

## RESTRUCTURING OF BEFORE CALCULUS COURSES

Robert Mayes  
West Virginia University  
Department of Mathematics, PO Box 6310, Morgantown WV 26506  
[rmayes@math.wvu.edu](mailto:rmayes@math.wvu.edu)

The Institute for Mathematics Learning (IML) was established in the West Virginia University Mathematics Department in 2001. The IML has three core missions:

1. The IML's priority mission is improving curriculum, instruction, and assessment in before-calculus classes through innovative and effective math learning models. This mission will be expanded to include calculus in the future.
2. Providing outreach to K-12 students and teachers.
3. Restructuring math education courses for K-12 teachers.

This report will focus on the first of these missions.

In the first four semesters of the IML the focus was on restructuring of the Before Calculus courses with the express goal of improving student learning and student perceptions about mathematics. Math 124, 126, 128, and 129 have been the IML focus over the Fall 2001 through Spring 2003 academic semesters. Math 121 and 150 were added to the IML course focus over the Fall 2002 and Spring 2003 semesters. These two courses are under partial implementation. Coordinator and development leaders for the courses are:

<u>Course</u>	<u>Coordinator</u>
• Math 121: Liberal Arts Mathematics	Mike Mays
• Math 124: College Algebra with Applications	Robert Mayes
• Math 126: College Algebra	Laura Pyzdrowski
• Math 128: Plane Trigonometry	Mike Mays
• Math 129: Pre-Calculus	James Miller
• Math 150: Applied Calculus	Eddie Fuller

Math 121 and Math 150 are focusing on computer based assessment and course management through WebCT. The plan is for these courses to move to lab-based courses in the 2004-2005 academic year. Math 124, 126, 128 and 129 have already implemented a lab based approach to instruction that includes the following components:

- Computer Lab – large lecture sections (up 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 manages these communities.

- Homework Quizzes – weekly homework quizzes are given on-line, with student access through any computer.
- Increased Student Accountability – required attendance at all lectures and labs, with attendance taken regularly and reported on-line. A swipe card system is used in taking attendance.
- On-line exams – students take all exams on WebCT and are allowed to use on-line mathematics tools such as the Grapher, Java based applets, and Math Write applets.
- Active student engagement in large lecture sessions – student participation activities that engage students in hands-on activities are being developed.
- Power Point slides have been developed that provide students with access to lesson notes before the class is taught and provide guidance for instructors on concepts to emphasize.

### **Success in Subsequent Courses**

With each successive semester the IML faculty have made refinements to the courses that increase academic expectations, while maintaining or improving student success rates. The success of students in subsequent courses (measured as receiving an A, B, or C) is one indication of the increased academic expectations and course success (Table 1). Note that Math 121 and Math 150 are terminal courses, so they are not listed in Table 1. Overall the success rate in subsequent courses of students receiving an A or B in the previous IML course are excellent, reaching 90% or higher. The exceptions are Math 126 (B) to Math 150 (82%) and Math 155 (29%); Math 128 (B) to Math 155 (58%), Stat 211 (67%), and Econ 225 (75%); and Math 129 (A or B) to Math 155 (78% and 61% respectively).

Both Math 126 exceptions and 2 of the 3 Math 128 exceptions resulted from students taking courses out of sequence or taking the wrong pre-requisite course. This calls for better advising and stronger enforcement or establishment of course sequences. The rates of success in Math 155 coming from Math 128 (B, 58%) and Math 129 (A, 78% or B, 61%) are lower than the rates for other IML courses, but they are also preparing students for a more technically difficult calculus course. Still, alignment of the objectives for these two courses with Math 155 should be examined.

Students earning a C in the previous course vary widely in their success in the subsequent course, which is not surprising. However, even the C students succeed at 57% or higher rates when they took the appropriate subsequent IML course, except in two cases: Math 128 (C) to Math 155 (11%) and Math 129 (C) to Math 155 (19%). While a C is not a strong endorsement for success in a subsequent course, the low rates in these later two cases needs to be addressed.

Math 126 lab based sections outscored the Math 126 5-day sessions (traditional course) in all appropriate subsequent courses for A, B and C levels except for C's in Math 150

**Table 1: Success in Subsequent Courses**

Initial Course Fall 2002	Grade Initial Course	in Spring 2003 Subsequent Success				
		Math 128	Math 150	Math 155	STAT 211	ECON 225
Math 124	A	0/0 0%	24/24 100%	1/1 100%	1/1 100%	2/2 100%
	B	3/3 100%	74/81 91%	0/0 0%	3/3 100%	12/13 92%
	C	1/3 33%	29/51 57%	0/0 0%	4/5 80%	8/12 67%
Math 126	A	6/6 100%	5/5 100%	3/3 100%	4/4 100%	2/2 100%
(Lab Based)	B	32/34 94%	9/11 82%	4/14 29%	9/9 100%	7/7 100%
	C	20/24 83%	11/17 65%	3/10 30%	5/10 50%	11/13 85%
Math 126	A	14/17 82%	2/3 67%	3/4 75%	3/3 100%	2/2 100%
(5Day)	B	25/29 86%	7/9 78%	3/7 43%	2/5 40%	1/1 100%
	C	26/33 79%	9/10 90%	3/11 27%	8/10 80%	6/6 100%
Math 128	A	N/A	0/0 0%	10/11 91%	1/1 100%	0/0 0%
	B	N/A	4/4 100%	21/37 58%	6/9 67%	3/4 75%
	C	N/A	2/2 100%	3/27 11%	0/0 0%	2/3 67%
Math 129	A	N/A	100%	78%	100%	100%
	B	N/A	100%	61%	100%	100%
	C	N/A	100%	19%	80%	0%

(65% to 90%) and Econ 225 (85% to 100%). Care must be taken in interpreting this data, since Math 126 5-day accepts students of lower ability (lower ACT scores), but provides a much lower student to teacher ratio than Math 126 lab based sections. However, this

does provide some evidence that larger section classes using a lab based approach can achieve success rates equivalent to small section traditional classes.

