College Algebra Reform

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Abstract

There is a call for change in College Algebra. The traditional focus on skill development is failing, resulting in withdrawal and failure rates that are excessive. In addition, too many students who are successful do not continue on to take a successive mathematics course. The Institute for Mathematics Learning at West Virginia University has been restructuring College Algebra with the objective of improving student attitude towards and success in mathematics. The following is a report of research into the successes and failures of this course.

The Institute for Mathematics Learning (IML) is developing a common vision for the restructuring of all lower division mathematics courses, including Liberal Arts Mathematics, Applied College Algebra, College Algebra, College Trigonometry, Precalculus, and Applied Calculus. Core components of this common vision are:

- **Computer Enhanced Course:** Course management software WEBCT and web sites provide student access to course materials, assessment, web based mathematical tools for exploring mathematics, student communication and assistance, and grade book. Students are provided an on-line current grade status a minimum of four times throughout the semester.
- **Curriculum Materials:** Creation of or selection of texts that support a constructivist model of teaching.
- **Lab Based Course:** Large lecture sections (from 80 to 200 students) are assigned to labs of 80 students once a week. The focus of the labs is on using technology to improve student conceptual understanding, engage students in applying mathematics to solve problems, and improving students' attitudes and beliefs about mathematics. Communities are formed in the lab consisting of 25 students mentored by an undergraduate or graduate student. The course coordinator, instructor, or lab manager oversees these communities.
- **Active Student Learning:** The course coordinator leads efforts to implement teaching strategies that engage students and informally assess student learning in large lecture sections and labs. Current strategies being explored are classroom participation problem sets, Personal Response Systems that allow for immediate student interaction, and Power Point slides that guide course discussion, serve as student lecture outlines, and provide guidance to instructors on key concepts.
- **Formative and Summative Assessment:** Quiz and exam development are implemented using the course management software WebCT. A formative assessment component includes weekly on-line homework quizzes which students access from any computer. A summative assessment component includes chapter

and final exams on-line at a secured location so students can be monitored. A future strategy is gateway exams that add a mastery-learning component for required skills.

- **Student Accountability:** Attendance is taken and posted on-line on WebCT. Active participation activities are assessed and posted on-line on WebCT.

The Applied College Algebra course is currently implementing all of the above components, however, not all of the components were in place for the entire time period of the study. Implementing the components has been a three-year project. Curriculum materials developed for the Applied College Algebra course include the ACT in Algebra Text (2003), 10 interactive laboratories, 10 on-line quizzes, 4 on-line exams and exam reviews, a gateway preassessment to determine students' mathematical deficiencies, 22 classroom participation activities, and 22 Power Point presentations to guide large lecture classroom teaching and provide real world data problems for class discussion.

Desired outcomes for the restructuring of the lower division mathematics courses can be classified into three types: student success outcomes, cognitive outcomes, and affective outcomes. Student success outcomes include improvement of students' success in completion of the courses and success in subsequent courses. Student failure to succeed in the course is defined as receiving a grade of D (pass but not recommended to take subsequent course), F (fail so must retake course) and W (withdraw from course so must retake). We will refer to students in these three categories as DWF. Success in a subsequent course is determined by tracking student grades in the subsequent courses. Those with a grade of A (excelled), B (above average), or C (average) in the subsequent course are considered successful. While this gives an overview of student success or failure, it does not provide insight into which course components are responsible for the change. In addition, it does not provide information on the cognitive and affective outcomes, since a course grade amalgamates these factors. Cognitive outcomes for the Applied College Algebra course, such as mastery of skills, improved conceptual understanding, and the ability to apply mathematics to real world problems, require a more detailed analysis that has not yet been conducted. Affective outcomes for the course, such as attitude and belief about mathematics, have been assessed through an attitude survey and interviews conducted with student focus groups.

