Technical Report

A Study on the White House Project Initiative for MyMathLab

Pearson Global Product Organization
Efficacy & Research
Impact Evaluation

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Overview of MyMathLab

MyMathLab is an online tutorial and assessment tool for teaching and learning mathematics. It is designed to provide engaging experiences and personalized learning for each student, so that all students can succeed.

MyMathLab's tutorial exercises regenerate algorithmically to give students multiple opportunities for practice on varying content. The exercises include immediate feedback when students enter answers, which research indicates strengthens the learning process (Bangert-Drowns, Kulik, Kulik, & Morgan,1991; Hattie, 2009; Hattie & Timperley, 2007; Sadler, 1989). MyMathLab also has several types of adaptive learning resources – adaptive study plan and companion study plan assignments – to support personalized learning.

MyMathLab automatically tracks students' results and includes item analysis to track classwide progress on specific learning objectives. MyMathLab is intended to make a measurable impact on defined learner outcomes related to educational access, completion, competence and progression. By providing every student a personalized remediation plan through the material and tracking progress towards goals. MyMathLab, in essence, gives students individualized instruction – a feature that is especially important for the success of developmental Math students.

Intended Outcome

One of the biggest challenges that colleges in the US face is that many students enter college unprepared to complete college level Math courses. Most colleges have a sequence of developmental Math courses that start with basic arithmetic and then go on to pre-algebra, elementary algebra, and finally intermediate algebra, all of which must be completed and passed before a student can enroll in a credit-bearing college Math course. MyMathLab is designed to provide students with a positive and personalized learning experience that will help students develop a beneficial mindset in Math so that they can achieve the prerequisite skills that will allow them to successfully complete credit-bearing Math courses.

Research Questions

The aim of this study was to uncover which features of MyMathLab were significantly associated with the probability of students passing their developmental Math course.

This study of MyMathLab addresses the following research questions:

1. What is the contribution of the following factors to students passing the developmental Math course?

   a. Students' usage behaviors with MyMathLab – number of attempts made and amount of time spent on homework, quizzes and tests.

b. Students' homework, quiz and test grades.

c. The number of MyMathLab learning objectives mastered.

2. Is the contribution of these factors to students passing the course similar across the three types of assignments – homework, tests and quizzes?

3. Is the contribution of these factors to students passing the course similar across groups of students – those enrolled before Fall 2015 and students newly enrolled in Fall 2015?

Key Findings

The key findings presented here adjusted for student background characteristics – including gender, whether students were non-white, enrolled full-time or majored in a STEM field. The findings were also adjusted for school characteristics – whether it was in an urban setting and whether the instruction was blended ((i.e. used both lab and traditional lecture) or emporium model (i.e. entirely lab-based). Table ES1 gives a visual overview of the findings for the three research questions, which we discuss in order here:

1. For the full sample of students participating in the study, grades in MyMathLab were consistently related to the probability of passing the developmental Math course, with higher grades corresponding to a greater probability of passing.

2. For both the number of attempts and the number of objectives mastered, the positive relationship with the probability of passing was only true for homework and quizzes in the full sample, meaning that for these two types of assignments, a greater number of attempts and objectives mastered were associated with a higher probability of passing. For tests, on the other hand, both the number of attempts and number of objectives mastered were unrelated to the probability of passing.

3. Time spent on the homework assignment was negatively related to the probability of passing the course, with students who spent more time having a lower probability of passing the course. For quizzes and tests, however, time spent on the assignment was generally unrelated to the probability of passing the course.

4. Overall, students enrolled before Fall 2015 and students newly enrolled in Fall 2015 showed almost the same pattern of findings as the whole group of students. One notable exception was for the number of objectives mastered, which had no relationship to the probability of passing for students enrolled before Fall 2015 but had a positive association with the probability of passing for students newly enrolled in Fall 2015. In the latter case, larger numbers of objectives mastered related to a greater probability of passing for both homework and quizzes. An additional exception was for time spent on tests, which had no relationship to the probability of passing except for newly enrolled students in Fall 2015, who had a higher probability of passing if they spent more time on tests.