Another item of interest evident in Table 1 is the number of students that go on to take a subsequent course. Only 48.3% (712/1474) of all students enrolled in Math 124, Math 126 (lab based), Math 128 and Math 129 go on to take the subsequent course they were preparing for in the next semester (Table 2). These students may be changing majors, leaving WVU, or delaying taking the next math course for a semester. All of these are undesirable options.

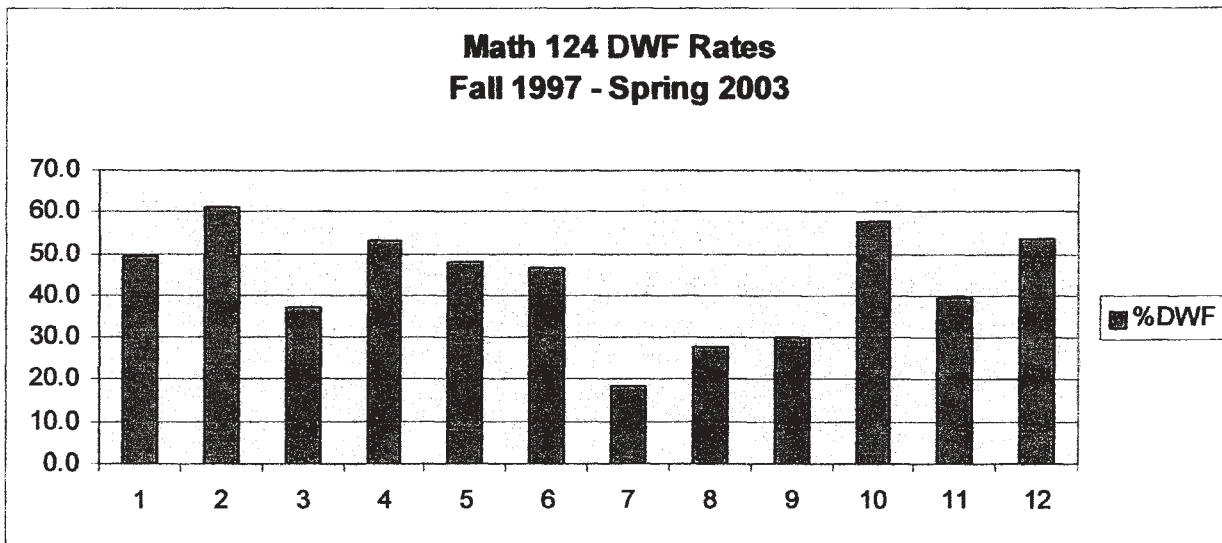
**Table 2: Continuing in Math**

Course – Fall 2002	Total Enrollment	Subsequent Course	Percentage
Math 124	443	232	52.4%
Math 126 Lab Based	467	214	45.8%
Math 126 5-day	446	202	45.3%
Math 128	302	141	46.7%
Math 129	262	125	47.7%

### Grade Distributions

The grade distributions and DWF rates over the last 12 semesters are presented for Math 124 in Figure 1. IML revisions in Math 124 began in the fall of 2001 (9). This data allows analysis of trends related to student success.

**Figure 1: DWF Rates**



Thirty-one students did not attend (DNA measured as less than 10% grade). It is difficult to affect change with students who never came to class or came to class for only a couple of meetings. With the DNA students removed, Math 124 had a 51% success rate (student received either an A, B or C) for the Spring 2003 semester. Examining past data we see

that this is an improvement over the spring of 2002 (42% success rate) and is a better or equivalent success rate to all spring semesters except the spring of 2000 and the spring of 2001. However, despite multiple adjustments to the course from the fall of 2002 to the spring of 2003, we were still not able to maintain the 61% success rate from the fall of 2002 semester. We still have not overcome the significant decline in grades that occurs in the spring semester.

We investigated the relationship between course components to determine how student success on attendance, homework quizzes, labs, and exams correlates (Table 3). Course exams and the final were the bases of comparison for the other course components, since the remaining components are more open ended and allow for student collaboration. The course components all correlate at a level of 0.7 or higher. The correlation of exams with quizzes and labs both exceed 0.8. This indicates that while there may be instances of a student passing the course with failing grades on exams and high grades on labs, quizzes, and attendance, this is not the norm. In fact there is a high correlation between success on exams and the other components of the course.

**Table 3: Course Components**

Math 124: Correlation among Course Components					
	Attendance	Exams	Quizzes	Labs	Final
Attendance	1				
Exams	0.743186	1			
Quizzes	0.783988	0.837527	1		
Labs	0.837332	0.822578	0.821035	1	
Final	0.693526	0.862642	0.735808	0.768732	1

While we are considering the issue of a student raising their overall grade levels from their exam scores, we do not want to plug a small hole in the dike at the cost of losing the open-ended and cooperative learning aspects of the course. If these later components are not given due weight in the grade, then students will not engage in completing them. This would have the effect of returning courses to the status quo of focusing on exams and skill acquisition, as well as removing multiple forms of assessment.

We are considering two adjustments to address concerns about skill acquisition.

1. Increasing the exam percentage from 50% to 60%. This will require reducing attendance/participation to 5% (only do as bonus points), retaining quizzes at 5% and labs at 30%.
2. If a computer-testing center is created, we are considering gateway exams that would require skill acquisition at an 80% level to complete the course. The gateway exams would be included in the 60% exam percentage.