AC 2011-1659: PEER-LED SUPPLEMENTAL INSTRUCTION IN AN NSF STEP PROJECT: THE EEES EXPERIENCE

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Peer-led Supplemental Instruction in an NSF STEP Project: The EEES Experience

Abstract

In recent years there has been a decline in the number of STEM students nationwide. Specifically, there is a high loss rate of early engineering students in the first half of their degree programs. The early "leavers" typically fall into two categories (i) those that face academic probation and (ii) those that perceive the education environment of early engineering as hostile and not engaging[1, 2, 3]. Undergraduate engineering enrollment has declined substantially over the last decade in the College of Engineering at Michigan State University (MSU). The downturn can be attributed partly to the rapid decline of the American automobile and manufacturing industry, a traditional mainstay for the Michigan economy.

In 2008, a five-year NSF STEP grant (STEM Talent Expansion Program) was awarded to support a partnership between the Colleges of Engineering and Natural Science at Michigan State University and Lansing Community College (LCC). LCC is an urban community college with an enrollment of approximately 30,000 students located in close proximity to MSU. The two institutions have a strong history of collaboration. The project is titled **Engaging Early Engineering Students** (*EEES*). A primary goal of *EEES* is to increase matriculation-to-graduation retention rate in the MSU College of Engineering by ten percentage points. *EEES* project functions through the synergistic operation of four components designed to maximize student engagement with both the college and the learning process. The components are (i) Connector faculty; (ii) Supplemental Instruction; (iii) Course cross linkages; and (iv) Early intervention.

The primary objective of this paper is to describe the implementation and outcomes associated with the first two and a half years of the Supplemental Instruction segment of the *EEES* project. Supplemental Instruction (SI) is an internationally recognized peer-tutoring program that integrates course content with active student learning in the form of peer facilitated study sessions. This approach to peer to peer learning has shown that participating students make greater gains than those achieved by classmates competing with each other or studying alone[4] Group learning has demonstrated benefits essential to creating a more welcoming educational environment, including helping to integrate students into academic life, teaching effective collaboration methods, and reducing prejudice[4]. Additionally, peer tutoring has been shown to positively affect those students leading the study sessions[4].

In this report we describe: (i) a description of SI in the MSU College of Engineering and its implementation process; (ii) SI program collaborations; (iii) supporting research on peer tutoring and collaborative learning; (iv) program outcomes; and (v) future opportunities.

Overview of Supplemental Instruction (SI) in the MSU Environment

A 2008 NSF STEP grant, allocated to address the demand for STEM graduates, was awarded to support the partnership between Michigan State University and Lansing Community College. A

primary goal of the grant is to increase retention and subsequently the number of degree recipients graduating from the College of Engineering at MSU. The project, titled **Engaging Early Engineering Students** (*EEES*), is comprised of four components intended to maximize student engagement with both the college and learning process: i) Connector faculty; ii) Supplemental Instruction (SI); iii) Course cross linkages; and iv) Early diagnostic of students facing potential course performance issues and early intervention to help the student address the problem. Earlier publications include an overview of the EEES project[5] and other aspects of the EEES project[6, 7, 8, 9, 10].

Lansing Community College (LCC) has utilized a peer mentoring program based on the SI model for over a decade. The LCC SI staff was instrumental in helping MSU project personnel learn about SI and how to tailor it to the institution.

The SI component of *EEES* is based on an internationally recognized peer-tutoring program that integrates course content with active student learning in the form of peer facilitated study sessions. Historical statistics from the university show that the majority of engineering attrition occurs before the second calculus course due to academic difficulties, or the perception that engineering fosters a hostile, disengaged learning atmosphere[11]. The tutoring program, referred to at Michigan State University as Peer Assisted Learning (PAL), caters to introductory algebra and trigonometry, calculus, and physics courses to combat the loss of early engineers through peer-led review sessions. These sessions are regularly scheduled, informal review sessions in which students compare notes, discuss readings, develop organizational tools, and prepare for upcoming exams. Students learn to integrate course content and study skills while working together. SI leaders, also called PAL leaders, foster an open, discussion based tutoring format rather than the one-dimensional lecture format that can be found in many large introductory courses.

All students enrolled in PAL supported courses are encouraged to attend PAL sessions, which are completely voluntary. There is no remedial stigma attached to PAL since the program targets difficult courses rather than individual, at-risk students[12, 13, 14]. Published research results highlight that students who attend SI sessions can experience the following benefits:

- Improved course grades compared to students who did not attend SI sessions.
- Lower drop-out rates in courses where SI is offered.
- Improved course management skills, critical thinking, and test taking skills.
- Increased enrollment rate in subsequent courses.

