A REPORT ON THE EFFECTIVENESS OF BLENDED INSTRUCTION IN GENERAL EDUCATION MATHEMATICS COURSES

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Abstract

Despite best efforts, hundreds of thousands of students are not succeeding in postsecondary general education mathematics courses each year. 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. The results also show the MMM as a potential vehicle for closing the achievement gap between Black and White students.

Key Words: Calculus, algebra, general education mathematics, retention, student performance

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 efforts to improve student learning and success rates are crucial. National recognition of the poor success rates in such courses has resulted in a series of proposed reform models over the past two decades, usually as curricular reform or delivery reform. Numerous reforms have focused on technology. They 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), and 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.

Background

There is a general belief that instructional delivery methods directly affect students' learning environment and hence indirectly affect student performance. For example, an environment in which students actively participate and engage in learning likely creates rich opportunities for deep learning of mathematics (Schoenfeld, 1994; Henningsen & Stein, 1997). Moreover, there is mounting evidence that integrating technology in undergraduate instruction positively associates with student achievement (Alldredge & Brown, 2006; O'Callaghan, 1998) and attitudes (Hauk & Segalla, 2005; Cretchley, Harman, Ellerton, & Fogarty, 2000). Similarly, research confirms that computer instruction may be as or more effective than traditional classroom instruction due to the self-paced and individualized nature of the instruction (Means, Olson, & Singh, 1995; Barrow, Markman, & Rouse, 2009; Liao, 2007).

The MMM is designed to reflect the current understanding of the effective use of technology in the classroom both to create an active blended learning environment that is aligned with cognitive principles and to allow for more effective management of the classroom and instructor time. In addition, utilizing the features of MyMathLab software, the MMM aims to more effectively engage students with mathematics in a non-threatening manner that bolsters student success and confidence.

Framework

The following diagram represents the conceptual framework driving the development of the MMM.

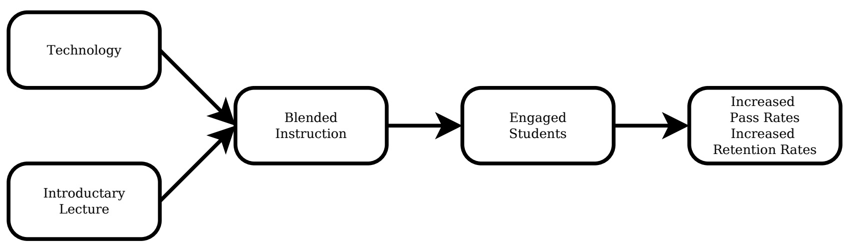

Figure 1. Framework used to guide the MMM model

In general, technology is believed to have a positive impact on student learning in mathematics. Many studies conducted in K–12 environments have reported significant gains in learning or learning speed (Koedinger et al., 1997; Fletcher, 2003; Anderson et al., 1995) when technology is incorporated into instruction. At the postsecondary level, studies have shown an increase in student success and learning when technology is employed in the classroom (O'Callaghan, 1998; Yaron, Cuadros & Karabinos, 2005; VanLehn et al., 2005; Ringenberg & VanLehn, 2006; Matsuda & VanLehn, 2005).

The implementation of technology through blended instructional strategy aligns with a variety of theoretical orientations that appeal to cognitive flexibility (Spiro, Feltovich, Jacobson, & Coulson, 1992), integrating abstract and concrete representations of concepts (Pashler, et al., 2007), embodied cognition (De Vega, Glenberg, & Graesser, 2008), combining inquiry and knowledge building (Mayer R. E., 2003), and other perspectives in the constructivist tradition. Recently, researchers have begun to make recommendations as to the appropriate proportion of student-centered and teacher-guided instruction (Chi, Siler, Jeong & Hausmann, 2001). For example, Mayer (2004) suggests that a blend of instructional methods be used rather than pure student-centered discovery. Using technology in the classroom can create a student-centered, active learning environment (White & Frederiksen, 1998; National Research Council, 2000; Fletcher, 2003). Computers and tutoring software are particularly effective tools in increasing learning (Sandholtz, Ringstaff, & Dwyer, 1997; Lowther, Ross, & Morrison, 2003; Smaldino).

This evidence suggests that a blended instructional method—technology coupled with guided lecture—may be ideal for increasing learning and success.