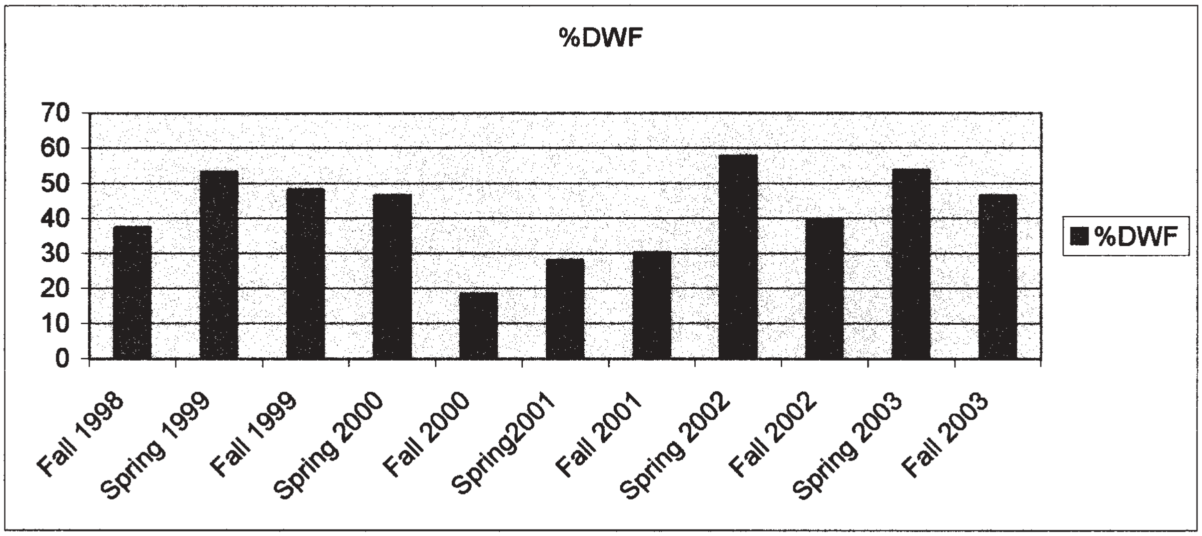
While data was collected on a number of the courses that IML restructured, this paper will only report those for the Applied College Algebra course. Table 1 provides a total of subsequent success for the three semesters that data was gathered. Success in subsequent courses for students receiving an A or B in the Applied College Algebra course is over 90% in all but one case with small numbers. For students receiving a C in Applied College Algebra the success rate for statistics is relatively high (67% and 80%), but for Applied Calculus the success rate is only 54%. This data supports the fact that students are prepared to be successful in the subsequent course.

While data for subsequent course success is positive, data on DWF rates is not. The restructured Applied College Algebra course began in the fall of 2001. Chart 1 provides a histogram on DWF trends from 1998 to 2003.

Table 1: Total Subsequent Success

Initial Course	Grade in Applied Algebra	Subsequent Success			
		College Trigonometry	Applied Calculus	Introductory Statistics	Business Statistics
Applied Algebra	A	*0/0* **0%**	*29/30* **97%**	*2/3* **67%**	*3/3* **100%**
	B	*4/5* **80%**	*90/100* **90%**	*4/4* **100%**	*17/18* **94%**
	C	*1/4* **25%**	*51/95* **54%**	*12/18* **67%**	*32/40* **80%**

Chart 1: Applied College Algebra DWF Trends



While the Applied College Algebra course has a better DWF rate average then the previous course, the DWF rate has increased each fall semester since 2001. This trend is in part due to efforts to increase student accountability by improving course requirements. Why has the DWF problem been so resistant to change? While we do not know all the causes for the continued DWF problem, we do have data indicating some probable causes. First, 33% of the students in the fall 2003 semester had serious deficiencies in previous mathematical knowledge as indicated by the course preassessment. The data in Table 2 represents the highest score the student received on either attempt on the preassessment. Of those scoring above 80% on the preassessment, 79% went on to be successful in the course (received a final grade of an A, B, or C). Only 38% of those scoring in the 60% to 80% range were successful in the class and none of them earned an A. In the below 60% range only 3 students received even a C. Note that 33% of the students could not score at a basic skill level even after review and with two opportunities on the preassessment.