In addition to the quantitative goals, the program aims to produce students that are valued in industry[15]. Peer assisted learning encourages the development of critical thinking skills and provides both the participants and the PAL Leaders with an opportunity to engage in collaborative learning. These benefits directly support the project's stated goal of improving retention of early engineering students, as well as criteria set forth by The Accreditation Board for Engineering and Technology (ABET), which is increasingly placing emphasis on "soft skills" development within engineering programs [16, 17, 18]. While the primary goals of the grant are aimed at students enrolled in targeted courses, our research has shown that the program also provides numerous benefits to the PAL leaders and will be presented later in the paper.

SI Program Collaborators and Their Responsibilities

Opportunities to participate in the Supplemental Instruction program are available at the undergraduate, graduate, faculty and administrative levels. Ensuring that the proper positions were occupied and operating properly was, and continues to be paramount to advancing progress of the program. Five categories of key contributors lend to the SI program's success:

- Students enrolled in the targeted courses
- PAL leaders
- Faculty members
- SI program coordinator
- Community college partners

Each contributor's role directly affects the outcome of the program and interdependently relies on the others' active participation.

Students enrolled in the courses supported by the PAL program. Students enrolled in the targeted courses must regularly attend lecture, interact in class with peers and faculty, and consistently attend PAL sessions in order to maximize their grade earning potential. In order to reap the most from the PAL program, it is essential that students sufficiently and actively participate in class and PAL sessions, as well as use provided resources with an intent to succeed in the course[19]. It is imperative for the students to recognize that a one-dimensional lecture format, consisting of an instructor talking and many students copying, is not a consistently effective learning method for many types of problems.

PAL Leaders. PAL leaders are students who have previously completed the course with an exemplary grade. Responsibilities of PAL leaders include: attending their assigned course, facilitating sessions, attending staff meetings, and completing administrative tasks.

PAL leaders must maintain a strong presence within the classroom; the PAL leader must attend lecture, take notes, engage students in class exercises, answer academic and social questions, and advertise the PAL sessions. PAL leaders facilitate 90 minute interactive, group tutoring sessions for the courses during which attendance is recorded for research purposes but not shared with faculty or administrators. Review sessions are held five evenings per week throughout the semester, and an additional one on Sunday afternoons.

In addition to hosting the study sessions, PAL Leaders are required to attend weekly staff meetings with the PAL Coordinator. The staff meetings provide a venue for PALs to share their observations and experiences from classes and tutoring sessions, learn new skills, and assess areas for improvement. Administrative tasks are also discussed, including program advertising and human resource issues. In order for students to experience the benefits of PAL, they must first attend the tutoring sessions. The program must rigorously publicize the positive, unique attributes of the sessions to ensure that session nonattendance reflects a student's conscious choice rather than an unknowing one. It is the responsibility of PAL leaders to advertise through various media that will best attract students. Common methods include consistent

announcements before class begins, and fliers that contain information regarding their tutoring locations and times. Other tactics to date incorporate Facebook groups and messages, specially created PALMAIL course specific email groups, and computer announcement pop-ups in the College of Engineering computer labs.

Pedagogical approaches used in sessions. The primary responsibility of the PAL leader is to help students understand course content and to facilitate organized review sessions. They foster student collaboration through problem-based learning, or the process of resolving a problem[19]. A correlation study done by Alexander Astin demonstrated that interaction between students and interaction between faculty and students affected a student's education outcome more than anything else, including course material[20]. The study's findings, while primarily geared toward faculty, also represent the guided teaching style of the PAL Leader. Copying problems from a blackboard or a dry erase board to a student's laptop or notebook should be avoided. The regurgitation process does not engage a student in the learning process, nor does it encourage or promote critical thinking ability, a skill required to solve more complex, multidimensional problems.

PAL leaders are trained in a variety of pedagogical approaches using the Supplemental Instruction Leader's Guide, which was created and published by the University of Missouri, Kansas City. Contained in the guide and taught during PAL leader training are a multitude of tactics and techniques to engage students in collaborative learning for a wide variety of subjects. Each of the PAL leaders has a copy of the manual and is familiar with those most appropriate for their particular subjects. During training, the PAL leaders practice and simulate several PAL sessions. They trade off playing the role of the student and the role of the PAL leader to experience the session from both angles and to see how some approaches can work better than others for certain topics.