The MMM utilizes MyMathLab software to deliver the technology component of the general education math courses. MyMathLab can provide students with instant feedback for their work which research has shown leads to improved student achievement (Brooks, 1997; de La Beaujardiere et al., 1997; Khan, 1997). In addition, MyMathLab offers student aid features that align with elements identified in the literature as fostering increased student learning and understanding. These five learning aids are: (1) step-by-step worked solution of a similar problem, (2) video example, (3) just-in-time, (4) view an example, and (5) ask my instructor. First, the "step-by-step worked solution of a similar problem" tool can help students scaffold the content being covered in the problem which can help promote a deep understanding of content in computer-based training (VanLehn, 2006). Second, the multimedia tool "video example" capitalizes on the advantages of multiple media and modalities in improving learning and memory (Mayer, 2005; Pashler et al., 2007). Third, the availability of the electronic textbook while working through a problem allows a learner to access information "just-in-time" for achieving learner goals during problem solving (Rouet, 2006). MyMathLab directs students to the appropriate location in the textbook for the topic they are working through. This retrospective learning strategy allows students to read text when it is needed, which has been shown to increase learning of difficult content (Bransford & Schwartz, 1999). Fourth, "view an example" guides the student through example problems with solutions, a technique that is compatible to the research of Sweller on worked-out examples (Sweller & Chandler, 1994). Fifth, the "ask my instructor" conversational aid is comparable to intelligent tutoring systems that help students learn by holding a conversation in natural language (VanLehn et al., 2007). Collectively, these tools define MyMathLab as interactive content delivery software that aligns with cognitive principles of learning and curriculum in a blended instructional setting.

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. The MyMathLab software was selected because it offers student aid features that align with elements identified in the literature as fostering increased student learning and understanding.

Instructors employing the MMM begin each class with a 25-minute lecture followed by a problem-solving session using MyMathLab. During the short lecture, instructors introduce basic concepts and provide examples that emphasize the use of mathematical techniques to solve problems motivated by other sciences. Each lecture contains a list of objectives, a few illustrative examples, and mathematical problems for discussion during the presentation. 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 the MyMathLab learning environment for course management and grading.

The remaining class time is dedicated to solving problems using the MyMathLab software. The problems chosen are a combination of review questions from the previous class period and problems directly related to the concepts presented in the introductory lecture. The instructor and an assistant, typically an advanced undergraduate student or a graduate student, are available during the class period to provide individual help and answer technical questions.

Final grades are computed as a weighted sum of all the points earned throughout the semester, including attendance, in-class lab assignments, tests, quizzes, and a final exam. Students complete proctored tests and the final exam online in the instructional lab.

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.[i] In 2008, based on positive student outcomes during the initial pilot, UM expanded the use of the MMM to regular sections of College Algebra; regular and DSPM sections of Foundations of Mathematics; and regular sections of Elementary Calculus.

Regular courses of Elementary Calculus; both DSPM and regular courses of College Algebra; and DSPM and regular courses of Foundations of Mathematics have used the MMM. This study includes data from fall and spring semesters from fall 2007 to spring 2010. 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.

College Algebra at UM covers basic algebraic tools and concepts with an emphasis on developing computational skills necessary for success in subsequent mathematics courses. During the course of the study, there were 4,777 enrollments in this course. Of these, 3,668 were taught in a conventional setting, of which 157 enrollments were in DSPM sections, and 3,511 were in regular sections. A total of 1,010 enrollments were in DSPM sections taught using MMM and 99 enrollments were in regular sections taught using MMM.

Foundations of Mathematics provides instruction in basic logic and problem-solving skills. Students who enroll in this course are typically non-STEM majors who choose this course to fulfill their general education requirement. From fall 2007 to spring 2010, there were 3,986 enrollments in this course. Of these 3,525 were taught traditionally, 264 were taught traditionally in DSPM courses, 461 were taught using MMM, and 115 were taught by MMM in DSPM courses.

Elementary Calculus introduces the tools of differential calculus with emphasis on solving problems motivated by the social and life sciences, economics, and business. From fall 2007 to spring 2010, there were a total of 3,207 enrollments in this course. Throughout the duration of this study, 2,729 enrollments were taught traditionally, and 478 were taught using MMM. Since completing College Algebra or having a sufficiently high ACT or SAT score were prerequisites for Elementary Calculus, there were no remedial sections of Elementary Calculus offered

Dependent variables.

To gauge student success in the three courses, we define an indicator variable "success" coded as 1 if a student obtains a grade of C or above and 0 if they obtained a grade of D or F, or withdrew from the course. 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. Table 1 provides the descriptive statistics.