Table ES1: Visual overview of findings for each type of assignment, MyMathLab factor and student group

MyMathLab factor	Student group	Type of assignment		
		Homework	**Tests**	**Quizzes**
Time spent	All students	🔻	🚫	🚫
	Enrolled before Fall 2015	🔻	🚫	🚫
	Newly enrolled Fall 2015	🔻	🔺	🚫
Number of attempts	All students	🔺	🚫	🔺
	Enrolled before Fall 2015	🔺	🚫	🚫
	Newly enrolled Fall 2015	🔺	🚫	🚫
Grade	All students	🔺	🔺	🔺
	Enrolled before Fall 2015	🔺	🔺	🔺
	Newly enrolled Fall 2015	🔺	🔺	🔺
Number of objectives mastered	All students	🔺	🚫	🔺
	Enrolled before Fall	🚫	🚫	🚫

	2015			
	Newly enrolled Fall 2015	⬆	🚫	⬆

⬆ Positive association, higher values for factor linked significantly with higher probability of passing the course.

⬇ Negative association, higher values for factor linked significantly with lower probability of passing the course.

🚫 No significant association, factor unrelated to probability of passing course.

Recommendation

The study found that grades in MyMathLab were consistently related to the probability of passing the course. Hence, a recommendation could be using assignment grades as an early indicator of success in the course. This is not surprising, as assignment grades frequently constituted a portion of the final course grade. The number of homework attempts made was also found to be related to passing the course. That is, making more homework attempts might matter.

Next Steps

We found that the number of unique objectives mastered made a difference in the full sample and the sample of students enrolled in Fall 2015 for homework and test assignments, but not in the sample of students who were enrolled before Fall 2015. This trend is noteworthy because we were able to adjust for prior achievement only for students enrolled before Fall 2015. So, it appears that the number of unique objectives mastered no longer makes a difference after adjusting for prior achievement. Additional studies may be able to include prior achievement on all students, not just students who were enrolled at their colleges or universities before taking developmental Math courses, and this could shed further light on the role that mastered objectives had on course achievement when using MyMathLab.

Worth noting is that the number of attempts made in MyMathLab was not significantly related to the probability of passing the course for tests and quizzes, but *was* significantly related for homework. Homework may play a different role than tests and quizzes. Future research may want to focus on the contribution of various features of MyMathLab within the framework of homework, as opposed to tests and quizzes.

Introduction

One of the biggest challenges that colleges in the US face is that many students enter college unprepared to complete college-level Math courses. Most colleges have a sequence of developmental Math courses that start with basic arithmetic and then go on to pre-algebra, elementary algebra and finally intermediate algebra, all of which must be completed and passed before a student can enroll in a credit bearing college Math course. MyMathLab is designed to provide students with a positive learning experience. That experience should lead to a positive attitude towards Math as well as Math skills, which will help students successfully complete credit bearing Math courses.

Overview of Foundational Research

MyMathLab is aligned with insights gained from more than three decades of research into intelligent tutoring systems (e.g., Ohlsson, 1986; Anderson, Corbett, Koedinger, & Pelletier, 1995). In particular, MyMathLab helps students turn the knowledge they gain in class and through studying their textbook into procedural fluency by offering extensive and well supported practice (Anderson & Schunn, 2000). This process of developing expertise is supported by immediate feedback, providing different kinds of support (i.e., worked examples, hints), focusing attention on critical elements, and managing the load on students' working memory (Sweller & Cooper, 1985). All these strategies and features are intended to enable students to succeed in Math, often for the first time.

MyMathLab contextualizes the help feature in its courseware so that developmental Math students would have the contextualized help they need to solve the problem at hand. Developmental Math students benefit from establishing a pattern of success in Math. The contextualized learning aids in MyMathLab help guide students to begin a positive journey through the material, with the aim of greater success.

Mindset

In educational psychology research, there are a number of research areas that deal with understanding the motivations, beliefs and attitudes that may prevent students from achieving their potential and that detail strategies for helping students adjust those noncognitive factors. Three important areas are: dealing with anxiety (Maloney & Beilock, 2012), personal relevance (Hulleman, Godes, Hendricks, & Harackiewicz, 2010), and growth mindset (Dweck, 1996). These are areas with which MyMathLab aims to help students.