The techniques employed in PAL sessions, range from problem solving worksheets for small groups, to deconstructing lengthy, complex problems in to steps as a group. The technique or strategy used in sessions depends on the course and the topic being studied. In PAL sessions serving calculus classes, PAL leaders regularly employ the "board explanation" method, having the students go up to the dry erase board and work through the problem while the PAL leader watches. When they are finished, the PAL leader will have the student(s) explain the steps of the problem one by one, offering hints or encouragement through out, but never doing the problem for the students. This method reinforces concepts and content through the students' own verbal communication to the group. PAL leaders also reported that working through problems together in PAL sessions builds a stronger sense of community. Text book based activities are also common in math sessions, where the PAL leader will assign practice problems similar to those assigned for homework, and pair students up to work on them for a specified length of time. When the time is up, the pairs will share their work with the PAL leader and the other session attendees. This is similar to the board explanation, but in pairs and working with the textbook on specific problem sets.

PAL leaders also share study skills and hold special midterm and final exam review sessions. In the physics course served by PAL, a popular study skill involves the use of note cards. PAL leaders help students create note cards in preparation for their weekly exams. Students will also

make their note cards in advance of PAL and bring them with them to the sessions where they will review the information on them in small groups called clusters. The PAL leader ensures that the information on the cards is correct, and engages the clusters in active discussion of the terms and concepts on the note cards. This method is helpful in that the students can share and compare note cards and get help with confusing concepts from their classmates and the PAL leaders.

Faculty members. The faculty teaching the PAL targeted courses is critical to the success of the program. Participation in PAL is not intended to create additional work for faculty. However, faculty members can support the PAL program by allowing time for occasional in-class announcements and encouraging students to take advantage of the help being offered. Additionally, the faculty may be asked to assist the coordinator (i) in selecting candidates to be PAL leaders for their courses; and (ii) by providing information for the PAL program evaluation, including a copy of the official class roster and a copy of grades after the first exam and the conclusion of the course.

SI (PAL) Program Coordinator. The Supplemental Instruction Coordinator (PAL Coordinator) is the staff member who manages program operations. The coordinator is responsible, with the cooperation of the faculty, for selecting SI leaders and placing them in course sections with the approval of the participating faculty member. The PAL coordinator is involved in the training of all PAL Leaders according to established guidelines and standards set forth by the SI Supervisor Manual published by University of Missouri-Kansas City (UMKC). This training encompasses administrative details, ethical responsibilities, and instructional strategies for the PAL Leaders to employ. Additionally, the PAL Coordinator monitors the leaders' activities and PAL sessions by helping plan the sessions and supervising their performance on a weekly basis.

During the first week of each semester, the PAL coordinator holds weekly PAL leader meetings, as previously stated, to debrief PAL sessions, discuss interactions between PAL leaders and faculty, and to review in class announcements and practice collaborative learning techniques. The coordinator provides supplies, in-service experiences, and consultations for the leaders. Issues with poor attendance, professor interactions, as well as student participation during the PAL sessions are also addressed. At the conclusion of each semester, the coordinator creates and distributes a comparative analysis of student performance based on participation in PAL to all participating faculty. The PAL Coordinator also administers end of semester surveys to PAL leaders to document their observations of program challenges, successes, and individual academic or personal growth. Examples of these responses will be shared later in this paper.

Community college partners. A strong collaboration between Lansing Community College and MSU proved crucial in implementing the PAL program; LCC has a large, well-established SI program that served as a successful model for MSU. Administrators of the decade old program served as active members of the pilot team along with faculty and administrators from two colleges within the university. The SI Coordinator at LCC helped to train and continues to mentor the PAL Coordinator at MSU. Additionally, students that have graduated from LCC's pre-engineering program have continued their engineering education at MSU and have served as SI/PAL Leaders in both programs.

Description of SI in the College of Engineering and Its Implementation Process

Campus preparations for implementing the program. Once the PAL program goals were outlined and the key personnel were in place, two important parts of the project needed to be identified in order for the program to come to fruition: the classes the program would target, and the PAL Leaders to facilitate the tutoring sessions.

