in the classroom. The workshops cover topics, typically over a two-day period, related to the following:

- Questioning (closed vs open questions, also referred to as convergent vs divergent questioning)
- Preconceptions
- Mental Models
- Metacognition
- Formative vs Summative Assessments

The monthly seminars during the semester were created 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. These seminars allow the UTAs to have support and feedback on interesting problems or situations that they have faced.

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 UTA implementation 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, therefore using undergraduate teaching assistants (UTAs) from PRIMES was a natural extension. The non-rewarded attendance voluntary SI meetings have had issues 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 rewards students for 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. Students need to have a recitation or lab time that fits into their schedule that prevents the students from being penalized for not attending.

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. The advantage to this method is outside of class sessions are not required and students do not have the option of not attending, unless they are not present in class sessions. Using this method forces faculty members of record to be aware of best practices of UTA usage in the classroom. One of these best practices is allowing the UTAs to meet with small groups of students and encouraging a more interactive class meeting, rather than just another lecture with UTAs.

The next section focuses on the implementation of UTA usage in the Department of Civil and Environmental Engineering's Mechanics I: Statics Course.

3. Department of Civil and Environmental Engineering's Mechanics I: Statics Course

The Department of Civil and Environmental Engineering is responsible for teaching the Mechanics I: Statics Course to all disciplines of students that require the course for their major. Thus, multiple sections of the course are offered every semester and about half of all engineering students need the course to complete graduation requirements. At the University of Louisville, student co-op experiences are required and thus, three full semesters of Statics are conducted each year. The summer semester is a compressed 10-week schedule, and 3-credit courses meet three times a week for 75-minutes. When students are in sequence, Statics is normally scheduled for the summer semester of their sophomore year. For the summer semester, two statics sections are offered and class sizes are approximately 130 students.

As with many introductory classes, the general format of the statics class is lecture followed by out of class on-line homework assignments. In general, instructors lecture and work example problems for the 75-minute class period. However, to meet the objectives of the PRIMES program, this format was modified such that the students would interact with the UTAs through a combination of mandatory in-class instruction and optional SI help sessions.

The “mandatory” UTA interaction was provided by modifying the traditional instructor teaching format. To facilitate student engagement with UTAs, the instructor lectured and worked example problems for approximately 45 minutes. Then the UTAs assisted students to complete a short, on-paper, graded in-class assignment that was due at the end of class. The in-class assignment was directly related to the current lecture topic and thus helped students assess their level of understanding before they left the classroom. As this activity took place in the classroom, the UTAs were immediately available to provide guidance or clarification as needed. In addition, once the in-class assignment was completed, the students and UTAs were free to work on out of class homework material if needed.

The student-UTA interactions initially appeared to be free-form, but in reality were relatively standardized. The intent of PRIMES was to establish a 10:1 student to UTA ratio to better facilitate peer-to-peer relationships. Within the classroom, the UTAs were directed to initially concentrate their activities to subsections, or specific groups of students. The students, however, were also free to move locations and self-select UTAs with whom they wanted to work. After a relatively short time, the students associated with specific UTAs became stabilized.

Quantifying the benefits of incorporating UTAs into the classroom has been challenging. While we observe the UTAs helping to build a sense of community, improving content knowledge, and providing support to undergraduates, these characteristics are difficult to measure. The University of Louisville is instituting a variety of programs to improve performance in these areas and to attribute trend changes to any one program is overreaching. However, some quantifiable information regarding the UTA program was obtained when evaluating student performance between class sections that hosted UTAs and those that did not.

To assess the impact of the UTAs on student performance, overall class grades were compared for Statics classes that utilized UTAs and those that did not. Between 2008 and 2017, one instructor taught 13 summer sessions of Statics. Four of the sections (324 students) did not have UTA support, and nine of the sections (942 students) did. Figures 1 and 2 (shown below) show the overall percentage of students receiving each letter grade. It is noted that while the same instructor taught all students, the data has not been adjusted for influencing factors such as GPA, ACT scores, time of day, number of students, repeat students, test difficulty between different semesters, etc.