Mindset is a key outcome validated by instructors as being important to them and their students. People tend to gravitate towards one of two mindsets when it comes to learning. People with a 'fixed' or ('entity') mindset believe that ability is innate (Dweck, 1996). For example, someone who believes that they are just not good at Math, and never will be, has a fixed mindset. By contrast, people with a 'growth' (or 'incremental') mindset believe that ability is developed through practice and effort. Research has shown that adopting a growth mindset has a positive influence on learning. Students with a growth mindset are more likely to adopt more

learning oriented goals, to persist longer (Diener & Dweck, 1978), to use better learning strategies, and, ultimately, to achieve better grades (Yeager & Dweck, 2012).

Key features of the research into learning design for MyMathLab

Scaffolding with worked examples

MyMathLab offers a variety of learner support tools to help students struggling with assessment items. These support tools include hints, videos, animations and etext. Students can also 'ask for help' and get step-by--step support in solving a Math problem. These support tools are aligned with research on best practices for scaffolding in technology-enhanced learning environments (Sharma & Hannafin, 2007).

Feedback

MyMathLab enables students to check frequently on their understanding and receive immediate feedback, which is one of the most effective means for building long-term retention and increasing student confidence and motivation (Hattie 2009, 2012). Feedback provided in association with practice activities in MyMathLab is specific, clear, concise and timely. Instructors see basic student performance (e.g., number of items correct/incorrect, attempted) on assignments, and students can see detailed performance on specific learning objectives.

Cognitive load

In cognitive psychology, cognitive load refers to the total amount of mental effort being used in working memory (Miller, 1956). Extraneous cognitive load is the mental effort spent on distracting elements that are not relevant to the learning. Research shows that reducing extraneous cognitive load for students when they are reading or studying improves the effectiveness of learning (Sweller, 1988). Put simply, when distractions are removed, learning is more likely to occur. In MyMathLab, extraneous cognitive load is kept low through the following approaches: topics and subtopics are organized coherently into manageable chunks, assessments are presented in a 'clean' area, and the etext is accessible and easy to read.

Adaptivity

Research has identified two types of adaptivity in learning technologies. One relates to adaptive responses to students (i.e., adaptive feedback). Similar to the research described above about feedback, adaptive systems that provide timely feedback to students as they engage with the learning technology have been shown to be as effective as human tutors (VanLehn, 2011). The other mode of adaptivity relates to adapting a learning sequence based on an understanding of a student's current proficiency. This can be done by estimating each student's mastery of skills and concepts based on their performance, and ensuring that students receive enough practice to achieve fluency with the content. This 'knowledge tracing' has been used to great effect (Corbett & Anderson, 1995). MyMathLab uses the latest advances in adaptive learning technology, offering

two options: the adaptive companion study plan and personalized homework. Instructors have the flexibility to incorporate the style and approach of adaptive learning that best suits their course structure and student needs.

Description of MyMathLab

MyMathLab is an online tutorial and assessment tool for teaching and learning mathematics. It is designed to provide engaging experiences and personalized learning so that all students can succeed. MyMathLab's tutorial exercises regenerate algorithmically to give students multiple opportunities for practice on varying content. The exercises include immediate feedback when students enter answers, which research indicates strengthens the learning process (Bangert-Drowns, Kulik, Kulik, & Morgan,1991; Hattie, 2009; Hattie & Timperley, 2007; Sadler, 1989).

As described above, MyMathLab also has several types of adaptive learning resources that support personalized learning. MyMathLab automatically tracks students' results and includes item analysis to track classwide progress on specific learning objectives. MyMathLab is intended to make a measurable impact on defined learner outcomes related to educational access, completion, competence and progression. By providing every student a personalized remediation plan through the material and tracking progress towards objectives, MyMathLab, in essence, gives students individualized instruction – a feature that is especially important for the success of developmental Math students.

The Present Study

The primary goal of this study was to assess whether use of MyMathLab is linked to student achievement in developmental Math courses. Student achievement in mathematics is known to be associated with a range of factors, including student and institution background characteristics. Our goal was to identify the unique contribution of MyMathLab use to student achievement, independent of other factors known to be related to achievement. We therefore used a design similar to the case-control design that is frequently used in health studies to adjust (or statistically control) for additional factors that might influence a student's level of achievement. Details of the design are presented below.