Identifying historically difficult courses. SI literature states that program efforts should focus on historically difficult courses. Statistics show the majority of engineering attrition occurs before the second course in the calculus sequence due to academic difficulties or a hostile, non-nuturing learning environment[11]. Grade data gathered from over 3,000 students, spanning four semesters, showed that approximately one-third of students scored a 2.0 or less on a 4.0 scale in the introductory calculus course. Based on this statistic and conversations with math and engineering faculty, academic advisors and the undergraduate dean, the decision was made to target introductory algebra and trigonometry, calculus, and physics courses. All of which are either a pre-requisite for, or are, a required course for admission to the College of Engineering.

Hiring and training of PAL leaders. PAL Leaders are highly successful engineering students, many of who had previous tutoring experience either in high school or in other programs within the college or the university. Minimum requirements for a PAL leader include a grade of 3.5 or higher in the targeted course assigned, a cumulative grade point average of 3.0, and sixty completed academic credits (junior standing or higher). Of equal importance to academic and professional experiences is a PAL Leader's ability to engage in conversation and communicate effectively. The PALs social skills are paramount to the success of the program, as it is their responsibility to encourage the students in their course to attend their PAL sessions. Other desired qualities include: previous work experience, faculty or academic advisor recommendations, general enthusiasm, and a general sense of excitement for the engineering profession. Leaders with engineering majors of junior or senior standing were purposely chosen because the program is aimed at retaining prospective engineering students. A study administered through an academic seminar at the University of Maryland found that students who developed a support community of peers were more likely to discover campus resources and persist in school[21]. The hope is that if early engineers experience positive learning interactions with mentors who can relate to their classroom affairs, then the student will feel more socially and academically comfortable in advancing towards an engineering major, thus directly combating the attrition from the College of Engineering.

Training The proper training of PAL leaders in peer assisted learning is essential to the success of the program. PAL leaders are required to attend and participate in an intensive two-day training program. The first day of training includes an overview of PAL and the *EEES* project; responsibilities of the PAL leader; and various administrative duties involving confidentiality statements, hiring forms, and session scheduling. The second training session includes information about completing the Institutional Review Board (IRB) and Family Educational Rights and Privacy Act (FERPA) tutorials; introduction of key players involved in the program; data collection needs; and instructional strategies aimed at strengthening student academic performance. Both sessions are lead by the PAL Coordinator, a Co-PI of the *EEES* project, and the SI Coordinator and SI Leaders from the community college partners. Because the project has

retained the majority of PAL Leaders across several semesters, and the number of new PAL Leaders hired each semester has been very low, training sessions at the beginning of the semester currently resemble review sessions, focusing on facilitation skills and group bonding activities.

Outcomes

PAL session attendance numbers and grade improvement based on frequency of sessions an individual student attended was the anticipated indicator of program success for PAL. However, after full implementation of the program it became apparent that the beneficiaries of the PAL program were not just students enrolled in PAL courses attending PAL sessions. PAL Leaders also realize positive outcomes due to their involvement in the program. Challenges associated with overall attendance has encouraged the program staff to consider successes with both groups of students, PAL Leaders and those enrolled in the courses, as well as to collect both qualitative and quantitative data from the groups moving forward.

Attendance. It has been a challenge to draw large numbers of students to PAL sessions. Several reasons for the struggle have been identified, including competition from other campus tutoring programs, the different style of engaged, collaborative learning used in PAL, and the large variety of times and locations initially offered by the program. In attempt to counter these issues, the PAL Coordinator and PAL Leaders employed creative advertising for the program in order to differentiate it from traditional models of tutoring. Training the PAL Leaders to be visible and recognizable in their assigned classes was key, as was their positive relationship with PAL Faculty, who can have a significant impact on student attendance. Faculty have assisted the program by encouraging their students to go to PAL, and allowing in class time for PAL Leaders to make announcements, utilize classroom board space to write session times, and to add PAL to the course syllabus as a resource. An additional challenge for PAL is the use of collaborative learning techniques in the sessions. Many of the students in the targeted courses are early in their college careers, and the pedagogical approaches used in peer assisted learning are unfamiliar and contrary to those used in traditional high school teaching in the United States and around the world. PAL encourages group work and participation, neither of which is typically associated with either high school learning or learning in large, introductory college courses.

There are many variables that we believe contribute to the differing levels of attendance in PAL sessions. We will continue to assess attendance by examining possible differences in: the various ways that PAL is promoted both in and out of the classroom, by both the instructors and the PAL leaders; previous math experience of the students in PAL targeted classes (including cumulative GPA and prior math courses); PAL leader approaches in PAL sessions; and session scheduling, including times and locations.

Table 1: Number of students impacted by the PAL program to date.

