AC 2009-1899: ENGAGING EARLY ENGINEERING STUDENTS (EEES): BACKGROUND AND GOALS OF AN NSF STEP PROJECT TO INCREASE RETENTION OF EARLY ENGINEERING STUDENTS

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Engaging Early Engineering Students (*EEES*): Background and Goals of an NSF STEP Project to Increase Retention

Abstract

Early "leavers" from engineering programs typically fall into one of two overlapping categories: (a) those who leave because of academic difficulties and (b) those who leave because they find the educational environment of early engineering to be hostile and/or not engaging. This paper describes a new NSF STEP project, ***EEES***, that is a suite of four articulated programs that is designed to ease the transition of high school students into engineering undergraduate programs, and, by making the transition smoother, to increase the retention rate of early engineering students. Analysis of internal statistics has revealed key courses that are pivotal in promoting retention: early mathematics courses, first term physics, and a computational tools-for-problem-solving course.

The ***EEES*** project is a collaborative effort between the College of Engineering at Michigan State University and Lansing Community College. ***EEES*** consists of four content subprograms: (a) a program to provide formative assessments in the key courses with follow-on "bootstrapping" tutorials, (b) a supplemental instruction program which we call the PAL (peer-assisted learning) subproject, (c) a program to directly engage engineering faculty with early engineering students, and (d) a program to develop and exploit course material from one key course in another. Our effort is not a conglomeration of the four independent subprojects; rather ***EEES*** is a *system* of four interrelated, articulated programs that will be more effective than the sum of its parts.

We are approximately six months into a five year project; we do not present results in this paper. Rather, here we describe the motivation for our project, our explicit goals, the broad project architecture for our entire effort, and end with our current status. This report will set the stage for three companion papers, and for a series of future reports. The three companion papers describe our subproject applying "supplemental instruction," a second subproject connecting our faculty more effectively to our early engineering students, and a third paper describing the methodology for research analysis that we will employ.

1. Motivation: Importance of increasing STEM numbers

To sustain US leadership in science and technology we must increase the number of undergraduate degrees in science, technology, engineering, and mathematics (STEM). An estimate from The Information Technology Association of America indicates that by 2015, a doubling in the number of STEM degrees will be required to keep pace with expected job openings.[1] Yet the National Science Board of the National Science Foundation (NSB/NSF) recently reported trends in the growth of STEM degrees that does not remotely approach the numbers required. Moreover, NSB also reported that the United States production of STEM degrees badly lags most of our economic competitors.[2] The data reveal that seven of our global competitors produce per capita more than twice the numbers of STEM graduates as the United States, and even more strikingly, two of our global competitors produce more than three times per capita: Finland and Taiwan.

Engineering disciplines are a significant part of the overall STEM story. The NSB projects a need for 109,000 additional engineers by 2012.[3] This is at a time when engineering enrollments have declined in some areas and at best remained stable in others. An increase in the numbers of engineering graduates is now a national priority.

In the College of Engineering at Michigan State University (MSU), undergraduate engineering enrollments have declined substantially over the last decade. The local decline has been beyond that in most other areas of the US. The exaggerated decline in engineering enrollments in our state is related to the rapid decline of the manufacturing industry, long a mainstay for the state's economy.

In general, there are two ways to increase undergraduate engineering degrees: (a) increase the numbers of students initially entering the programs (recruitment) and (b) decrease the numbers of students who choose to leave the engineering programs once started (retention).

Enrollment patterns for the MSU College of Engineering are shown in Figure 1. Although the downward trend for the decade-long period is clear, it is important to note that an upturn in Fall 2006 took place. Over the last three years, the MSU College of Engineering has initiated an aggressive program of recruitment. That program is now bearing fruit as evidenced by the 2006 uptick in freshman enrollment shown in Figure 1. Because of this path we believe we are adequately addressing issues of recruitment. This is a tentative conclusion because it is based empirically on a one-year uptick. However, given the effort and resources we are applying to recruitment, we are confident that recruitment issues are being handled adequately. Thus, ***increased retention is the primary goal of the project we report here.***

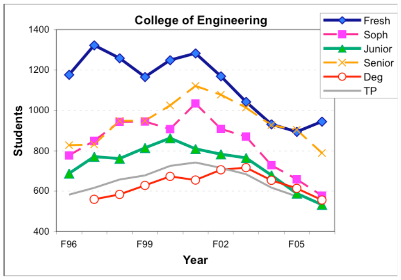

Fig 1: MSU College of Engineering enrollment patterns 1996-2006

From a thorough review of enrollment and graduation statistics over the last decade we found that our most vulnerable period of loss is the interval between the time a student enters MSU and the time the student completes the second calculus course. 65% of students who enter MSU as pre-engineering students graduate within five years with an engineering undergraduate degree; for students who complete the second term of calculus the graduating percentage jumps to 85%. Thus, ***increased retention of early engineering students is our specific project goal***.