Table 1. *Descriptive Statistics of the Variables*

Variable	N	Mean	S. D.	Min	Max
Independent Variables					
ACT Math Score	9984	19.44	3.82	9	35
Redo	11970	0.15	0.35	0	1
Female	11970	0.59	0.49	0	1
Race					
White	6,059				
Black	5,354				
Hispanic	210				
Other	311				
Teaching Method					
Traditional	9,501				
MMM	923				
DSPM - Traditional	421				
DSPM - MMM	1,125				
Dependent Variables					
Dropout	11970	0.13	0.34	0	1
Succeed	11970	0.54	0.50	0	1

Estimation approach.

To estimate the effects of the MMM on student success and dropout rates in these courses, we fit a total of 6 regressions – three interactive models for remedial courses, and three interactive models for non-remedial courses.

To model the success rate and the dropout rate for both DSPM and regular courses, we fit logistic regressions for each of the three courses separately. Thus, we estimate the following:

$$logit(p_i) = ln(p_i/1-p_i) = a + X_{1i}\beta_1 + X_{2i}\beta_2 + X_{3i}{*}X_{2i}\beta_3 + u_i$$

where p_i is either the probability of student i succeeding or dropping out, X_1 is a vector of observed student characteristics (gender, racial/ethnic background, ACT score, and redo), β_1 is the associated coefficient vector, X_2 is a dummy variable for whether student i was exposed to the MMM pedagogy, and β_2 is its associated coefficient, X_3 is the vector of dummy variable for the different racial/ethnic backgrounds of students and β_3 is the associated coefficient vector for the interactive term.

Results

Descriptive results. Table 1 illustrates that of the 11,970 enrollments, 5,530 ended in a passing grade reflecting a 54% success rate over the three courses. Of the 11,970 enrollments, 1,596 ended when the student withdrew from the course.

To begin exploring whether the MMM is effective in increasing student success and retention in core general education mathematics courses, we first examine descriptive breakdowns of success rates and dropout rates by teaching pedagogy. Table 2 provides a numeric breakdown of student success and dropout over the study period. Overall, the tables illustrate that students in the MMM classrooms withdraw less and perform better.

Table 2. *Cross tabulates of succeed and dropout by teaching method for each course*

	Foundations of Mathematics				College Algebra			
	Traditional	MMM	DSPM Traditional	DSPM MMM	Traditional	MMM	DSPM Traditional	DSPM MMM
Not succeed	1,713	49	68	414	1,540	185	119	50
Succeed	1,909	57	89	647	1,823	181	146	66
Dropout	459	12	21	104	429	33	30	10
Not dropout	3,163	94	136	957	2,934	333	235	106

For every course, the percentage of students who withdrew from the MMM classes is lower than in the traditional classes. For example, 17.7% of students in traditional Elementary Calculus withdrew while only 8.2% withdrew from the equivalent MMM courses. In College Algebra, students in MMM classes drop out at a rate of approximately 9%. Their equivalent conventional teaching method courses have dropout rates of 12.8% for regular students and 11.4% for DSPM students.

With respect to performance, more students are succeeding in MMM classes than in traditional classes. In DSPM courses for Foundations of Mathematics, for example, 56.7% of students received passing grades, while 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, in Table 3, we compare the numeric breakdowns of student performance and retention by racial/ethnic background for each course, and find that racial disparities between Black and White students in performance seem to be greatly reduced in the MMM classes.

Table 3. Cross tabulates for race by success & dropout by teaching method

	College Algebra	Foundations of Mathematics	Elementary Calculus

	Black	Hispanic	Other	White	Black	Hispanic	Other	White	Black	Hispanic	Other	White
Not Succeed												
Traditional	855	36	49	730	817	30	19	622	676	18	29	665
MMM	24	2	0	18	109	5	0	59	43	2	2	86
DSPM-Traditional	55	1	1	11	85	2		32				
DSPM-MMM	295	2	3	97	30	3	0	17				
Succeed												
Traditional	603	38	59	1141	604	27	39	1103	356	20	71	894
MMM	21	0	3	31	71	6	3	93	134	6	14	191
DSPM-Traditional	44	4	1	40	84	3		58				
DSPM-MMM	412	5	17	179	36	0	1	28				
Dropout												
Traditional	194	9	13	228	201	10	5	203	231	8	9	241
MMM	6	0	0	5	20	2	0	9	12	1	2	25
DSPM-Traditional	17	1	0	3	21	0		9				
DSPM-MMM	74	1	0	26	4	0	0	6				
Not Dropout												
Traditional	1264	65	95	1643	1220	47	53	1522	801	30	91	1318
MMM	39	2	3	44	160	9	3	143	165	7	14	252
DSPM-Traditional	82	4	2	3	148	5		81				
DSPM-MMM	633	6	20	26	62	3	1	39				

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 the MMM. This difference is staggering. In DSPM courses, Black students dropout at a rate of 10% for the MMM method compared to a rate of 14% for traditional teaching.

