USING AN ONLINE LEARNING SYSTEM TO ENHANCE DEVELOPMENTAL MATHEMATICS

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Problems with Lecture-based Courses

College mathematics courses are often challenging for many students. Students who enter college without adequate preparation are often placed in courses designed to compensate for their inadequate preparation and prepare them for so-called mainstream mathematics courses. These compensatory courses often make use of the same lecture-based techniques that have failed these students in the past.

Lecture-based approaches to teaching mathematics assume that all students are the same and encourage students to be consumers of mathematics rather than producers of mathematics. The traditional approach of a mathematics professor standing at the front of a class lecturing to a class of students treats the students as identical raw material. Each student is assumed to enter the class with the same knowledge and to learn at the same pace. Some professors make concessions to reality by giving first-day assessments to determine the overall mathematical preparation of the class. The professor begins

teaching material appropriate for that level of preparation. Professors can also pace the class at an appropriate level by obtaining periodic feedback about students' understanding as the class progresses. Some ways of obtaining feedback include quizzes, class work, taking up homework, and student response devices (clickers).

"The essence of learning math is doing math, rather than passively listening." (Thiel, Peterman, and Brown, 2008) Lecture-based mathematics classes encourage students to be consumers of mathematics rather than producers of mathematics. Students watch mathematics professors talk about mathematical definitions and concepts and then work example problems. But mathematics is not a spectator sport. Ideally, students abstract from the examples the mathematical concepts and are able to apply those concepts in solving problems on their own. The majority of these student problems are given as homework and students must try to figure out on their own how to apply the concept. For students who are already inadequately prepared mathematically, such abstractions and applications prove problematic.

Suggested Solutions

A number of different approaches have been proposed to move away from a lecture-based approach. The University of Missouri-St. Louis has implemented a redesign of their college algebra course in which a three-day per week lecture format was replaced by a hybrid format with one lecture and two computer lab sessions (Thiel, Peterman et al. 2008). Students did homework during lab sessions using a program that gave them immediate feedback. Students learned how to work the practice problems with support

from the software. They received immediate feedback and could rework problems of the same type they had answered incorrectly. As a result, the college algebra course has seen a rise in successful completion of the course from 55 percent to 75 percent without reducing the standards of the curriculum.

The college algebra course at the University of Missouri-St. Louis reflects some of the practices recommended by organizations such as the American Mathematical Association of Two-Year Colleges (AMATYC) and the National Center for Academic Transformation (NCAT). In their standards document, *Beyond Crossroads* (AMATYC 2005), AMATYC argues that student learning today is participatory with knowledge being constructed through action. According to AMATYC, students today learn better through discovery, respond rapidly, and expect rapid response in return. The organization recommends incorporating technology to enhance student learning of mathematics and to promote distance learning through a number of formats including the hybrid format used by the University of Missouri-St. Louis.

The National Center for Academic Transformation has studied and provided resources for redesigning classes around the nation. The organization has been involved in more than four dozen redesigns of courses from a number of disciplines including mathematics and other STEM disciplines. Their Roadmap to Redesign (R2R) (NCAT 2010) provided the basis for the University of Missouri-St. Louis redesign of their college algebra course.

Using NCAT's most radical redesign model, the emporium model, institutions have

reported dramatic increases in student success. NCAT has identified many of the reasons that the emporium model succeeds in general education or compensatory mathematics courses. First, students spend more time actually doing mathematics. NCAT argues that the three hours students spend attending lectures would be better served by actually having students do mathematics. Second, students' efforts are focused on learning material they do not know rather than reviewing material they already know. Finally, students obtain assistance and teaching at the time that they encounter problems. The point at which a student is having difficulty solving an equation or trying to understand how two equations are related is a teachable moment. Students' normal mathematical thinking is perturbed, leaving them open to changing that way of thinking.

Using an Online Teaching Tool to Enhance Developmental Mathematics

The Pre-College Algebra course, MATH 0099, at the author's institution was designed to address some of the ideas of course redesign from NCAT and AMATYC. This innovative design includes self-pacing, early exiting which allows the students who just need a review to finish the course early, just-in-time teaching which helps students with what they need when they need it, and is web-based which gives the students flexibility to work on the course at home or at school.

The self-paced nature of the course allows students one, two, or three semesters to learn the content in traditional compensatory courses. The content includes topics from Arithmetic, Beginning Algebra, and Intermediate Algebra. Instead of students being placed into specific levels (which can often include topics the student has mastered and

omit topics the student has not mastered), the students are placed in one course. In this classroom, each student can begin with what they know. In addition, this course eliminates the need for distinct courses by placing students at different levels in the same course.

