How Activity Based Learning in Introductory Mathematics Courses Impacts College Students' Attitudes toward Mathematics

Ching-chia Ko, Barbara Edwards and Gulden Karakok
Oregon State University

This paper describes a nontraditional, activity-based algebra curriculum that was first introduced into a college freshman introductory level mathematics course in the 2006-2007 academic year and the attitudes of students toward mathematics and toward the class. The curriculum emphasized conceptual mathematics over procedural skill and encouraged students to actively participate in their own learning. A -survey of students' attitudes towards mathematics was given to all students at the beginning of the term, and again at the end. In Fall 2007, we revised our content based partially on the results from these surveys. This year, conceptual mathematics remains the center focus, but procedural skills are also covered. In this talk we will discuss the curriculum change as well as the results of a current survey of students in the Fall 2007 class.

Issues in College Algebra

College Algebra is a required course for many college majors at our university. Despite the important role that this course plays in students' academic careers, students are less than enthusiastic about taking it. At our university College Algebra is notorious according to many students for being the hardest freshman course on campus. The fact that this is a very fast paced course taught in a 300 seat auditorium lecture hall makes the situation worse. Because there are so many students in the course multiple choice exams with no partial credit are typically given. Low attendance for the class is a common problem, and in general, students have a negative attitude toward the course. Thus, College Algebra has a much higher failure

and withdrawal rate than other courses on campus, a fact that is also true nationally.

The College Algebra Guidelines adopted by the Mathematical Association of America's committee on Curriculum Renewal Across the First Two Years (CRAFTY) recommend that college mathematics courses, especially College Algebra, should be student-centered, activity-based, and include small group activities and projects (CRAFTY, 2007). Research studies support the CRAFTY Guidelines. A study by Shaughnessy (1977) showed that small-group problem solving activities in class not only appear to have a positive effect upon college students' attitude toward mathematics, but these activities also boosted student confidence in their abilities to do mathematics. Another study (Geske et.al, 2000) confirmed Shaughnessy's results showing that student confidence is affected by an alternative activity-based, experiential teaching format. Furthermore, mathematical explanations by peers often seem to be more helpful to students than are explanations by instructors in facilitating original thinking and problem solving (Laws, Rosborough & Poodry, 1995).

Evidence from our own experiences and from these studies encouraged us to improve the way that freshman-level mathematics courses were offered at our institution. This led to the design of a new course in Algebraic Reasoning for students who failed to place in College Algebra upon entering the university and recently to a new approach to teaching College Algebra itself.

Algebraic Reasoning: 2006-2007

Algebraic Reasoning was first introduced in Fall 2006 as a course to prepare students for College Algebra. Enrollment was restricted to freshman only and class size was limited to 35 students per class. The course was designed to emphasize conceptual mathematics and to address the topics of rates of change and functions. Procedural skills practice was addressed only in a minimal way during the first year. The course was activity-based with very little lecture; students worked in groups of three or four during most of the class time. Homework was assigned weekly and often preceded class work on a topic. Two mid-term examinations and one final examination were given. A total of eight sections were offered the first term. Four of the eight sections met daily from Monday to Thursday 50 minutes each, while the other four met twice a week 110 minutes each. A total of thirteen sections of this course were offered in 2006-2007.

Algebraic Reasoning: 2007-2008

We modified our curriculum after the first year based upon observations we made while teaching the course in the previous year and on the results of our student attitude surveys. Algebraic concepts still form the core emphasis in the course but we have included daily skills practice in the form of warm-ups at the beginning of each two-hour session. In addition, an out-of-class small group modeling project is

assigned to replace one of the mid-term examinations.

Results

Pre and post surveys were given to students to examine their attitudes and beliefs about mathematics before the course and to compare those to their attitudes and beliefs after the class. We also used the post surveys to investigate student attitudes toward the course itself. In addition, we have also tracked our students' performance in College Algebra, which until now has been taught in a traditional large-lecture format.