Semester	Spring 2009	Fall 2009	Spring 2010	Fall 2010
# of students enrolled in PAL supported courses	149	1358	1024	1442
# of unique PAL participants	95	167	153	215
# of unique PAL participants as a	63.8%	12.3%	14.9%	14.9%

percentage of total students				
# of student contacts	114	540	410	455
# of PAL leaders	5	18	21	23
% of PAL leaders returning from the previous semester	Program begins	40%	72%	67%

The attendance numbers from the pilot semester, Spring 2009, as shown in Table 1, demonstrated promising attendance for unique PAL participants compared to the total number of students in the targeted courses (see '# of unique PAL participants as a percentage'). However, the following semesters to date show a plateau of unique PAL participation as a percentage of total students. Additionally, 92% of the PAL leaders returned to the program for the Spring 2011 semester.

PAL Leaders

While it is common to focus on gains solely regarding the academic performance of the students and changes in early engineer retention numbers, this paper considers the effects the program has on the student leaders of the program as well. Even though their academic status within their desired engineering major is proven and stable, the leadership growth and practice of "soft skills" that ABET highlights essential to engineering success should also be touted as resounding successes for the PAL Program.

Research has shown that students that have common learning experiences or share similar academic histories are more likely to have academic discussions outside of the classroom as well as build strong social bonds with their peers[20]. While one may be quick to apply the benefits of these findings to the students receiving the tutoring, the positive implications for PAL Leaders are also significant. Student mentors, already modeled as peer leaders, can expand their intellectual and emotional development further through experiences in PAL. According to Astin, critical factors that enhance educational development are student to student and faculty interactions; these are major characteristics of a PAL leader's responsibilities[20]. An assessment study of Harvard students concluded that the magnitude in which a student is involved at the undergraduate level will result in exponentially positive outcomes for the student, both academically and socially[19]. The payoffs gained from the combined academic and social atmosphere in the PAL sessions further enhances the undergraduate experience for the PAL leaders as well; practice in collaborative learning is not restrictive to the tutored students alone[22, 23].

PAL leader experience surveys. At the conclusion of the spring 2010 semester, the PAL Coordinator created and administered a six question, open-ended response survey that was distributed to each of the 21 PAL Leaders that had participated in the program that semester. The purpose of the survey was to see what effect, if any, the program had on the peer tutors. The students hired to facilitate the sessions as PAL Leaders are high achieving, highly involved upper level engineering students who spent, on average, ten hours per week working as a group and holding study sessions for their peers. The questions and a sample of their responses are below:

Has being a PAL leader influenced your career goals or your personal goals? If so, in what ways?

- I really enjoy working with people. Working as a PAL leader has confirmed that. For my career, I want to be in a position where I am managing people and interacting with them on a daily basis. To be an effective leader, you must gain people's respect.
- I already planned on going to graduate school, but being a PAL leader helped to solidify those plans by showing me that I enjoy teaching and would enjoying being a TA in grad school.
- One of my goals has always been to get a job that lets me work closely with people instead of sitting at a desk. Being a PAL leader and working with these students has solidified this desire.

Do you feel as if being a PAL leader has affected you socially?

- As a PAL leader, I am able to connect with so many more people from other departments in Engineering that I would not have known otherwise. Being a part of a group in the EB really makes it enjoyable for me to be there when I need to study. I have flourished in this environment. I have gained new friendships and strengthened other ones.
- I do think that PAL has affected me socially. It has given me more self-confidence and know that I'm able to do things that I would have never thought I was able to do. I feel like I can do more things now because of it, and I'm more confident and willing to try things or meet new people.
- I have met a lot of new people through PAL, including the students, teachers, and other PAL leaders. I am very grateful to have worked with such a great group of people.

Given that there are many other student employment opportunities at MSU, why are you choosing to return to PAL?

- I like PAL because it actually puts to use something that I have learned while I was at college. I feel like taking the class is actually benefiting me. Also, I realize how difficult the class was when I took it, so I feel like if I can make the class a little more manageable for them, then we are accomplishing something good.
- I really enjoy the camaraderie that we as PAL leaders develop. There are not many jobs that I can think of at MSU where we attend most of the same classes, meet once a week together, and do things together outside of work.
- It is a fun, interactive, and creative job that allows me the chance to organize, manage and learn in the attempt to benefit my fellow peers.

What do you feel has been your greatest accomplishment as a PAL leader?