The project team is an active and established collaboration between MSU and Lansing Community College (LCC). Targets for the project are increasing retention and graduation rates in the MSU College of Engineering and the pre-engineering programs of LCC. Evaluation of our project is headed by a well-established center for evaluation located within MSU, the Institute for Public Policy and Social Research (IPPSR).

Our methods and results should generalize to the single most important source of engineers in the United States: “R1” universities - research active, usually large public institutions. Although producing more engineers is now a critical item in our state’s economic recovery, the need for more engineers is a nationwide phenomenon. Lessons that we by necessity must learn and apply in our state now will generalize across the country.

2. Current status of Engineering STEM enrollments/graduations in our Institutions

LCC and the College of Engineering at MSU enjoy a strong working relationship. LCC is one of the most important feeder programs sending transfer students on to MSU after two years. We are strengthening, expanding, and learning in the context of this relationship as part of our overall strategy to retain students in the engineering majors. One strong link between LCC and MSU has been the “2+2+2” program in which qualified urban high school students are supported and mentored through their junior and senior years in high school with an emphasis on mathematics and science, then continue on as a cadre through two years of engineering preparatory courses at LCC. Finally, in the last two years of the program, students complete their B.S. degrees at in the MSU College of Engineering. Students in “2+2+2” are supported by LCC and MSU and typically include a high percentage of under represented groups.

3. Prior Efforts and Status in Engineering at MSU

MSU enrolls approximately 45,000 students, and is the seventh largest university in the United States. MSU admits approximately 7600 freshmen per year; these incoming freshman may freely declare any major. However, third and fourth year engineering classes have enrollment restrictions to balance resources, especially resources needed to offer laboratory and project courses. To continue as an engineering student after the second year, five core courses must be completed (Calc1 and Calc2, Physics1, Chemistry1 and one problem solving with computational tools course) with a GPA (weighted by technical courses) of 2.80 to 3.00 or better, dependent on major.

In the MSU College of Engineering, incoming undergraduate engineering enrollments have declined 33% from 2001 to 2006. (Figure 1) From calendar year 2003 to 2006, the number of B.S. degrees dropped from 716 to 556 (-22%) and are expected to continue to drop to about 450 (-37%) in CY 09. In CY 09 a recent rise in enrollments will begin to manifest itself as a halt to the decline in graduations. In the same time frame, the number of B.S. degrees across non-engineering STEM disciplines at MSU has risen from 653 to 822. The decline in MSU engineering enrollments and degrees began earlier and has been of greater magnitude than in other areas of the United States. Similar trends have been observed in some other state schools, notably those near major urban areas and other regions with economies historically centered on manufacturing and the automotive industry. In the same time frame as the engineering enrollment declines, the state has lost about 350,000 jobs, with approximately half being high-paying, manufacturing jobs

As enrollment has declined, the MSU College of Engineering has purposefully maintained high GPA entrance requirements. Experience has shown that students with GPAs below approximately 2.80 in core mathematics and science courses are not well prepared to continue through an engineering curriculum, nor will they be marketable in a global workplace and a tough economy. Rather than lower academic standards to maintain enrollment numbers, the MSU College of Engineering is working on two fronts to increase our graduation rates.

- Programs have been instituted to increase the numbers of students entering MSU to pursue engineering. The addition of an Assistant to the Dean for Recruiting and K-12 Outreach in December 2005 was largely responsible for the increase in first-year enrollments shown in Figure 1. The academic ability of new first-year students (as measured by ACT scores) has also risen.

- Long standing efforts to retain engineering students such as the MSU Residential Option for Science and Engineering (ROSES) program have been accelerated, and new developments that will play strongly in retention are online or in final preparation, including a newly redesigned first year experience (in place now) and a residential program that will include most freshman and sophomore engineering students in one living, learning community (to roll out in Fall 2009).