We note that the pedagogically traditional mathematics courses that many of our students have experienced through their K-12 education have had a profound impact on their understanding of the nature of mathematics and on their expectations for college mathematics courses. Many of our students had difficulties adjusting to a mathematics course that requires them to do more than just take notes, memorize and follow template solution strategies. Below are two examples of comments from students who experienced this difficulty

- [In the Algebraic Reasoning class] we were never told the answer to anything. My style of learning is, show me how then I'll do it.
- In all my other classes, all I have to do is sit and take notes, but in this class, I have to think. [We assume this student viewed this as a bad thing.]

This type of frustration in students is most commonly seen at the beginning of the term. Students can be very resistant at first, but gradually most of them come to enjoy the course as the term moves on and many realize that learning mathematics is not just about being told directly what to do by the teacher. Some positive comments from the student surveys follow.

- I liked how you made us think of definitions and answers, not giving it to us directly. It made me remember more.
- I like how you never tell us the exact answer so we can think for ourselves more deeply. I feel discovery in learning can store in peoples mind more effectively
- Even though it pissed me off when I asked a question, and you said, "what do you think?", it helped me think about the problem for myself and I learned how to do a lot of things on my own.

In addition to the surveys, we also compared the passing rate of students in College Algebra at the end of winter 2007 among three groups of students:

- students who in fall 2006 took Intermediate Algebra, a more traditional course offered outside the mathematics department,
- students who took Algebraic Reasoning in fall 2006,
- students who enrolled in but failed or withdrew from College Algebra in

the fall and then enrolled for the second time in the winter.

Our data shows that the percentage of students who successfully completed College Algebra by the end of winter 2007 was greatest in the group of students who began with Algebraic Reasoning in the fall. (See the table below.) However, a 33% success rate is far from acceptable and the improvements we have made between 2006-7 and 2007-8 should produce better results.

	Math 95 Fall	Math 103 Fall	Math 111 Fall DWF
# of Students	137	280	308
% DFW	37 %	6 %	**
# Enrolled in Winter Math 111	71/137 (51.1 %)	176/280 (63 %)	83/308 (26.9 %)
% DFW Math 111	36/71 (51%)	84/176 (47%)	30/83 (36.1%)
% Fall Students Passing Winter Math 111	35/137 (25.5 %)	92/280 (33 %)	53/308 (17.2 %)

Where we are now

We are currently in the process of modifying our pre and post surveys and we have continued to follow the student performance in subsequent mathematics courses. We plan to conduct interview with a group of volunteer students to study these students' experiences in the Algebraic Reasoning course and to see from their perspective how this course influenced their attitude toward mathematics in long term.

In spring 2008 we will offer five experimental sections of an activity-based, modeling approach to College Algebra. These sections will be limited to 35 students and students will do an out-of-class group project instead of one mid-term. In our research we will focus on two questions.

- In what ways do our students' understandings of concepts related to rates of change and functions differ from those of students who have enrolled in a traditional College Algebra course?
- In what ways do students' attitudes toward mathematics differ among students who took both Algebraic Reasoning and our College Algebra course, students who took only our College Algebra course, and students who took a more traditional College Algebra course.

References:

Bradford, M. (2005). Motivating students through project-based service learning. *THE Journal*. 32(6), 29-30

CRAFTY College Algebra Guidelines, MAA (2007). Washington, DC.

Geske, J.A., Mickelson, W.T., Bandalos, D.L., Jonson, J., & Smith, R. W. (2000). Predicting acquisition of learning outcomes: A comparison of traditional and activity-based instruction in an introductory statistics course. Paper presented at the 2000 annual meeting of the American Educational Research Association in New Orleans, LA.

Haver, B., & Turbeville, G. (1995). An appropriate Culminating Mathematics Course. *AMTYC Review*, 16(2), 45-50.

Laws, P.W., Rosborough, P. J. & Poodry, F. J. (1995). Women's response to an activity-based introductory physics program. *New Directions for Teaching and learning*, 61, 77-87.

Leikin, R., & Zaslavsky, O. (1997). Facilitating Student Interactions in Mathematics in a Cooperative Learning Settings. *Journal for Research in Mathematics Education*. 28(3), 331-354.

Shaughnessy, J. M. (1977). Misconceptions of probability: An experiment with a small-group, activity-based, model building approach to introductory probability at the college level. *Educational Studies in Mathematics*, 8, 295-316.