- My greatest accomplishment has been that I have helped several students remain in engineering and get through classes that they thought they were not going to pass. I have retained several students through multiple years. I feel helping these students has been my biggest accomplishment in college, not just in PAL.
- The greatest accomplishment because of PAL is learning that I can be confident, and I can be social and put myself out there, and nothing terrible will happen. Knowing that I can conduct a room of people, and that I can do it well, has helped me so much and made me feel so accomplished.

- A couple of my PAL students have told me that they were positive that they would not have done as well as they did in class if it hadn't been for PAL. I believe that providing these students with the help that they needed to succeed is my greatest accomplishment.

What do you feel is the most important skill you have gained as a result of being a PAL leader? Explain.

- I think that the most important skill I have gained is the ability to convey my thoughts more clearly and concisely so that it is easy to understand. Being able to solve a problem is one thing, but being able to explain why you solve it that way so that others can understand it too is quite another, and often it is more difficult I think.
- Teamwork and diligence are very important skills that I gained as a PAL leader. Being diligent in my studies so that I can help students is a key factor. Also, as a PAL leader, I get to work with other PAL leaders and collaborate with them in meetings as to how we can improve PAL.
- The ability to be thrown into a situation with random people and comfortably interact with them. I think that I have improved my ability to organize and manage a group of my peers. I also think my communication and leadership skills have improved. The ability to lead a group of my peers. If I can manage the students that come to PAL sessions, I can use this skill in the workplace while working on teams.

As the survey responses illustrate, the PAL leaders feel that they are benefitting from their participation in the program both academically and socially. Key words and phrases consistently appear throughout the responses, and specifically address the skills highlighted by ABET criteria. “Problem solving” was mentioned by 11 of the 21 respondents, “helping others” or “helping peers” was addressed 47 times, and the word “leadership” appeared in 12 responses. Ten leaders mentioned increased ability to “convey” thoughts or information. The words “diverse,” “patience,” and “communication skills” were each used five times. When asked about skills gained, many commented on their improved abilities in relation to communicating technical problems and the steps involved in solving them. Experiences related to teamwork include working with and managing people, working with peers, and working on teams. Many mentioned their accomplishments with helping students academically as well as making new or strengthening existing friendships. These comments also help illustrate the collegial, welcoming environment created by PAL Leaders, contrary to the sentiments expressed by those that left engineering majors, and those that we are targeting through the grant’s activities. Additionally, the number of PAL leaders returning to work for the program from semester to semester has ranged from 40% from the pilot semester to 92% in the current semester, which indicates a strong cohesion among the leaders. The survey responses support these statistics, with the majority of PAL Leaders citing high levels of job and work place satisfaction.

Adjustments Made to Maximize Program Resources

Over the past two and a half years adjustments have been made at various points to meet students’ academic needs, maximize attendance, and to continue to provide learning opportunities for both the PAL leaders and the students enrolled in the targeted courses. Changes have been based mainly on PAL leader survey data, attendance records, and anecdotal evidence. As we approached the second semester of full implementation, we made the following changes:

(1) replaced MTH 116 (College Algebra and Trigonometry) with MTH 133 (Calculus II) for the spring semesters; (2) hired additional PAL leaders for math courses; (3) reduced the number of PAL leaders in physics; and (4) increased and improved our marketing strategies utilizing a broad array of outlets.

Based on conversations with Math Department faculty, PAL leaders, and a variety of engineering students in the Fall of 2009, it was determined that MTH 133 would replace MTH 116 the following semester. MTH 133, Calculus II, is a historically difficult course with a reputation of being challenging among the majority of students who provided feedback. Data from the Math Department revealed that students' grades point averages in math courses decreased as students progressed from MTH 132 (Calculus I) to MTH 133. This indicated a common challenge with MTH 133. Since then, we have targeted MTH 116 in the fall semesters and MTH 133 in the spring. Most incoming engineering students test into either MTH 116 or MTH 132 in the fall of their first year, and then move to either MTH 132 or MTH 133 that spring.

Five new PAL leaders were hired for the spring 2010 semester. Four of the newly hired leaders had a specific interest in working with students in MTH 133, and three had previous experience working with students struggling in math in various tutoring capacities. As part of ongoing PAL leader training, a mentor program was implemented, which paired the five new PAL leaders with five returning leaders who are assigned to the same subject. This training tactic continues to be used and both the returning PAL Leaders and new leaders learn and benefit from the partnerships.