Looking at these figures within each course, Table 3 reveals that this pattern of improvement persists. For example, in traditional DSPM College Algebra, 44% of Black students received passing grades compared to 78% of White students; that is, there is a 43% differential between Black and White students. In the equivalent MMM courses, however, this differential is reduced to 6%. In Elementary Calculus, the racial disparity between Blacks and Whites is completely erased with the MMM pedagogy with 75.7% of Black students and 68.9% of White students receiving passing grades. These results identify the MMM as a potential vehicle for decreasing the achievement gap.

In addition to reducing racial disparities in the passing rate, racial disparities in the withdrawal rate are also decreased. In traditional Elementary 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 relationships are further examined in the following section using regression.

Regression results. The regression output for success is presented in Table 4 and the output for retention is presented in Table 5.

Table 4. *Logistic Regression of Success Against Explanatory Variables*

	Regular			DSPM	
Variables	Foundations	Algebra	Calculus	Foundations	Algebra
Female	1.18*	1.38***	1.47***	1.89**	1.33**
	(0.102)	(0.108)	(0.128)	(0.546)	(0.185)
ACT Math Score	1.13***	1.17***	1.11***	1.19**	1.15***
	(0.014)	(0.015)	(0.013)	(0.106)	(0.062)
Redo	0.66***	0.36***	0.92	1.06	0.68*
	(0.080)	(0.042)	(0.104)	(0.486)	(0.152)
Black	0.62***	0.71***	0.51***	0.84	0.30***
	(0.056)	(0.061)	(0.054)	(0.269)	(0.132)
Hispanic	0.64	0.66	0.92	0.54	0.91
	(0.184)	(0.184)	(0.359)	(0.518)	(1.213)
Other	0.98	0.81	1.79**		0.24
	(0.276)	(0.169)	(0.422)		(0.325)
MMM	1.03	1.24	1.78***	1.09	0.51*
	(0.200)	(0.478)	(0.290)	(0.454)	(0.205)
Black * MMM	1.13	1.01	4.94***	1.06	2.84**
	(0.314)	(0.530)	(1.406)	(0.562)	(1.320)
Hispanic * MMM	1.10		0.82		2.50
	(0.825)		(0.762)		(4.505)
Other * MMM			1.00		19.04*
			(0.767)		(29.686)
Constant	0.14***	0.06***	0.11***	0.05*	0.29

	(0.039)	(0.018)	(0.031)	(0.074)	(0.289)
N	2,984	3,102	2,595	309	983

Robust standard errors are reported below each coefficient in parenthesis

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

Success. Consistent patterns emerge across all three general education mathematics courses targeting regular students. 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 students have 79% higher odds than White students to succeed in Elementary Calculus.

The MMM teaching pedagogy is significantly effective in increasing the odds of succeeding in Elementary Calculus — students exposed to the MMM have 78% higher odds of succeeding than those in traditional Elementary 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 the MMM have 779% (computed as 1.78*4.94 -1) higher odds of succeeding than Black students receiving conventional instruction.

Interpreting coefficients within a logistic regression is difficult since while the marginal effect on the logit, or on the odds ratio, is constant, the marginal effect on the probability depends on the other variables (more generally the marginal effect depends on the probability). As an example, we can compute the predicted probability for a male black student taking Elementary Calculus for the first time who obtained the average overall ACT Math score of 19. Using our model, such a student has 29.0% chance of succeeding when taught traditionally and a 78.2% chance of succeeding if receiving the MMM instruction. This computation concretely illustrates the effectiveness of the MMM on increasing student success in Elementary Calculus.