Table 2: Preassessment and Success

Course Grade	Preassessment Score			
	80 to 100	60 to 80	40 to 60	0 to 40
A	23	0	0	0
B	95	8	0	0
C	85	32	2	1
D	33	27	6	0
F	21	37	7	3
W	0	3	1	0
Total	257	107	16	4

A second cause for the DWF problem is lack of student engagement. Despite required class attendance and participation activities that count towards the final grade, student attendance is often only moderate. In fall 2002 and fall 2003 the mean attendance was only 75% and in spring 2003 only 62%. Even when students attend some do not actively engage in the course, but rather undermine activities meant to assist them in learning mathematics. Students engage in courses they find motivational. The modeling aspect of the Applied College Algebra course is intended to provide students with a reason to engage, such as the utility of the mathematics in their chosen major and in being a viable member of a democratic society. There is still a lot of work to do in the area of student engagement.

Data on affective change was gathered through an attitude survey in fall 2002 and spring 2003, and focus group interviews in fall 2002 and spring 2003. The attitude survey consists of 40 Lickert scale items that measure seven subscales concerning student attitude about mathematics and learning mathematics. All student responses were converted so that a 1 represents a very strong positive response and a 7 represents a very negative response. Table 3 summarizes the seven subscales and provides means and standard deviations for each application of the measure, including a pre and post attitude survey in fall 2002 and a post attitude assessment in spring 2003.

Table 3: Attitude Survey Data

Subscale	**Fall 2002 Pre-attitude**		**Fall 2002 Post-attitude**		**Spring 2003 Post-attitude**	
	Mean	SD	Mean	SD	Mean	SD
1. Technology in learning math	3.14	0.96	3.72	1.16	3.79	1.28
2. Intrinsic versus Extrinsic	4.71	1.38	4.64	1.22	5.14	1.38
3. Applicability of mathematics	3.46	1.08	3.95	1.11	4.29	1.28
4. Construction vs. reception	3.74	1.41	3.99	0.66	3.46	0.80
5. Cooperative learning	3.00	0.64	3.05	1.41	3.08	1.52
6. Understanding versus skill	3.64	0.75	3.95	0.67	3.84	0.68
7. Problem solving	3.92	0.75	4.02	0.68	4.16	0.74

A key observation from the attitude data is that all the observations fall within the range of 3 to 5, indicating that the average attitude on all subscales was close to neutral (a value of 4). While a quantum shift in attitude in one semester is not expected, in the fall 2002 semester only subscale 2 indicated any improvement in attitude from the pre to the post attitude measure. Using the fall 2002 pre-attitude measure as a baseline, in the spring semester only subscale 4 indicated improvement in attitude.

Efforts at transforming the Applied College Algebra course are still underway at the Institute for Mathematics Learning. There is still much to be done to address issues of student success, student active engagement, and assessment. In the spring 2004 semester changes in the course were adopted to address areas of concern. Student accountability was strengthened by requiring all labs to be completed under mentor supervision, individual students were required to submit participation activities as evidence of attendance and participation in class, and exam reviews were made mandatory. Course management was improved to include weekly grade postings on all course components, weekly postings of an overall grade calculation, and posting of student participation. Both student accountability and course management are aimed at improving student active engagement in the course and tracking where students are at risk.

A support initiative for at risk students was initiated in spring 2004 semester. The initiative is called Algebra Aid. Students are identified as at-risk at the outset of the course if they score less than 80% on the retake of the Preassessment gateway exam. These students were required to attend an additional help session each week for 1 ½ hours. These help sessions focused on algorithms and skills by actively engaging students in working problems. If students scored higher then 70% on the first exam, then Algebra Aid become optional for them. However, at each exam the need for assistance was reevaluated, and all students scoring 70% or lower were required to attend Algebra Aid.

In fall 2004 the IML is already examining the use of Personal Response Systems (PRS) and gateway exams as new tools in the struggle against student failure in College Algebra. A PRS system allows students to provide instantaneous data in class on what they understand and where they are struggling. With the push of a button on their transmitter, data is sent to a receiver that collects it and allows the data to be displayed. The IML views the PRS as a means of improving the in-class participation activities, so that all students are required to actively engage in the lecture sections. In addition, gateway exams are being considered as a means of allowing for independent student mastery of the skills based component of the course.

The challenge of engaging students at the before-calculus level in mathematics that moves beyond rote manipulation is a daunting one. The students enrolling in these courses often lack adequate preparation and the majority lack the intrinsic motivation to actively engage in the course. The IML believes that demonstrating the utility of mathematics in modeling real world problems is a viable means of addressing the engagement issue. But there is much work to be done on the how and why of implementing this approach.