This study of MyMathLab addresses the following research questions:

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    b. Students' homework, quiz and test grades.

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3. Is the contribution of these factors to students passing the course similar across groups of students – those enrolled before Fall 2015 and students newly enrolled in Fall 2015?

Using a course pass as the achievement outcome of interest was necessitated by characteristics of the study sample. Across the five participating university, technical college and community colleges, course grades were calculated in different ways. For example, developmental Math courses at some institutions involved a final exam, while others did not. For this reason, using a pass or fail as the learner outcome, rather than a finer-grained measure like course grade, allowed us to aggregate student data across institutions. This data aggregation, in turn, allowed a more rigorous assessment of how MyMathLab use related to achievement, independent of specific course characteristics at different institutions.

We attempted to collect data on, and statistically control for, as many extraneous factors as possible – factors that might affect student achievement beyond their use of MyMathLab. This was done to strengthen the quality of the study and to further support the validity of any claims about the impact of MyMathLab. We wanted to be able to make valid claims about the strength of the association between using MyMathLab and student achievement after controlling for confounding variables.

Method

This report assesses the effect of MyMathLab use on students' academic achievement in their Fall 2015 developmental Math course, after controlling for background characteristics and previous academic achievement. It investigates the amount of time spent, number of attempts, grades and number of objectives mastered on assignments for MyMathLab and determines the relationship between all these factors and the probability of students passing their developmental Math course. In examining the relationship between components of MyMathLab and the probability of passing the course, the study separately analyzes according to (a) the type of assignment – homework, tests or quizzes – in MyMathLab and (b) the group of students – those enrolling before Fall 2015 or those newly enrolled in the Fall 2015 term – as well as all students as a whole.

Participants

Institutions

Five institutions were involved in the White House Project MyMathLab study, where three were community colleges, one was a technical college and one was a state university. They were located in the southern, northeastern or mid-western parts of the US. A total of 181 classes and 73 instructors took part in this study. Figure 1 shows the number of participating classes and instructors at each institution.

Figure 1: White House Project participating institutions, with the number of classes and instructors at each institution
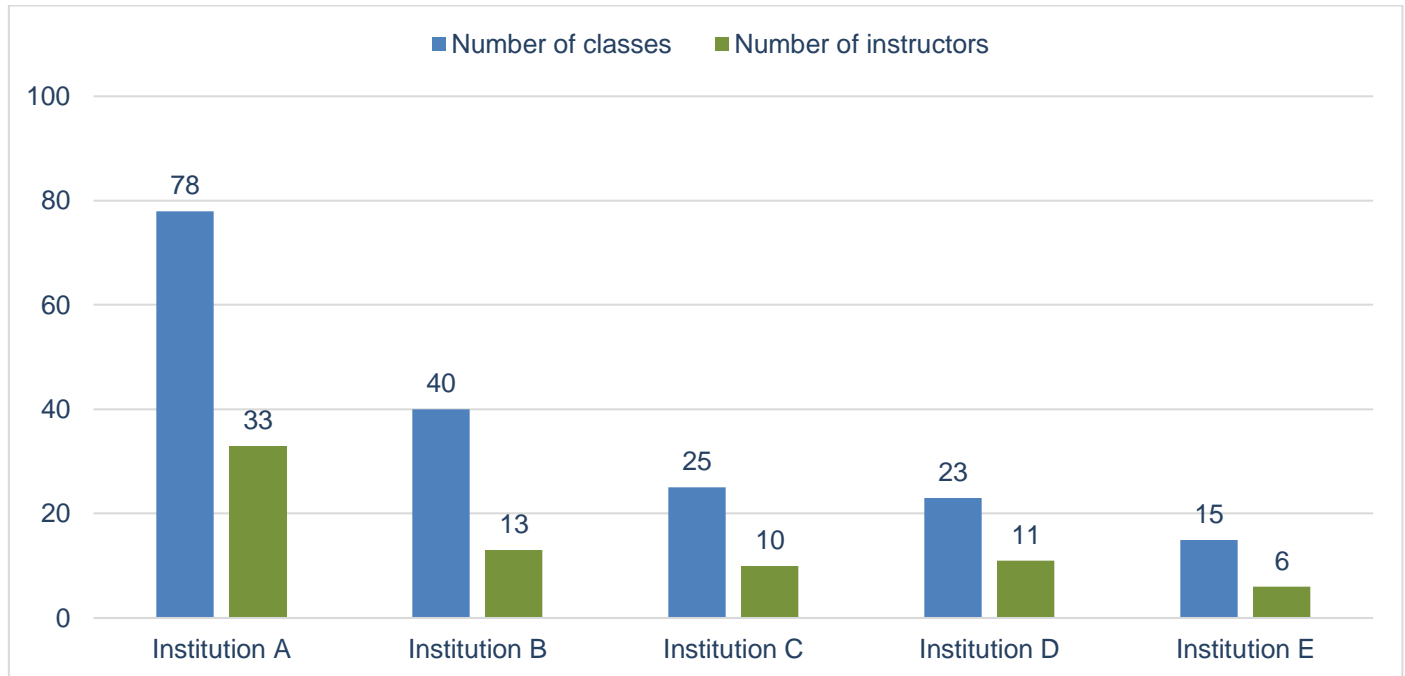
Courses

