

The Effectiveness of Blended Instruction in Postsecondary General Education Mathematics Courses

Contributed Research Report

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Abstract

Despite best efforts, hundreds of thousands of students are not succeeding in postsecondary general education mathematics courses each year. Low student success rates in these courses are pervasive, and it is well documented that the nation needs to improve student success and retention in general mathematics.

Using data from 11,970 enrollments in College Algebra, Foundations of Mathematics, and Elementary Calculus from fall 2007 to spring 2010 at the University of Memphis, we compare the impact of the Memphis Mathematics Method (MMM), a blended learning instructional model, to the traditional lecture teaching method on student performance and retention.

Our results show the MMM was positive and significant for raising success rates particularly in Elementary Calculus. In addition, the results show the MMM as a potential vehicle for closing the achievement gap between Black and White students in such courses.

Key Words

Calculus, general education mathematics, classroom research, teaching experiment

Introduction

In the U.S., students who pursue a postsecondary baccalaureate degree are required to complete at least one general education mathematical science course. Low student success rates in these courses are pervasive, and it is well documented that the nation needs to improve student success and retention in general mathematics. National recognition of the poor success rates has resulted in vigorous debate and a series of proposed reform models over the past two decades, usually as curricular reform or delivery reform. Particular attention has been paid to reforming College Algebra and Calculus curriculum and pedagogies. Technology focused reforms have included attempts to change instructional delivery methods by training students to use technology to solve problems (Lavicza, 2009; Heid & Edwards, 2001; Smith, 2007), using technology as an instructional tool (Peschke, 2009; Judson & Sawada, 2002; Caldwell, 2007; Fies & Marshall, 2006), or using a technology based assessment system (Zerr, 2007; Nguyen, Hsieh, & Allen, 2006; Vanlehn, et al., 2005).

In this paper, we report results comparing the impact of the Memphis Mathematics Method (MMM), a blended learning instructional model, to the traditional lecture teaching method on student performance and retention in general education mathematics courses at the University of Memphis (UM). The comparison includes a total of 11,970 enrollments in College Algebra, Foundations of Mathematics, and Elementary Calculus

from fall 2007 to spring 2010. Results indicate that the MMM is effective in increasing student achievement and retention.

The Memphis Mathematics Method

The MMM substitutes traditional lecture-style instruction with a brief introduction of a topic followed by a laboratory session requiring students to complete classroom-based assignments using MyMathLab software. During the short lecture, instructors introduce a concept and provide examples that emphasize the use of mathematical techniques to solve problems motivated by other sciences. The remaining class time is dedicated to solving problems using the MyMathLab software. Over the course of a 15-week semester, students log 30 hours of class time practicing problems on MyMathLab. In addition to its use as an instructional tool, instructors use MyMathLab for course management and grading.

Data and Methods

The MMM intervention was piloted at UM in 2007 in a specialized Developmental Studies Program in Mathematics (DSPM) College Algebra course, which combined a remedial Intermediate Algebra course with a regular College Algebra course. Students were eligible for the DSPM course only if their ACT scores would have required them to take remedial Intermediate Algebra. Based on positive student outcomes during the initial pilot, UM expanded MMM in 2008 to regular sections of College Algebra; regular and DSPM sections of Foundations of Mathematics; and regular sections of Elementary Calculus. Instructors in both DSPM and regular MMM-taught sections reported anecdotal evidence of greater student engagement. There were 11,970 enrollments in the sections across the three courses. Of these, 10,424 enrollments were in regular sections while 1,546 enrollments were in DSPM sections.

We analyze data from College Algebra, Foundations of Mathematics, and Elementary Calculus from fall and spring semesters beginning in 2007 and ending in 2010. These data contain information about student characteristics, student performance, and teaching methodology.

Dependent variables.

To gauge student success in the three courses, we define an indicator variable “success” coded as 1 if a student obtains a passing grade and 0 otherwise. The variable success thus combines the effects of changes in pass rate and changes in dropout rate.

In addition, we are interested in separately determining the effects of the MMM pedagogy on dropout rates. We define an indicator variable “dropout” coded as 1 if a student dropped out of a course and 0 if a student completed the course. Success and dropout serve as our dependent variables in this study.

Independent variables.

We include the student’s gender, the student’s racial/ethnic background (White, Black, Hispanic, and Other), and the student’s prior mathematics knowledge as measured by their ACT math score, as three independent variables in the analysis. In addition, we control for whether a student is repeating the course and define an indicator variable “redo” coded as 1 if a student has attempted the course before and 0 if this is their first attempt. Also, an indicator variable for whether a student was exposed to the conventional or to the MMM pedagogy is included in the analysis.

Estimation approach.

To estimate the effects of MMM on student success and dropout rates in these courses, we fit a total of 10 regressions – four interactive models for remedial courses and six interactive models for non-remedial courses.

Results

Descriptive results. Of the 11,970 enrollments in College Algebra, Foundations of Mathematics, and Elementary Calculus at UM from fall 2007 to spring 2010, 5,530 ended in a passing grade reflecting a 54% success rate over the three courses. Of these 11,970 enrollments 1,596 ended when the student withdrew from the course.

For every course, we found that the percentage of students who withdrew from the MMM classes is lower than in the traditional classes. With respect to performance, more students were passing in MMM classes than in traditional classes. In DSPM courses for Foundations of Mathematics, for example, 56.7% of students received passing grades, while only 60.7% passed the equivalent MMM classes. Furthermore, a striking difference of grades across instructional methods is seen in Elementary Calculus. Approximately 49% of students in traditional courses passed while about 72% passed when exposed to the MMM teaching methodology.