As is true for many undergraduate engineering programs, our most significant attrition is from the group of early engineering students. Data below indicate that the bulk of our attrition comes from (a) students who are performing well academically, but choose to leave; and (b) students who fall just short of the academic threshold we set.

An examination of the relationship between GPA and completed credits for the 2005 first-year student cohort was undertaken. Figure 2 shows data from this cohort as of summer, 2007.

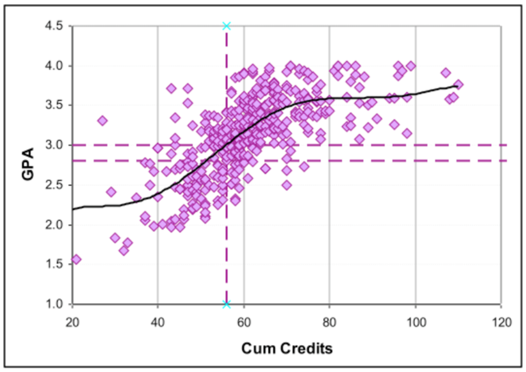

Fig 2: MSU College of Engineering Freshman Cohort (entering Fall 2005) - Snapshot in Summer 2007 for STUDENTS WHO STAYED IN ENGINEERING

Students in the lower left quadrant have not completed 56 credits in two academic years and remain just short of the 2.80 to 3.00 they need for admission. These are the students who are at academic risk for admission to engineering.

MSU awards grades in 0.5 increments (2.0, 2.5, 3.0, etc.), and if many students earned a 0.5 higher grade in several key technical courses it would increase their likelihood of admission to engineering. By shifting the grade distribution higher, we will enable a significantly higher number of students to reach the threshold for admission to engineering.

Figure 3 shows data for those students from the 2005 cohort who have left engineering. Our two target groups are shown.

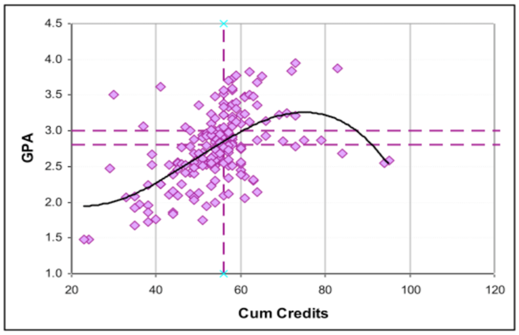

Fig 3: MSU College of Engineering Freshman Cohort (entering Fall 2005) - Snapshot in Summer 2007 for STUDENTS WHO LEFT ENGINEERING

- Very significant numbers of students who left engineering majors were just under the required GPA threshold (Strong clustering in Figure 3 just to the left of 56 credits and just under the 3.0 GPA line.)

  These students, leavers[4] with addressable academic issues, have likely left because they did not meet academic GPA cutoffs and were unlikely to raise their grades sufficiently to do so. This supports our assertion above that a small increment in GPA will have a large effect on retention.

- Significant numbers of students choose to leave engineering even though their GPAs would indicate no debilitating academic difficulty. (Upper right quadrant in Figure 3.)

  While about eight percent of these students – leavers in good standing – went to other STEM majors, most changed to non-STEM majors. We believe that these students choose to leave STEM disciplines because of concerns over pedagogy and lack of social support in STEM classes, as suggested by Seymour and Hewitt.[4]

The target of ***EEES*** is to address <u>both</u> groups of students identified above:

- **leavers with addressable academic issues:** students who leave engineering because they fall just short of the academic standards, and

- **leavers in good standing**: students who leave engineering although they have not experienced severe academic difficulty.

4. Prior Efforts and Status for STEM at Lansing Community College (LCC)

At LCC the same set of core technical courses are key to success of pre-engineering students who intend to transfer to four year engineering programs: Calc1, Calc2, Physic1 (Physics: Mechanics), and computer science. LCC students must achieve a GPA of 3.0 in these courses to be considered for transfer to MSU engineering. As part of a long standing program implemented at LCC, Supplemental Instruction (SI) is offered for a number of courses, including Calc1.[5] Experience with the LCC SI Program is consistent with other studies of SI with an increasing number of students succeeding once SI is in play.[6]

At LCC, calculus enrollments are typically an indicator for enrollment in pre-engineering curricula. From fall, 2002, to fall, 2007, enrollments in Calculus 1 declined 24%, with a large drop in fall, 2005 (see Figure 4). This drop during this time period parallels the drop at MSU. Fall 2006 and 2007 data indicate that enrollments may be rebounding, although earlier levels have not yet been reached. Calculus II enrollments have followed a similar trend.

