Active Learning in Mathematics: Using the Supplemental Instruction Model to Improve Student Success

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Abstract

With the support of the Hewlett Foundation's Engineering Schools of the West Initiative, Boise State has implemented a program called Active Learning in Mathematics, based on the model of Supplemental Instruction (SI). This paper reports on the progress and lessons learned in the first 3 semesters of ALM support for pre-calculus and Calculus II, two well-known gate-keeper courses in the engineering programs. The program is currently in its 2nd semester and has already undergone major modifications due to lessons learned in the pilot stages.

Motivation

Boise State University is a metropolitan university with more than 18,000 students enrolling every semester. The College of Engineering was formed in 1996 and offers B.S. M.S, and M. Eng. Degrees in Electrical Engineering, Civil Engineering, Computer Science, Mechanical Engineering and Materials Science & Engineering. A large fraction of the students at Boise State are non-traditional students defined as those older than 24 years of age. Because of this and because of the general population that Boise State serves, many of our engineering students begin their studies under-prepared in math and often require 2 or even 3 semesters of math before they are ready for Calculus. In addition, many of our students struggle through the math sequence and often take Calculus I and Calculus II two or three times before earning a passing grade. Yet many of these students succeed and graduate as capable engineers. A snapshot of the 2003 graduating class in Mechanical Engineering is a good indicator. More than 50% of the students were not ready for Calculus when they enrolled at Boise State. In addition more than one quarter needed two semesters of math preparation before taking calculus.

While the makeup of the incoming class demonstrated the challenge in meeting the needs of under-prepared students, it's compelling to consider the makeup of successful students to see where they began in mathematics. By analyzing the transcripts of 37 recent graduates with BSME degrees from Boise State, we ascertained the first college-level math course taken by each student. Since Boise State (like nearly all universities)

requires a process of math placement for students to register for math classes, this is an indicator of the students' preparedness for mathematics instruction (as determined by the mathematics faculty).

Figure 1 shows a chart with this population broken down by percentages and their first college mathematics class. It is worth emphasizing that this chart shows a wide variety of backgrounds, not of students entering the program, but of students who have successfully completed the program.

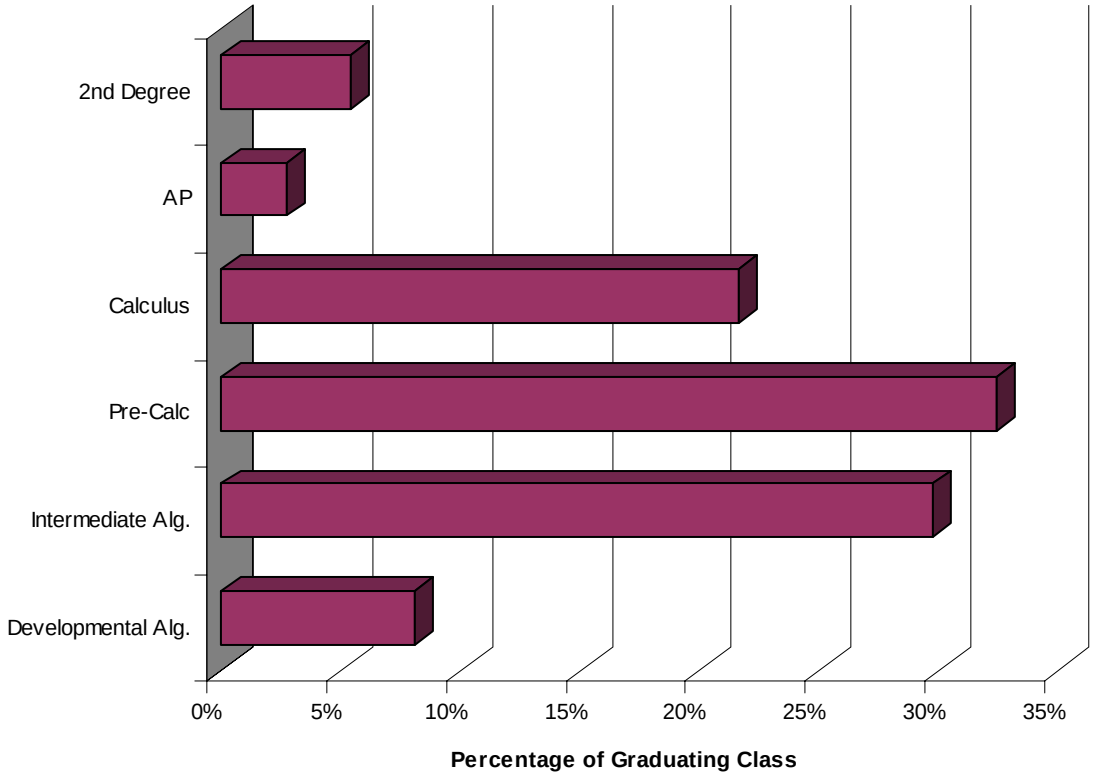

Figure 1: Make up of a 37-member graduating class in Mechanical Engineering as determined by their first college-level mathematics class.

For two of these students, this was their 2nd degree so their first college-level course was not categorized. Of the remaining students, only 1 started the program with Advanced Placement credit for calculus, and hence began the program in Calc II. Even more surprising, only 8 of the students (less than one quarter) started at the typical starting point for engineering students, Calc I. The majority of students began one semester behind, in pre-calculus (made up of advanced algebra and trigonometry). Perhaps the must stunning statistic is that three students began their college studies in non-credit bearing developmental algebra.