Columns 4 and 5 of Table 4 illustrate the succeed regression results for DSPM students only. As with the regular student population, female students have a higher chance of succeeding, as do students with higher ACT scores. We see that the MMM method is not statistically significant in increasing student success rates in Foundations and is only marginally significant in increasing success in College Algebra. Black DSPM students in College Algebra taught with MMM pedagogy, however, do see a benefit with respect to Black student taught conventionally. In fact, we find a 45% (computed as 0.51*2.84 -1) increase in odds for success for Blacks taught College Algebra with the MMM.

Table 5. *Logistic Regression of Dropout Against Explanatory Variables*

	Regular			DSPM	
Variables	Foundations	Algebra	Calculus	Foundations	Algebra
Female	0.89	0.80*	0.72***	0.68	0.84

	(0.114)	(0.093)	(0.084)	(0.289)	(0.190)
ACT Math Score	0.93***	0.88***	0.93***	0.79*	0.92
	(0.018)	(0.018)	(0.016)	(0.103)	(0.079)
Redo	1.27	1.21	0.71**	1.75	1.02
	(0.207)	(0.186)	(0.110)	(1.097)	(0.378)
Black	0.90	0.69***	1.33**	0.79	1.98
	(0.125)	(0.093)	(0.177)	(0.439)	(1.354)
Hispanic	1.20	0.93	1.88		4.20
	(0.492)	(0.380)	(0.850)		(5.721)
Other	0.84	1.02	0.65		
	(0.403)	(0.314)	(0.235)		
MMM	0.49*	0.21	0.52**	1.55	1.19
	(0.186)	(0.212)	(0.136)	(0.966)	(0.772)
Black * MMM	1.78	5.09	0.40*	0.37	0.60
	(0.841)	(5.912)	(0.189)	(0.340)	(0.443)
Hispanic * MMM	1.65		1.31		
	(2.014)		(1.583)		
Other * MMM			4.33		
			(3.885)		
Constant	0.58	1.84	0.91	7.31	0.31
	(0.238)	(0.804)	(0.347)	(16.031)	(0.504)
N	2,984	3,102	2,595	305	959

Robust standard errors are reported below each coefficient in parenthesis

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

Dropout. Table 5 shows that regular female students have a lower probability of dropping Calculus compared to male students. For example, female students have 28% lower odds of dropping out of Elementary Calculus compared to their male counterparts. We find a strong ACT score effect illustrating that students with higher ACT scores have lower odds of dropping out. This result holds across all courses thus illustrating the importance of background mathematical knowledge on retention. Students who are retaking a course are more likely to persist in Elementary Calculus and have 29% lower odds of dropping out.

As with the succeed variable, we compute predicted probabilities for a male black student obtaining the average ACT math score of 19 taking Elementary Calculus for the first time. Using our model, such a student has a 23.4% chance of dropping out if the student receives conventional instruction and a 6.0% chance of dropping out if the student receives MMM instruction.

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 have 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.

No significant relationships were found for the DSPM Algebra and Foundations courses in relation to drop out rates.

Discussion & Conclusion

Despite best efforts, hundreds of thousands of students are *not* succeeding in postsecondary general education mathematics courses each year. This situation is of particular concern, because failure to pass a required general education mathematics course jeopardizes one's ability to complete an undergraduate degree. In addition, this issue takes on an added dimension of urgency as the US struggles to improve both the overall percentage of citizens who attain a postsecondary degree as well as to close the educational attainment gap between minority and non-minority populations.

MMM was developed and implemented at UM with these factors in mind. Our results suggest that MMM was positive and significant for raising success rates particularly in Elementary Calculus. In addition, the results show that the MMM is a vehicle for closing the achievement gap between Black and White students. For the remedial DSPM courses, the MMM instructional method was not found to be statistically significant for retention; however, as seen in the descriptive Tables 1-3, students in the MMM courses showed a smaller number of overall dropouts. In general, our data suggest that the MMM increases success and decreases dropout rates. 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.

From a practical standpoint, postsecondary institutions need to find a cost effective, scalable, and impactful method to address low success rates in general education mathematics courses. After an initial start-up cost in establishing suitable computer labs, the MMM distributes department resources in a cost effective way. First, the MMM can employ undergraduate student assistants, rather than graduate students, second, because grading is automated in MyMathLab, this eliminates the need to have graders for these classes. This then frees up advanced graduate students to be employed as instructors instead of graders.

The MMM implementation has resulted in overall improved student success in Elementary Calculus, lower dropout rates in College Algebra, and lower costs. As such, future work is needed to perform a scientific, comparative evaluation of the model is in order to provide concrete statistical evidence of its validity and in turn offer motivation for scale-up.

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