The developmental Math courses that used MyMathLab at the participating institutions were:

- Pre- Algebra
- Elementary/Basic Algebra
- Intermediate Algebra
- Basic Math
- Plane Geometry
- Developmental Math Shell Courses

MyMathLab was a required component of these courses at each institution. However, the instructional format of these courses differed across institutions: three institutions used a blended format, while the other two used an emporium format. All five institutions used a different textbook (see Table 1).

Table 1: Instruction type and textbook used at each institution

Type of instruction	Institution	Textbook used
Blended	Institution C	- Algebra: A Modular Approach, Custom Edition at Institution

	Institution D	- Lial: Introductory and Intermediate Algebra, 5e
	Institution E	- LEAP Log Workbook, Pearson Education, Inc.
Emporium	Institution A	- Prentice Hall Geometry 2011 - Bittinger: Intermediate Algebra, 12e - Martin-Gay: Pre-Algebra and Introductory Algebra, 4e
	Institution B	- Martin-Gay: Algebra Foundations, 1e

Students

To assess the influence of MyMathLab use on student achievement, while statistically controlling for extraneous factors known to influence achievement, this study required multiple sources of student data: MyMathLab platform data, course grades and institutional transcripts. Many students were missing one or more of these critical data sources and hence were excluded from the final analysis. Although platform data was available for 3,385 students, not all of these students actively participated in the study. A more accurate count of the number of participants is 1,282 – the number of students for whom consent to participate was given and for whom we were then able to extract transcript data.

After joining the three sources of student data together and eliminating students with missing data from any of those sources, this study included a total of 861 participants with some students counted more than once in this sample if they took more than one developmental Math course in Fall 2015. See Figure 2 for more information on the number of students with each data source available.

Instructors

Instructors also participated in the study by completing a survey on their perceptions of MyMathLab, their students and their views more generally as instructors. A total of 68 instructors took part in the survey, but due to crucial information missing for five of them, the number of instructors with data that could be used in the study was 63.

Data Collection

Multiple procedures were carried out during the semester to collect data on the range of factors known to have a potential influence on student achievement. These data collection procedures included the following: (i) an instructor survey at the end of the semester; (ii) an interview with each course instructor; (iii) course grade data; (iv) course information requested from the instructor at the end of the semester; (v) students'

MyMathLab platform data, and (vi) student transcripts requested from the institution. Each of these procedures is described in detail below.

Instructor survey

Instructors were given a link to an online end-of-semester survey. The instructor survey was based on the Faculty Survey of Student Engagement (FSSE) with changes to capture information about experiences with MyMathLab. The FSSE was designed to complement the National Survey of Student Engagement (NSSE), and it measures instructional staff expectations for student engagement in educational practices that are linked to student learning and development. Specifically, this survey gathers information from instructors about (a) in-class time spent on a variety of instruction activities (such as, lecturing, discussion, hands-on activities); (b) time that the instructors had expected students to spend on various learning activities related to the course; (c) perceptions of the impact of the use of digital technology (i.e., Pearson MyMathLab services) on their instruction and student learning; (d) their likelihood of recommending MyMathLab to colleagues, and (e) their expectation of changing the implementation of MyMathLab the next time the course is being taught. The complete instructor survey is included in Appendix 1.