Physics 183 was the other course that we determined needed reassessment. In the fall of 2009 two PAL leaders were assigned to two sections of the course, and the data indicated that four PAL sessions per week for physics were unnecessary. The total enrollment in the sections was 475 students; thirty-two attended PAL sessions. Upon further conversations with students in the class and the PAL leaders it was determined that the majority of students seeking help with physics were attending the Physics Help Room. The answer keys for physics assignments were posted to on-line websites, making students less likely to seek on-going help or attend study sessions. Subsequently, in the fall of 2010 the MSU Physics Department changed the structure of the introductory physics course for scientists and engineers. Included in the changes was the addition of an in class exam each Monday for the duration of the semester. We observed a large increase in PAL attendance this semester, and will continue to monitor the attendance data for this course carefully. For the spring of 2011, we have added a fifth PAL Leader to PHY 183, as well as an additional Sunday afternoon review session to help students study for the Monday exams.

Combined subject sessions. Based on both PAL leader feedback and student focus group feedback collected in the spring of 2010, we modified the PAL tutoring session structure for the fall semester. Originally, each PAL Leader held individual sessions twice each week for their assigned course section in various locations around campus. The result was that one-on-one tutoring occurred due to low attendance, at scattered times and locations around campus. The structure was modified to sessions now called PAL Pods. Three PAL Leaders for each course hold sessions together, allowing for collaboration among the PAL Leaders allowing for group

work and community among first year students working together in a shared space. The leaders are able to rely on each other for assistance with challenging problems, and it sets an example for the students to follow a similar collaborative approach. Also, a student can go to a session for physics and also seek assistance with math at the same time in the same location, either in the Engineering Building or in a centrally located classroom in a residence hall. Students are no longer restricted to one session in one location for PAL; they can go to any of the offered times for their course to receive assistance. Location and timing for the sessions were also centralized; rather than different classrooms or lounges, and changing hours for each PAL leader, the tutoring hours remain consistent each day of the week in the same two classrooms. With this change the hope is that students will be more likely to remember the time and location, making it easier to attend the sessions.

Conclusions and Future Opportunities

PAL at MSU benefits both the students attending the study sessions and the upper level engineering students serving as peer leaders. This approach to academic assistance allows students to seek help and study in a friendly, non-threatening, non-competitive environment. It encourages collaborative learning, leadership, and teamwork among engineering students of various levels. It allows younger students to make connections with upper level engineering students, and to have positive academic role models in the College of Engineering. Advanced engineering majors are able to review material from courses that they took early on in their educational careers and connect it to the higher-level courses in which they are currently enrolled. Making these connections is important not only for their academic success, but it enables them to share with students earlier on in their course work the importance of success in foundational courses. The PAL program at Michigan State University is unique in that it serves all students enrolled in targeted courses. High achieving students as well as those needing extra help attend PAL sessions and study together with the help of a PAL leader. PAL is the only academic assistance program at Michigan State University that has the peer tutor embedded in the classes. Knowledge of the daily lecture topic and discussion make PAL leaders invaluable resources for the students they are assisting. As we begin the 2011 spring semester, we are striving to increase attendance and improve visibility in the College of Engineering and the greater university.

Attendance & advertising. A sub-committee of PAL leaders has been formed to work on publicizing PAL sessions and generating interest in the program among their peer group. Tactics include creating and distributing PAL schedule flyers with individual PAL leader photos and mini-biographies to introduce the PAL leaders to their assigned classes, announcing PAL sessions on computer pop-up ads in the main computer laboratories in the engineering building, creating a Facebook page on which PAL leaders and students can interact, and posting schedules on a main website describing PAL, the *EEES* Program, and giving contact and background information on key individuals associated with the project. PAL Leaders also wear brightly colored staff t-shirts to be easily recognizable and stand out in the larger lecture courses.

Evaluation. On-going evaluation and data collection is critical to the success of the PAL Program. The main purpose of future evaluation will be to (i) determine progress toward project goals; (ii) document project activities, processes, and products; and (iii) provide evaluative data

to the project team for planning and project improvement and future implementation. Evaluation will be used to help strengthen the planning process by providing data to the coordinating staff and an external assessment of progress toward goals. The evaluation will continue to document PAL activities and processes, gather information from stakeholders (students and PAL faculty), and assess accomplishment of objectives. Both qualitative and quantitative data collection and analysis procedures will be used, including existing institutional data, student records, surveys of students and faculty, focus groups and interviews of stakeholders, observation of project activities, and review of materials and products.

As the project expands its course offerings and improves its services, we will continue to collect attendance data and grades, as well as administer further surveys on impact on both PAL Leaders and attendees.