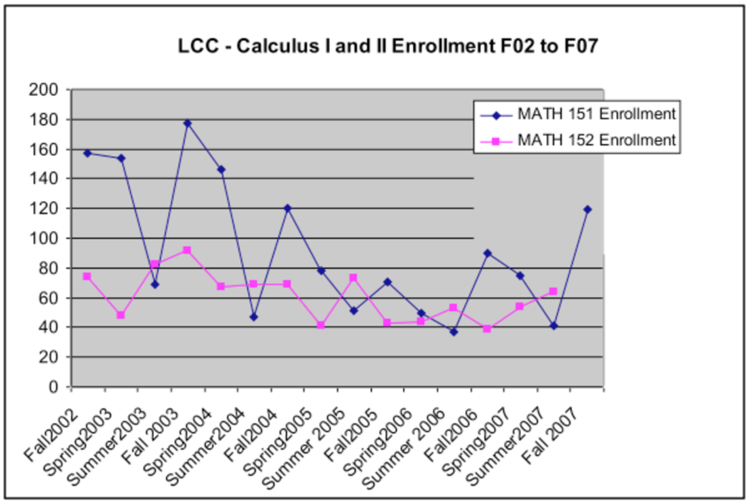

Fig 4: Enrollments in Calc1 (151) and Calc2 (152) at LCC, Fall 2002 - Fall 2007

Historically, LCC students who have transferred to MSU's College of Engineering have been successful as a group in their MSU programs regardless of the numbers of students enrolling. As mentioned above, one program of particular note is the "2+2+2" program. This successful scholarship program has targeted urban youth, many from under-represented groups of students in secondary schools in the greater Lansing public school system. Selected high school students are mentored in small groups starting in their junior and senior years of high school with the goal being to develop college level mathematics and science proficiencies prior to entering LCC. At MSU, for two years, students further develop technical competencies, retain group identity, and group mentoring is continued. The third "2" is spent obtaining an MSU College of Engineering degree. The middle "2" at LCC and the final "2" at MSU are funded by LCC and MSU, respectively. The 2+2+2 program has proven to be effective largely because of the building of group cohesiveness and personal ambition in the students served. In particular, the mentoring aspects of "2+2+2" are lessons that will be extended in ***EEES***.

5. Project Goals and Implementation Components

> ***By the end of the EEES project (end Phase 1, after five years), we will increase the matriculation-to-graduation retention rate from its current value of 65% to a value of 75%.***

Internal MSU statistics indicate that primary losses in engineering come while students are early engineering students, operationally defined as the time before engineering students complete Calculus II. Once students successfully complete their core technical courses and are formally admitted to their major, 85% of them will complete their engineering degrees. Thus, in ***EEES*** we specifically target retention of early engineering students.

There are two entering pipelines for MSU engineering students: (a) the pipeline of transfer students from LCC and other like institutions and (b) the pipeline of students who matriculate as first year students at MSU. The programs we are implementing in ***EEES*** span both institutions. We will raise the retention rate of early engineering students by applying a multi-faceted approach, and in synergy with large-scale developments in the MSU College of Engineering. The two most salient developments that the ***EEES*** program articulates with are (a) a program to redefine the first year engineering experience and (b) a large scale program to expand our current residency program in undergraduate engineering to encompass most first year engineering students. An important focus in both efforts is on community building for early engineering students. These programs and the synergy with ***EEES*** will be described later in this paper.

The four ***EEES*** components are:

- a program of Supplemental Instruction for the key core courses taken by early engineering students. For local reasons, we call this subprogram “peer assisted learning” - PAL,

- a program of content cross-linkages among key technical core courses taken by early engineering students,

- a program to develop a set of formative course diagnostics and linked capability-building exercises that students will use to strengthen skills important for course success, and

- a program to increase engineering faculty connections and mentoring with early engineering students. We call the “connector faculty” program - CF.