Instructor interview

Close to the end of the semester, a 30-minute interview interview was conducted with the instructors who taught the course for that semester. The interviews used a standard protocol designed to (a) gather information about the course, including the type of instruction used (i.e., emporium or blended learning); (b) determine the extent to which MyMathLab was implemented/carried out as originally planned, and (c) obtain any information necessary to interpret the student data provided by the instructors.

Course grade data

After the end of the semester, the instructors provided the grades and pass/fail status of the students enrolled in the courses that were part of the White House Project. In addition, the instructors also provided course information (e.g., course identification numbers), which was used to extract MyMathLab platform data for students on those courses.

MyMathLab platform data

With the course information obtained from the instructors at the end of the semester, platform data for students enrolled in the course and who had used MyMathLab was extracted. The platform data provided detailed data regarding MyMathLab usage, such as the time spent in MyMathLab, the number of attempts made in each assignment type, and the number of objectives mastered.

Student transcript data

As well as obtaining students' final grades in their developmental Math course, we obtained institutional

transcripts containing final grades in previous courses (where applicable), background information such as race/ethnicity and gender, and information on their college program including full- versus part-time status and major. This transcript data was used to control for students' prior achievement, their race/ethnicity and gender, whether they were full-time students, and whether they majored in a STEM field. Additionally, transcript data revealed whether students were new to their college in Fall 2015 when enrolled in the developmental Math course or whether they had taken courses in the past at their school[1].

Institutional data

Institutional data was considered to address the cluster of students within schools in the analysis. One of the institutional variables considered in the analysis was the urban locale of the school, which was obtained from the Integrated Postsecondary Education System (IPEDS)[2]. In addition, each institution varied in the type of instruction it used with MyMathLab, whether it was an emporium type of instruction or a blended type of instruction (i.e. the use of both lab and traditional lecture). The instructor interviews included a question asking the type of instruction used at the institution.

Data Preparation and Exclusions

The goal of this study was to assess the relationship between MyMathLab use and student achievement, while controlling for confounding student and institution characteristics that may be tied to achievement. To this end, it was necessary to link each student's MyMathLab platform data with their course grade data and their institutional transcript data (which provided evidence of prior achievement and a source of background information and college enrollment information). Figure 2 shows the number of students, or sample size, for each data source plus the number of students after linking the different data sources together.

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[1] For students who had transcript data before Fall 2015 at Institution D, only one previous term – Spring 2015 – was provided, so prior achievement for Institution D is based on a single term. The four remaining schools provided data for multiple terms before Fall 2015.

[2] IPEDS is a series of annual surveys conducted by the US Department of Education's National Center for Education Statistics (NCES). It collects data from every US college, university and technical/vocational institution that participates in the federal student financial aid programs. All five institutions participating in this study have IPEDS data.