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Bibliography

1. Bernold, L. E., J. E. Spurlin, et al. (2007). "Understanding our students: A longitudinal study of success and failure in engineering with implications for increased retention." *Journal of Engineering Education 96*(3): 263-274.

2. Seymour, E. (2002). "Tracking the processes of change in US undergraduate education in science, mathematics, engineering, and technology." *Science Education 86*(1): 79-105.

3. Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO, Westview Press.

4. Bok, D. (2006). *Our underachieving colleges: A candid look at how much students learn and why they should be learning more.* Princeton: Princeton University Press.

5. Sticklen, J., Wolff, T., Bauer, W., Briedis, D., Buch, N., Courtney, J., Ehrlich, N., Fleming, D., Heckman, R., Paquette, L., Mickelson, R., Urban-Lurain, M., & Weil, C. (2009). *Engaging early engineering students (EEES): Background and goals of an NSF STEP project to increase retention.* ASEE 2009 paper 1899.

6. Urban-Lurain, M., Sticklen, J., Briedis, D., Buch, N., & Wolff, T. (2009). *Understanding factors contributing to retention in engineering: A structural equation modeling (SEM) approach.* ASEE 2009 paper 1022.

7. Briedis, D., Buch, N., Collins-Eaglin, J., Ehrlich, N., Fleming, D., Hinds, T., Sticklen, J., Urban-Lurain, M., & Wolff, T. (2009). *Connector faculty: A friendly face for early engineering students.* ASEE 2009 paper 864.

8. Micomonaco, J., & Sticklen, J. (2010). *Toward a better understanding of academic and social integration:*

A qualitative study of factors related to persistence in engineering. ASEE 2010 paper 1467.

9. Punch, W., Enbody, R., McDonough, C., & Sticklen, J. (2010). *Measuring the effect of intervening early with at risk students in a CS1 course.* ASEE 2010 paper 1565.

10. Briedis, D., Ehrlich, N., McDonough, C., Sticklen, J., & Wolff, T. (2010). *The EEES/Connector Faculty program: Surveys of attitudes, experience and evaluations.* ASEE 2010 paper 420.

11. Bauer, W. B., Briedis, D., Buch, N., Sticklen, J., & Wolff, T. (Eds.). (2009). Proceedings from ASEE '09: *Engaging early engineering students (EEES): background and goals of an NSF STEP project to increase retention*. Austin, TX: IEEE.

12. Arendale, D.R. (1994). "Understanding the supplemental instruction model." *New Directions for Teaching and Learning, 60*(4), 11-22

13. Dreyfuss, A. E., Liou-Mark, J., & Younge, L. (2010). Peer assisted learning workshops in precalculus: an approach to increasing student success. *Mathematics and Computer Education, 44*(3), 249-259.

14. Widmar, G. E. (1994). "Supplemental Instruction: From small beginnings to a national program." *New Directions for Teaching and Learning, 60*(4), 3-10.

15. Sheppard, S. D., Macatangay, K., Colby, A., & Sullivan, W. M. (2009). *Educating engineers: Designing for the future of the field*. San Francisco, CA: Jossey-Bass.

16. Accreditation Board for Engineering and Technology (ABET). (2010). *Criteria for accrediting engineering programs*. Baltimore, MD.

17. Besterfield-Sacre, M., McGourty, J., & Shuman, L. J. (2005). The ABET 'professional skills' – can they be taught? Can they be assessed? *Journal of Engineering Education, 94*(1), 41-55.

18. National Research Council. (2005). *Rising Above the Gathering Storm: Accelerating Progress Toward a Brighter Economic Future.* Washington, D.C.: The National Academies Press.

19. Smith, K. A., Sheppard, S. D., Johnson, D.W., & Johnson, R. T. (2005). Pedagogies of engagement: classroom-based practices. *Journal of Engineering Education, 94*(1), 1-15.

20. Astin, A. W. (1993). *What matters in college?: Four critical years revisited*. San Francisco: Jossey-Bass.

21. Sedlacek, W.E. (2004). *Beyond the big test: Noncognitive assessment in higher education.* San Francisco, CA: Jossey-Bass.

22. Astin, A., & Astin, H. (2000). *Leadership reconsidered: Engaging higher education in social change*. Battle Creek, MI: W.K. Kellogg Foundation.

23. Light, R. (2001). *Making the most of college: Students speak their minds.* Cambridge: Harvard University Press.