Figure 1: Years Before UTA Percentage of Students Receiving Letter Grade

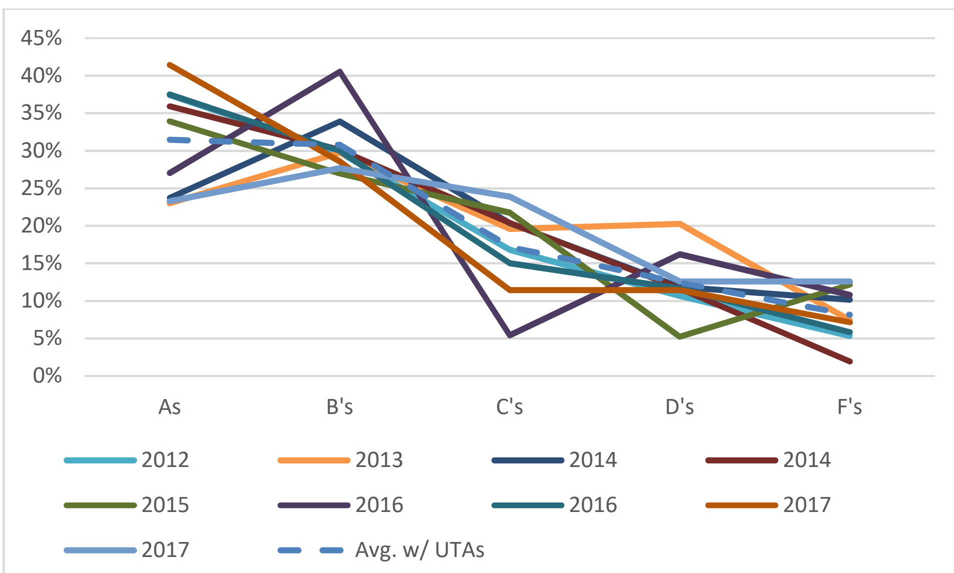

Figure 2: Years After UTA Percentage of Students Receiving Letter Grade

Figures 3 and 4 (shown below) compare the average student performance of Statics sections that did not utilize the UTAs (pre UTA data) and Statics sections that did utilize the UTAs (w /UTAs). The overall performance trends of the two groups is very similar and certainly within error bounds of the data set. The similarity of the datasets is further displayed in Figure 4, where the cumulative number of students receive a specific grade or better are compared. While significant improvement in student performance could not be attributed to the UTAs, the program did not adversely affect the students, and is believed to help mentorship, sense of belonging, and other qualitative aspects of the program.