Additionally, we compared the percentage breakdown of student performance and retention by racial/ethnic background for each course, and see that racial disparities between Black and White students in performance seem to be greatly reduced in the MMM classes. For example, across all three regular courses, Black students pass at a rate of 39.9% when taught using traditional pedagogy compared to 56.2% when using MMM. This difference is staggering. Also, in DSPM courses, Black students dropout at a rate of 10% for the MMM method compared to a rate of 14% for traditional teaching. In traditional DSPM College Algebra, 49.7% of Black students received passing grades compared to 64.4% of White students; that is, there is a 14.7% differential between Black and White students. In the equivalent MMM courses, however, this differential is only 7.7%. In traditional Elementary Calculus, the racial disparity between Blacks and Whites is completely erased with 75.7% of Black students and 68.9% of White students receiving passing grades.

With respect to withdrawal rates, in traditional Calculus, 22.4% of Black students dropped compared to 15.4% of White students, while in the MMM calculus courses, only 6.8% of Blacks withdrew compared to 9% of Whites. These results indicate that the MMM is a potential vehicle for decreasing the achievement gap. These relationships are further examined in the following section using regression.

Regression results. The regression output is illustrated in Table 1.

Succeed. Female students in each course have a higher chance at succeeding than their male counterparts, and the higher a student's ACT score the higher the likelihood of succeeding in a course. We find that students who were retaking a course have significantly lower odds of succeeding compared to those taking a course for the first time. With respect to the racial/ethnic disparities, we see that under conventional instruction Black students have 38%, 29%, and 49% lower odds of succeeding than White students in Foundations, College Algebra, and Elementary Calculus, respectively. Other student have 79% higher odds than White students to succeed in Calculus.

The MMM teaching pedagogy is significantly effective in increasing the odds of succeeding in Calculus — students exposed to the MMM have 78% higher odds of succeeding than those in traditional Calculus. Furthermore, the large magnitude and

significance of the interaction of teaching method and race illustrates a particular benefit of this teaching method for Black students. In Elementary Calculus, Black students instructed via MMM have 779% (computed as $1.78 * 4.94 - 1$) higher odds of succeeding than Black students receiving conventional instruction.

Dropout. Columns 6-8 show that regular female students have a lower probability of dropping Calculus compared to male students. We find a strong ACT score effect illustrating that students with higher ACT scores have lower odds of dropping out. Students who are retaking a course are more likely to persist in Calculus and have 29% lower odds of dropping out.

Black/White differentials persist when comparing the probabilities of dropping out. Black students in College Algebra have 31% lower odds of dropping out compared to White students. The MMM is positive and significant for students taking Calculus. Calculus students in the MMM are about 48% lower odds of dropping out with respect to conventionally taught students. This positive finding provides evidence that the MMM is effective in increasing retention.

Discussion & Conclusion

Despite best efforts, hundreds of thousands of students are *not* succeeding in postsecondary general education mathematics courses each year. Our results suggest that MMM was positive and significant for raising success rates particularly in Elementary Calculus. In addition, the results show the MMM as a vehicle for closing the achievement gap between Black and White students in such courses. Overall, our data suggest that MMM increases success and decreases dropout rates for these general education mathematics courses. The positive results may be attributed to the structure and interactive nature of the MMM which forces a daily involvement on the part of the student. This type of active engagement along with the use of technology is in-line with reform pedagogy. The MMM implementation has resulted in overall improved student success in Elementary Calculus, lower dropout rates in College Algebra, and lower costs.

Table

Table. Succeed & Dropout Regressions

Variables	Succeed					Dropout				
	Regular			DSPM		Regular			DSPM	
	Foundations	Algebra	Calculus	Foundations	Algebra	Foundations	Algebra	Calculus	Foundations	Algebra
Female	1.18*	1.38***	1.47***	1.89**	1.33**	0.89	0.80*	0.72***	0.68	0.84
Act Math Score	1.13***	1.17***	1.11***	1.19**	1.15***	0.93***	0.88***	0.93***	0.79*	0.92
Redo	0.66***	0.36***	0.92	1.06	0.68*	1.27	1.21	0.71**	1.75	1.02
Black	0.62***	0.71***	0.51***	0.84	0.30***	0.90	0.69***	1.33**	0.79	1.98
Hispanic	0.64	0.66	0.92	0.54	0.91	1.20	0.93	1.88	NA	4.20
Other	0.98	0.81	1.79**	NA	0.24	0.84	1.02	0.65	NA	NA
MMM	1.03	1.24	1.78***	1.09	0.51*	0.49*	0.21	0.52**	1.55	1.19
Black*MMM	1.13	1.01	4.94***	1.06	2.84**	1.78	5.09	0.40*	0.37	0.60
Hispanic*MMM	1.10	NA	0.82	NA	2.50	1.65	NA	1.31	NA	NA
Other*MMM	NA	NA	1.00	NA	19.04*	NA	NA	4.33	NA	NA
Constant	0.14***	0.06***	0.11***	0.05*	0.29	0.58	1.84	0.91	7.31	0.31
N	2,984	3,102	2,595	309	983	2,984	3,102	2,595	305	959

*** p<0.01, ** p<0.05, * p<0.1

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