At this point, it bears pointing out that even though many students arrived at Boise State under-prepared in Math, our graduating students have one of the highest pass rates on the Fundamentals of Engineering exam in the nation.

From these and similar data, the faculty at Boise State have concluded that the under-prepared students (those who are determined to be unready for Calculus when they begin their studies) represent a significant and often overlooked population of potential engineering students. When you combine this observation with the common perception that under-represented groups are often over-represented in this population, it becomes clear that it is worth exploring ways of supporting this group in any way possible.

Support for the Under-prepared Student

Boise State University is fortunate to be part of the Engineering Schools of the West Initiative (ESWI), funded by the William and Flora Hewlett Foundation[2] to help improve engineering education at public institutions in the Western United States. At Boise State, we chose to focus our efforts on support for under-prepared students, and for most of those, that means mathematics. Boise State already has an extensive tutoring program, providing drop-in tutoring at all levels of mathematics instruction. Therefore, it was decided that more aggressive support should be developed, aimed at specific courses that are known to be historically difficult for engineering students. Surprisingly, we discovered that Calc I was not one of those courses as the success rate of Calc I is rather high. Further analysis showed that only a minority of students in Calc I are beginning their college career, hence the high attrition often seen in the pre-calculus and developmental algebra courses.

Supplemental Instruction and Mathematics

The Supplemental Instruction (SI) model has proven to be successful in many settings, particularly for at-risk students in gate-keeper courses [3,4]. Surprisingly, this model has not been widely used in developmental mathematics courses as noted by Wright[5]. One of the reasons that SI has not been used much in mathematics is that SI has been found to be less effective in courses that require certain prerequisite materials and skills[1]. Yet, in spite of these issues, the ESWI team at Boise State targeted MATH 147: PreCalculus for the pilot of SI in the engineering college at Boise State.

SI program

The program at Boise State was originally conceived to be substantially similar to the model used in nearly all SI programs. Successful engineering students, usually Sophomores or Juniors, who have completed the mathematics sequence (3 semesters of Calc, one of Differential Equations) are hired as SI facilitators (later called Active Learning Facilitators, ALFs). The ALFs complete a single session of training in which the aims of the program, their roles and their responsibilities are described. Each ALF is assigned to one or more section of the math class and are expected to attend all lectures

of that section. On the first day of class, the ALF is introduced by the course instructor so that they are a familiar face to the students.

Each ALF will then run an Active Learning session each week in which interested students meet in a separate classroom with the ALF. The ALF will spend a few minutes fielding questions, but will then pose problems for the students to solve. The problems are chosen each week (through a single coordinator) to be both indicative of the skills required of the students at this point of the semester and to be very applied in nature, representative of the kind of engineering problem that this mathematical tool could be used to solve. Finally, students in the session are told to solve the problem as a group, articulating their problem solving approach to each other and to the facilitator while they solve the problems. The facilitators are told to be coaches rather than instructors, attempting to elicit, as much as possible, the correct answer from the student without explicitly leading them there.

Lessons Learned

The first two semesters of SI for MATH 147 were disappointing. While students who regularly attended SI sessions reported high satisfaction and good outcomes, the percentage of students who participated was very low, uniformly below 10% of each section's enrollment. This occurred in spite of strong support from the mathematics faculty and generally good 'PR' from the students. Boise State's role as a commuter campus has been found to interfere with any student activities not specifically scheduled by their course work and it is felt that this greatly hinders the participation by students who might otherwise be motivated to attend the sessions. It was also feared that the term Supplemental Instruction is unfamiliar to the majority of freshman college students and that it carried a stigma similar to "remedial" programs. Based on our early assessments, the following changes were made:

- The name of the program was changed to "Active Learning in Mathematics" to better reflect the nature of the program and to eliminate possibly negative language.
- The students were encouraged to attend any session that fit their schedule, not just the one run by the facilitator who is attending their session.
- Facilitators were permitted to hold additional sessions in any week if students from the class requested a more convenient time.
- Advertisements were taken out in the school newspaper to publicize the existence of the program to prospective students.

In addition, as we begin our 3rd semester of supplemental instruction, the following new features are being added to the program

- A 'virtual' systems is being piloted through which student facilitators will be available through internet discussion rooms (through the university's BlackBoard™ portal).

- The SI facilitators are receiving additional training, coordinated by the university Tutoring Service.
- The program is being expanded to the first two semesters of Calculus to ensure that we retain students at a high rate through those courses.
- The program is being expanded to include MATH 108 (Intermediate Algebra) which is the prerequisite course for MATH 147.
- Relationships between ALFs and students will be enhanced through periodic e-mails and phone calls.

In addition, other changes are being considered. It is argued that SI for calculus or other mathematics courses may be more effective if the sessions are longer and more frequent.[1] Therefore, our own model of SI for math will be revisited in an attempt to do a better job of fostering meaningful improvement in mathematics preparation for students at Boise State.

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5. Wright, G.L., R.R., Wright and C.E. Lamb. 2002. Developmental mathematics education and supplemental instruction: Pondering the Potential. Journal of Developmental Education. Vol 26, No 1, pp 30-35.