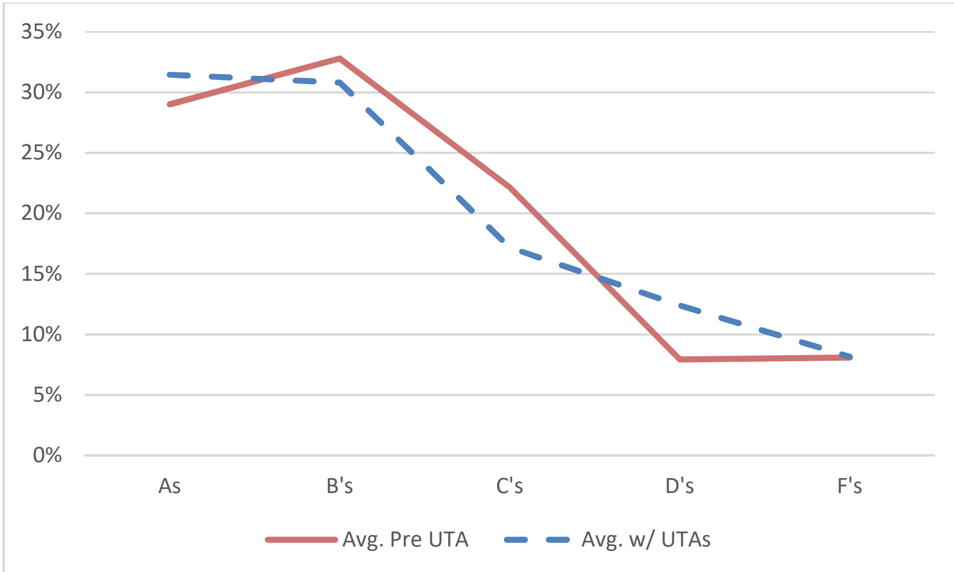

Figure 3: Overall Average Grade Comparisons Pre-UTA vs UTA years

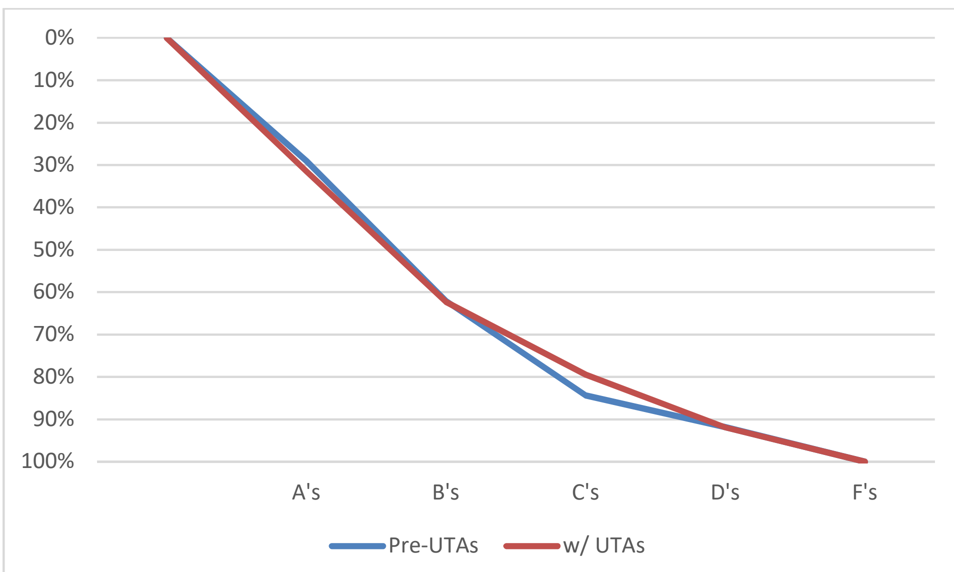

Figure 4: Cumulative Percent Exceeding Grade Comparisons Pre-UTA vs UTA years

While there are many qualitative advantages of incorporating the UTAs into the classroom, there are some limitations.

- Classroom order and structure is very different from a typical classroom environment. The small group work necessitates student interaction and discussion, which often appears un-orderly and chaotic.
- Class time during which the instructor could be leading the discussion or providing commentary to example problems is transferred to the UTAs. It is not reasonable to expect that the UTAs would emphasize or highlight the same materials as the instructor.

- The UTAs must be very knowledgeable in the subject matter. A poorly equipped UTA can negatively affect a significant portion of the class.
- There has been a tendency for students to reduce their out-of-class homework and time dedicated to the topic. Students will work on the materials during the in-class work sessions, but not review the material between lectures. As the students have been lead through example problems and watched problems being worked, many believe they have mastered the topic.

The "optional" UTA interaction was provided by having UTAs host supplemental instruction (SI) help sessions. Each UTA was asked to host a one-hour help session each week. The intent of the SI sessions was to address specific student questions and clarify any difficulties. Depending upon the current course material, time, and other activities, attendance at the SI sessions ranged from zero to over 20. Interestingly, while there were many help sessions available each week, students would generally self-select UTAs and tended to return to the UTAs with which they had prior contact.

While there are many immediately apparent advantages of utilizing the UTAs to direct voluntary help sessions, there are some limitations.

- The UTA commitment to the program must be strong. It takes a substantial amount of time for the UTAs to prepare for a one-hour help session.
- As before, there is a tendency for students to rely on UTA direction to help them solve the on-line homework problems. If the students are always guided through the materials, they never master it themselves.
- The instructors may not be immediately available to check in on, or assist the UTAs if they get into a difficult situation. Thus, the UTAs must be prepared to act independently.

Based on self-reported comments from the students, the students that worked with UTAs reported feeling more engaged in the class, as well as a connection to the UTAs. A sampling of student feedback follows:

- The UTAs were very helpful to my understanding.
- The UTAs were a very good resource for this course. The large group of TAs helped to split students into smaller groups that they could learn in. The TAs also gave students someone that they may have felt more comfortable approaching with a question. This is definitely something that should be continued for this course.
- This class was a success for me due to the UTA that helped teach me the material.

As you can see, the students felt more engaged and seemed to have a better connection to the other students and the school. Part of the PRIMES program is to increase retention, and by helping these third semester 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 Mechanics I: Statics Course and across the other schools and departments, we conclude that UTAs have a positive impact on their students. Student performance did not increase with this project, however with an increasing enrollment each year (from ~50 students per section to ~150) students were still self reporting a better understanding of the material. In addition to the self reported results, we have observed numerous examples of mentor-mentee relationships. UTAs have expressed that students from their course sections have asked them about future courses, co-ops, etc. This mentor-mentee relationship also helps the students realize that they can be as successful through courses as their UTAs did before them. One of the key aspects is assuring that the UTAs and the students have regular contact. The Mechanics I: Statics Course provides this regular contact between students and UTAs in both a classroom and out of classroom setting. Based on student responses and other feedback, the "sense of community" built by UTAs should be continued.

PRIMES is a very encompassing project, and there are a large number of research initiatives that have yet to be started or completed. Several of these initiatives focus on the students of the courses. Attempts will be made to normalize the 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 the Mechanics I: Statics courses. These students will also be tracked as they matriculate through the degree program to determine if the UTA exposure early in the curriculum has a lasting impact on the student's retention and performance. The anticipated result is that repeated exposure to UTAs in the classroom environment will help better engage the students throughout their curriculum.

The UTAs are also being studied within this project. One of the project goals is to increase UTAs' depth of content knowledge and determine the impact of their UTA experience as they matriculate through their degree program. The UTAs will also be tracked through their curriculum to determine if being an UTA has an impact in their advanced courses as well as their future career paths. The anticipated result is the UTAs will show a deeper understanding of the materials they have taught, and they will use some of the educational techniques they have learned to improve their personal learning methods. A possible secondary outcome of being an UTA is that the teaching experience may influence them to pursue an academic career at either the primary, secondary or collegiate levels.

5. Acknowledgements

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