We discuss the four components of ***EEES*** in the next section. However, a central feature of ***EEES*** is that it is not a single program to cut early engineering attrition, nor is ***EEES*** a conglomeration of four unrelated programs. Rather ***EEES*** is a ***system of four interrelated, articulated programs*** that will be more effective than the sum of its parts. We will return to this point.

6. ***EEES***: Description of the system and its four content components

Causes of attrition from STEM majors have been studied extensively and are fairly well known. Faculty perceptions of introductory courses as a place to "weed out" ill-prepared or incapable students combined with student perceptions of many introductory courses as being disconnected with their future work as engineers result in national attrition rates similar to those at MSU.[4, 7-9] As Seymour and Hewitt have pointed out, the primary way to address these issues is to change the content and pedagogy of introductory courses, and to build infrastructure for student support into them.[9] In the ***EEES*** project, there are four integrated components that are designed to involve engineering faculty in rethinking the structure of the introductory courses. In the ***EEES*** system we will address both of the issues that Seymour and Hewitt point out.

The ***EEES*** architecture is shown schematically in Figure 5. ***EEES*** targets students in four key technical courses taken by early engineering students to prepare them for upper level disciplinary courses: pre-calculus algebra and trigonometry (MTH 116), calculus 1 (MTH 132), physics 1 (PHY 183) and computation-based problem solving (EGR 102). The four ***EEES*** components are shown in the light colored bubbles in Figure 5. The dark boxes show groups of faculty or students who are part of the implementation of ***EEES***. And the dark green bubble shows the

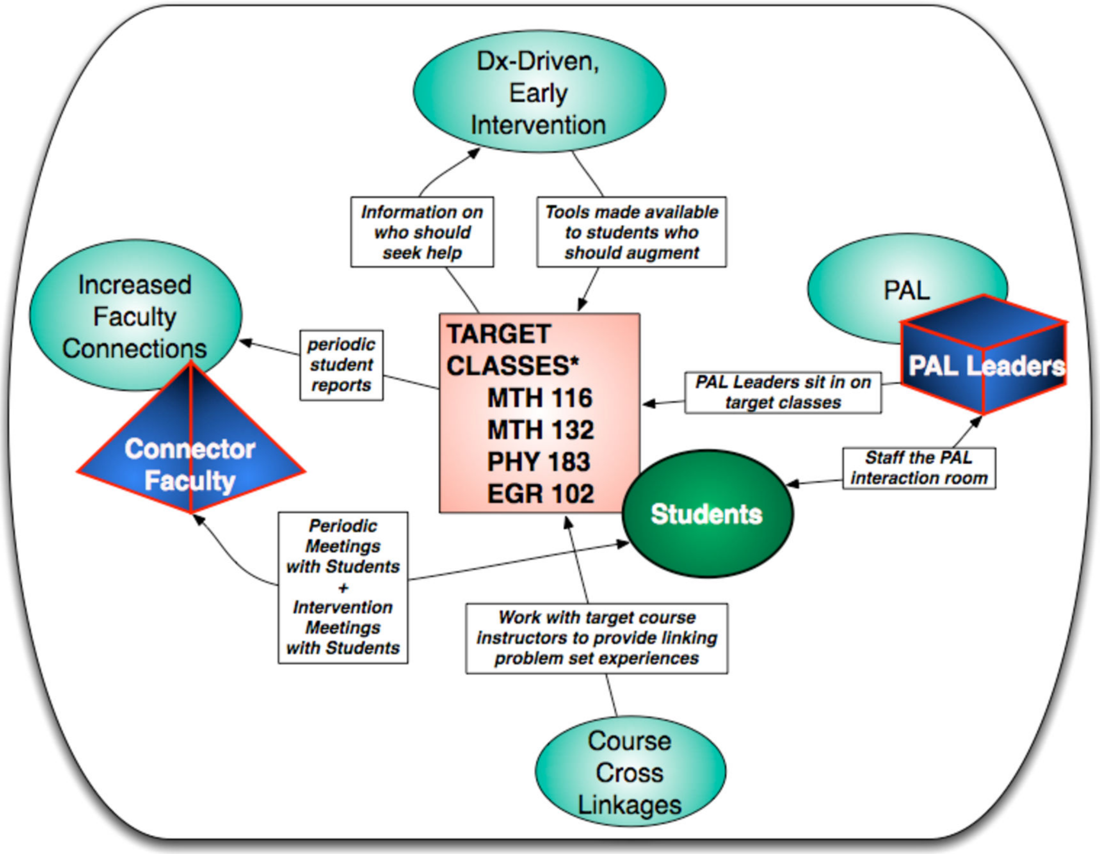

*Fig 5: The **EEES** Architecture*

target group: early engineering students.