Another key aspect of the course design is that it is mastery-based. Initially, students are given an assessment to determine what they know. Based on the assessment, topics are available for the student to study which build upon the topics that are mastered. More difficult topics covered in the course are locked until the student has mastered prerequisite topics. Once the prerequisite topics are mastered new topics are opened up. The students are also encouraged to revisit content that they have already mastered. Frequent assessment is also built into this component to ensure that students retain the material that they are learning. Assessments can be automatically or manually-triggered, and they can be designed to include topics previously mastered by the student.

There are some challenges that come with a classroom filled with students with different preparedness levels. Most of the challenges are for the instructor although there are some challenges for the student. One challenge faced by students is that they tend to be mindful of where they are in a class. If they're ahead of other students, they tend to want to slow down, and they can become discouraged if their classmates are far ahead. Keeping the students motivated and reminding them that their math preparation is unique is one way to get past this challenge.

Instructors are challenged to be flexible and to prepare to give various mini-lectures to suit a particular student's learning style. Because of the use of an online learning system, the course is taught in a computer lab. Instructors must also battle the students' misperception of them as a lab supervisor (for technical support) as opposed to an instructor (for mathematical support). The students tend to focus on areas they can learn on their own while they are in class instead of those topics that are more difficult for them. As a result of this challenge, students end up with a list of topics that are more challenging (for them) which can be discouraging. At that point, they will require more of the instructor's time and attention in order to continue to progress through the course. One approach to avoiding this challenge is to give mini-lectures on selected topics to students who are working on those topics. This serves two purposes. The students get the just-in-time assistance that they need, while other student are reminded that a math instructor is present.

Results

The results of the redesign of MATH 0099 have been positive overall. We will examine the results both in terms of exit rates and preparation for the subsequent mathematics course, college algebra. Prior to fall semester of 2007, there was no MATH 0099 course being offered at the author's institution. The course was offered for the first time in Fall 2007 in essentially its current format. Therefore, no data exist prior to Fall 2007.

From Fall 2007 to Summer 2009, 490 students enrolled in MATH 0099. The population included students from diverse backgrounds including both traditional and non-traditional

students, students whose majors were undecided and students who had already declared their majors. Almost all students were freshmen when they began MATH 0099. Placement into MATH 0099 was based on the results of their scores on the COMPASS placement test; a score of 36 or below placed them in MATH 0099. State policies required students have a final grade of C or better in MATH 0099 in order to take the COMPASS test again and exit the course by scoring above 36 on the COMPASS test.

Of the 409 students who enrolled in MATH 0099, 306 or 62.4% qualified to take the COMPASS test. Two hundred thirty-six students scored above 36 on the test and successfully exited the course. The number corresponds to 77.1% of those tested for an overall exit rate of 48.8% over the period from Fall 2007 to Summer 2009. The mean time that students took to exit the course was 1.57 semesters.

Because of the open-ended nature of the course with students progressing at their own pace, it is difficult to compare exit rates of MATH 0099 with exit rates of other institutions. Some institutions have a one-semester compensatory mathematics course that offers only a review of college algebra while others have a three or four-semester program that includes basic arithmetic. An examination of state colleges similar to the authors' institution whose programs follow the same state policies shows a mean time to exit of 1.89 semesters, a difference of almost a half-semester (USG 2010). In addition, the data shows that the exit rate across the state colleges surveyed was 46.2%, nearly identical to the authors' institution.

Exit rates and time to exit are important pieces of information, but a more important piece of information is how well students do in their subsequent mathematics course, college algebra. Table 1 (University System of Georgia 2010) shows the performance of students in college algebra who successfully completed MATH 0099 compared with the students in the state college system (University System of Georgia 2009). The percentage of students making A's, B's, or C's from the MATH 0099 course is 77% compared with the state colleges at 47%. A further comparison of performance between students enrolled in college algebra who scored just above the cutoff score of 36 and so did not take MATH 0099 with those who scored just below the cutoff and took MATH 0099 showed no significant difference in performance.

	N	A's		B's		C's		D's		F's	
MATH 0099	153	27	18%	46	30%	44	29%	13	8%	23	15%
System-wide (Su 2005-Sp 2006)*	2356 NR	225	10%	382	16%	497	21%	289	12%	373	16%

Table 1: Comparison of scores of MATH 0099 with other state colleges

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