Figure 2: Number of students from each data source
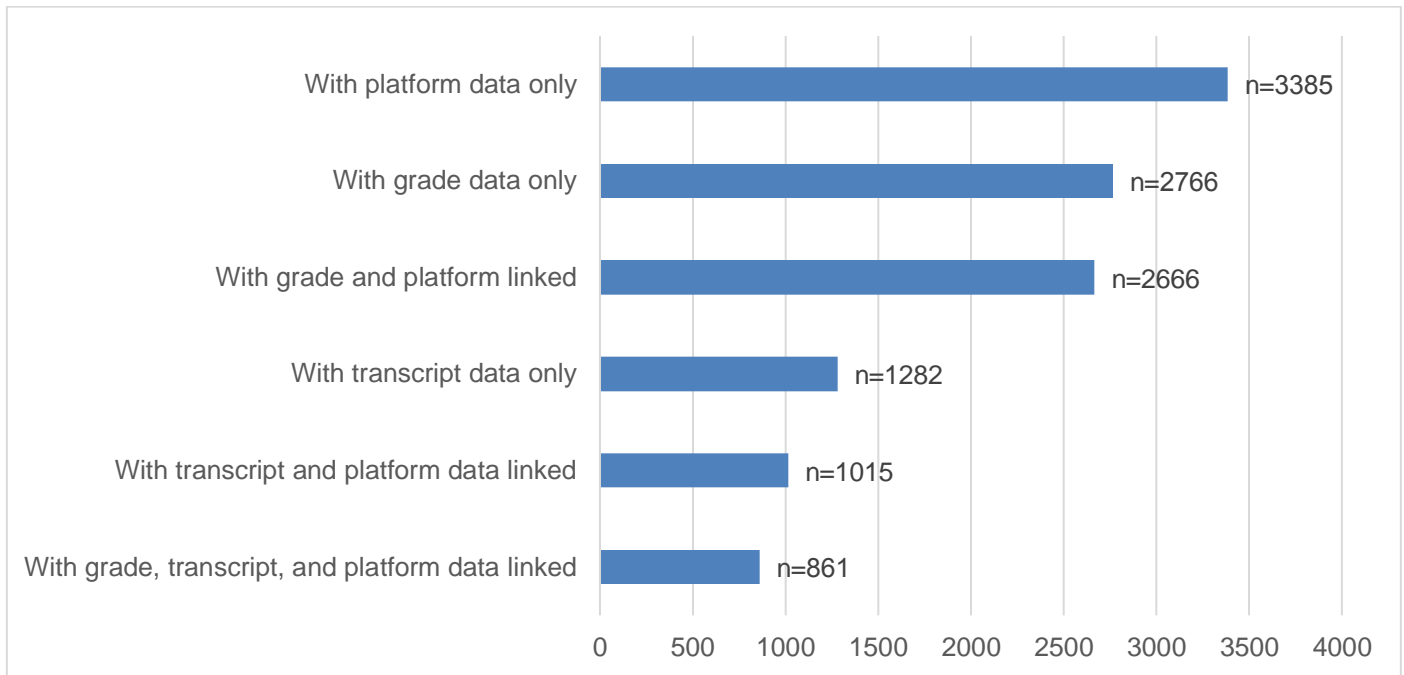
Note. Students are represented more than once in the numbers reported if they took more than one course. The final analysis of student achievement included only those students for whom all necessary data sources were available (n = 861, though some of the students were missing values on specific variables, resulting in a lower final n for the statistical models reported below). Where appropriate, however, descriptive analyses included the full sample of students (e.g., descriptive analyses of MyMathLab usage behavior involved a sample size of more than 3,000 students). For each analysis reported below, the corresponding sample sizes are clearly indicated.

Results

We first present a descriptive analysis of the instructors' perceptions of MyMathLab before moving on to a descriptive analysis of students who participated in this study. We then proceed to a descriptive analysis of how MyMathLab was used in the developmental Math courses before ending with an analysis of the relationship between MyMathLab use and student achievement.

Instructors' Perceptions of MyMathLab[3]

Though the instructor variables could not be considered in the analysis, since not all instructors responded to the survey and not all instructors provided their names to link them to their student grades for analysis[4]. Nonetheless, we present the characteristics of the instructors here to provide context before presenting the results of MyMathLab use and learner outcomes.

Towards the end of the semester, the instructors involved in the White House Project at the five participating institutions were asked to participate in a survey. A total of 63 instructors took part in the survey, with more than half of them (61%) being adjunct professors. Of the instructors who took the survey, only 14% of them were teaching the White House Project course for the first time.

When asked about their experience using MyMathLab, the vast majority of instructors (79%) indicated that MyMathLab was easy to use. Nearly half of all instructors indicated that students were more engaged when using MyMathLab and that students improved overall (see Figure 3).

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[3] All percentages reported ignore missing answers to questions, so if 63 professors filled out the survey but only 61 answered a given question, the percentage reported would be out of the 61 instructors who responded to that question.

[4] Note that though 73 instructors who provided course grade data for the students in this study, more than 15% of them were missing all the survey or important parts of it. To avoid further reducing the sample due to the missing instructor survey data, we did not assess whether instructor level covariates (derived from survey responses) influenced student achievement for this analysis.