The mathematics and physics courses are outside of the College of Engineering. The EGR 102 course will a primary locale for engaging engineering faculty in 1) changing the curriculum; 2) incorporating more active-learning, team-based projects, and integrating mathematics and physics into the curriculum; and 3) fostering a sense of engineering community among faculty and students.

The four components of ***EEES*** are being implemented at LCC and at MSU Engineering. Faculty members at the two locations have varying familiarity with each component. For example, LCC has had a program of supplemental instruction for over a decade, but as part of ***EEES*** it is not now implemented for early engineering students as a PAL component. To implement the PAL component of ***EEES***, the successful LCC model for PAL and SI PAL training has been imported to MSU. Faculty at both LCC and MSU have experience with web-based diagnostic-driven early intervention. Extensions created at both institutions will be shared and implemented cross-institution. Full implementation of ***EEES*** for both institutions is a collaboration between ***EESE*** principals.

7. Subproject focused on Increased faculty connections: Connector Faculty (CF)

The goals of the "increased faculty connections" component of ***EEES*** are two-fold: (a) link early engineering students to engineering faculty and (b) to project the core value of the College of Engineering that engineering faculty "care about" the early engineering students. Studies have repeatedly shown that one important factor in promoting early student engagement in coursework is the degree to which the students perceives that the instructor wants them to succeed, and genuinely cares about their academic progression.[10-12] The central charge to the "increased faculty connections" component is to foster faculty engagement and concern for students.

The key to this ***EEES*** component is a cadre of engineering faculty members recruited to become "Connector Faculty" (CF). Each CF receives a yearly draw against an ***EEES*** supplies fund of approximately $500 to use for educational or faculty development purposes. This has proven to be an effective driver for faculty participation in other local initiatives. Each faculty person recruited is trained before becoming Connector Faculty with emphasis being on faculty/student interaction.

Once trained, each CF is assigned approximately 8 students. CF have two responsibilities. First, the CF will receive periodic academic progress reports for their students in the target courses shown in Figure 5. If the reporting indicates to a CF that a student is falling behind or having difficulty, then the CF faculty will make an appointment with the student for a discussion. This intervention is largely aimed at the potential "leaver" who may leave engineering because of academic difficulty.

A second charge to the CF is to meet at least once per term with students assigned to them. This charge is aimed at the other type of leaver - the leaver who chooses to go to another discipline even through there is no academic difficulty. These “leavers” were studied extensively by Seymour and Hewitt[4], with a major conclusion being that this type of “leaver” goes elsewhere largely because he feels isolated, not connected, and adrift. Faculty engagement with the student, particularly at critical times, can make the difference between a student remaining in engineering versus leaving. The second CF responsibility is to these academically qualified but unengaged leavers.

The CF play a critical role in the ***EEES*** program. They are the “face” of the faculty as seen by the student and provide encouraging contact, timely intervention, and career role modeling. The cadre of CFs includes the entire instructional group for the first year program/computational tools course (EGR 102 in Figure 5), plus other faculty closely involved with the newly renovated MSU first year program (e.g., the associate dean, the course design team, other committed faculty) such that the target faculty to student ratio is approximately 1:8. As much as possible, these faculty have a demonstrated commitment to education and sincere interest in student success. As Tinto points out, “students are more likely to persist when they find themselves in settings that hold high expectation for their learning, provide needed academic and social support, and actively involve them with other students and faculty in learning.”[13] Such modes of interaction have been particularly effective in the retention of underrepresented groups and women as well. A deviation from our steady state procedure for the CF program is operating in our pilot semester, Spring, 2009. During that semester, our target is students in the first course of our first year engineering program.

A companion paper in these proceedings (Briedis et al) describes our Connector Faculty subproject in detail.

8. Subproject focused on “Peer Assisted Learning” - PAL

Supplemental instruction (SI) is a type of peer mentoring / tutoring activity. Substantial successes have been attributed to SI. (See for example, Blat[14].) Unlike some approaches, standard SI targets high-risk courses instead of trying to target high risk students. In the ***EEES*** context, SI is not aimed at remediation, but rather seeks to link more advanced engineering student peers to early engineering students, and by giving students in the target class both a role model and source of non-threatening help, the goal is to lift the aggregate performance of the students and thereby increase the percentage of students doing well in the course. In the ***EEES*** context, and for procedural reasons at our institutions, we have termed this SI component as our “peer assisted learning” subprogram - PAL, as shown in Figure 5.

The most salient characteristic of the target classes enumerated in Figure 5 is that all are viewed by the students as abstract classes. All require early engineering students to reason at levels of abstraction that they are typically not comfortable or facile with. This makes all each course a good candidate for PAL application.

Our PAL subprogram modifies some of the standard attributes of SI. Typically there is a close relationship between the faculty in the SI target course and the SI Leader. In our case, the cadre of PAL Leaders are all engineering students, and have primary linkage back to monitoring and organizing supervisors in the College of Engineering. The instructor in the target class approves the use of PAL for students in his classroom, and assists in reviewing the course materials to be used by PAL Leaders. But primary responsibility for the operation of PAL does not rest with the course instructors, but rather with the ***EEES*** project members.

A companion paper describing our PAL subproject in detail is in preparation. Contact the lead author for a preprint.

9. Subproject focused on Course cross linkages

The goal of the ***EEES*** component on course cross linkages is to help students build and strengthen connections between ideas/problems in engineering and the ideas they encounter in their core technical courses. In particular, the curriculum materials will be designed to help students make connections between abstract concepts seen in science and mathematics and their application in engineering.

The ***EEES*** component in Figure 5 labeled "Course Cross Linkages" is focused on curricular development. The target course EGR 102 is a course taken by most early engineering students in the second term of the freshman year. EGR 102 is a problem solving with computational tools course that is part of our newly renovated first year experience intended to introduce first year students to engineering and develop teamwork skills. MTH 116 (Pre-calc algebra and trigonometry) is typically taken either before EGR 102 or concurrently with it. MTH 116 may not be a required course if a student is placed directly into MTH 132 (Calc1). MTH 132 is typically taken before or concurrently with EGR 102. PHY 183 (Physics 1) is typically taken after EGR 102.

Here or somewhere indicate that the CF and PAL have been implemented but this is not yet implemented as we phase in the project.

We will develop exemplar problems for EGR 102 as the focus for the ***EEES*** course cross linkages component. ***EEES*** principals will work directly with faculty in MTH 116/132 and in PHY 183 to incorporate concepts from these courses in EGR 102. Linking EGR 102 to material studied in MTH 116/132, and as foreshadowing to material that will be studied after 102 in PHY 183 will help beginning engineering students to understand how mathematics and physics are foundational to engineering.

For example, conservation of energy is a topic covered in PHY 183. A computational problem set or project for EGR 102 could be developed around computing the energy budget for a commercial airliner. Conversion efficiency from fuel burned to turbine rotation to thrust developed to airfoil lift all could be presented in the context of conservation of energy to help students see physics as a core part of the engineering discipline, rather than a “requirement” to be endured.

Since the mathematics and physics courses are offered to a broad range of students beyond engineering, we cannot expect mathematics and physics faculty to incorporate engineering problems into their course content. Rather, ***EEES*** principals will work with relevant faculty in physics and mathematics to articulate principles from these courses with relevant engineering problems for use in 102.

It is important to note that many R1 institutions do not have lock step curricula. Hence our results in developing and implementing course linkages will be of broad interest, particularly in large R1 institutions in which, like the local case, engineering faculty do not determine the sequencing or content of core prerequisite courses.

10. Subproject focused on Diagnostics-driven early intervention

The fourth component of ***EEES*** is diagnostics-driven early intervention to identify and intervene with students who either do not realize they are misunderstanding important technical concepts or they put off acting on their understanding that they are “behind.”

There are formative assessments available to students in all target courses. The results of these assessments are available only to the student and to the instructor, and are only for formative purposes. The results also come back to the student with an indication of any concepts the students does not seem to understand correctly, and with pointers to materials and services that are available to the student to help with the concept. Services pointed to include the Connector Faculty for the student, the PAL sessions for the class, and web-based, highly targeted material the student can access to more fully master a troublesome topic or concept.

For the two target mathematics courses MTH 116 and MTH 132, the diagnostics will be an extension of existing “gateway test” developed in part by two of the ***EEES*** senior researchers. Gateway Exams in mathematics were originally developed at the University of Michigan. With MSU internal support, in 2004, faculty in our Mathematics department designed a new version of these gateway tests. Test questions are automatically generated. A student registers with the proctor and is given a test whose number is recorded with the student's name. The student works the test and returns it to the proctor, who, using the identification number, can view the correct answers on a computer. The proctor marks each question as right or wrong and returns the test to the student to keep. The background and experience with the Gateway Exams in Mathematics will be leveraged strongly in our ***EEES*** component for course diagnostics and intervention.

In addition, in PHY 183 and EGR 102, a bank of diagnostic formative tests will be developed by ***EEES*** Principals working with instructions for PHY 183 and EGR 102. Likewise, a set of highly targeted web resources to help students address the difficulties they may uncover will be either indexed for students (existing resources) or developed (implemented in house).

11. Summary of *EEES* Architecture - Integration of Components

The four components of ***EEES*** as described above interoperate. There are two goals that are central if we are to reduce attrition of early engineering students: (a) increase retention of those students who leave because of academic difficulty and (b) increase retention of the those students who are not in academic difficulty but who leave because they feel isolated, because they feel their coursework is composed of isolated and unrelated silos, and/or because they sense no interest in their progression on the part of engineering faculty. Table 1 summarizes the four components of ***EEES*** and the contribution of each component to these sources of attrition in early engineering.

Table 1: Summary of student issues addressed
by ***EEES*** components

EEES Component	reality or perceived academic difficulty	perceived unrelated coursework	perceived isolation as individual	perceived lack of faculty concern
Connector Faculty	x	x	x	xx
PAL	x	x	x	
Course Cross Linkages		x	x	
Diagnostics-based bootstrapping	x			

Table 1 shows that the Connector Faculty play the central and pivotal role in ***EEES***. This is appropriate given the central point of literature studies on attrition across the board in instructional programs: that without direct engagement of faculty both in reality and in the perception of students, increasing retention is difficult at best. Connector Faculty will be the "glue" that holds the entire ***EEES*** effort together.

12. Current Status

The six months from August 2008, to January 2009, has been a time of very concentrated planning by the entire ***EEES*** project team. The project involves two institutions of higher learning, MSU and LCC; two major colleges within MSU, the College of Engineering and the College of Natural Science; and fifteen senior researchers.

One of our subprojects has been up and running since September, 2008: diagnostic-based bootstrapping in MSU is expanding from existing "gateway" programs in our Calculus 1 course, and is being implemented in LCC in Calculus 1. Results however are not yet available to characterize the impact of the effort.

Our Connector Faculty subproject pilot began in spring term, 2009. The recruitment and training of over 30 engineering faculty who have stepped forward to participate is completed, and in February 2009, these engineering faculty started meeting with their students. This effort is described in a companion paper in these proceedings (Briedis et al).

Our PAL subproject likewise is being piloted in spring term, 2009. Recruitment and training of an initial set of five PAL leaders has taken place. The target classes for the PAL pilot are 5 sections of our Calc 1 course. Although it is too early to draw any conclusions on the effectiveness of our PAL implementation of supplemental instruction, initial counts for student attendance at our PAL sessions has been encouraging.

Our other content subprojects are current under design and will pilot in fall, 2009: a second diagnostics-based bootstrapping program (this one targeting students in physics 1) and our subproject on class course linkages.

EEES is at the same time a development project to increase retention of early engineering students ***and*** a research project to determine effective methods for increasing retention. It is not enough at the end of our five year project to proclaim success if we reach our goal of increasing retention by 10 percentage points. We must also determine in a very complex environment the effect of each of our subprojects on retention. Reaching this ambitious research goal will enable transference from our experience to like institutions. The core research analysis methodology that we have selected is the "structural equation modeling" (SEM) approach. Our planned application of SEM is also described in a companion paper in these proceedings (Urban-Lurain et al).

We look forward to the challenges of next four and a half years as we mature, modify and evolve the ***EEES*** project.

13. Acknowledgements

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