Figure 3: On a scale of strongly disagreed (1) to strongly agreed (7), percentage of instructors who agreed (6) or strongly agreed (7) to the following about MyMathLab (number of respondents=62-63)
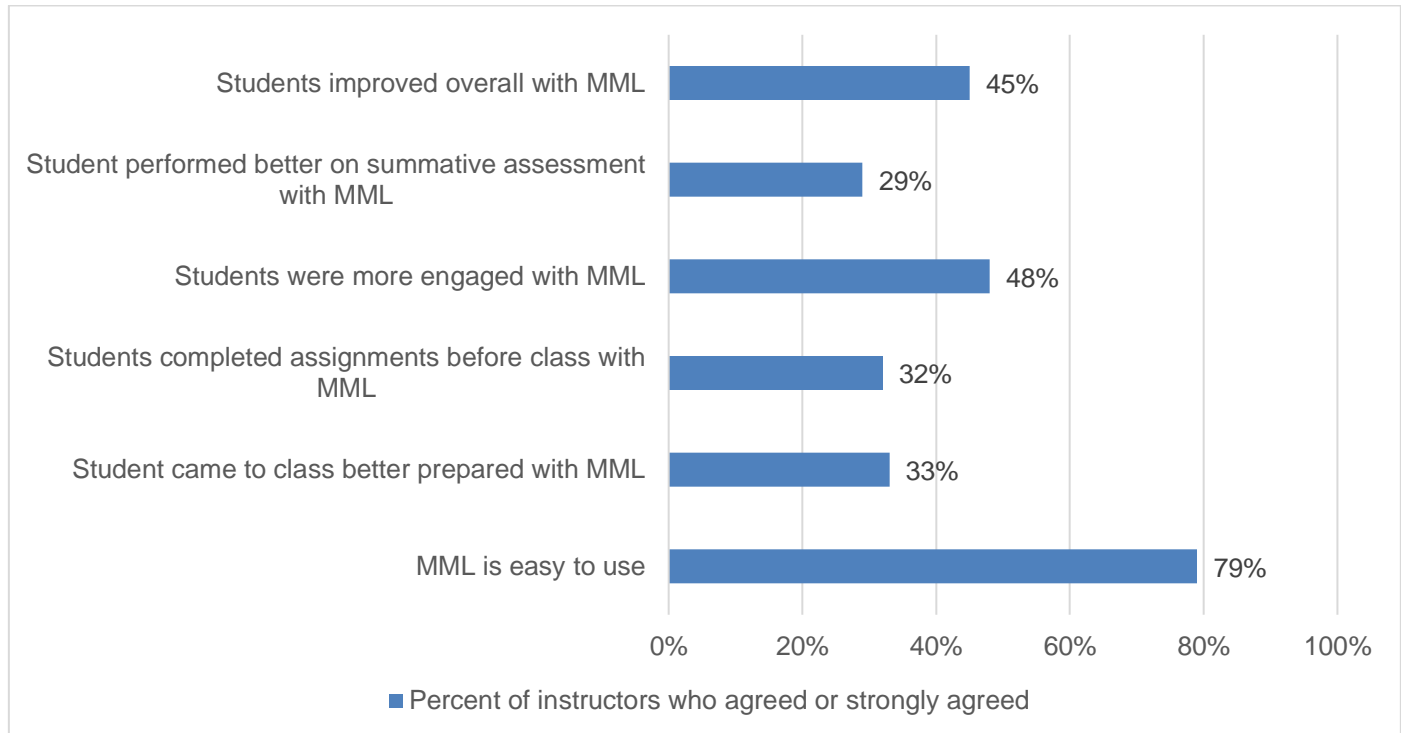
Instructors were also asked to reflect on whether, and if so how, they would change their implementation of MyMathLab the next time they taught the same developmental Math course. A majority of instructors (65%) indicated that they did not plan to change their implementation (see Figure 4). One interpretation of this finding is that instructors were satisfied with the role of MyMathLab in their course. It is possible, however, that even if instructors were dissatisfied with MyMathLab, factors such as large teaching demands with limited course preparation time could prevent instructors from anticipating changing their implementation.

Among instructors who planned to make changes to their implementation of MyMathLab, 14% planned to require MyMathLab for a *greater* percentage of student grade, whereas only 6% of instructors planned to require MyMathLab for a *smaller* percentage of student grade. The fact that more instructors want to increase as opposed to decrease the contribution of MyMathLab to course grade indicates that instructors tend to have a positive view of this education software.

Figure 4: Percentage of instructors who indicated how they would change implementation of MyMathLab the next time they taught the course (number of respondents=63)
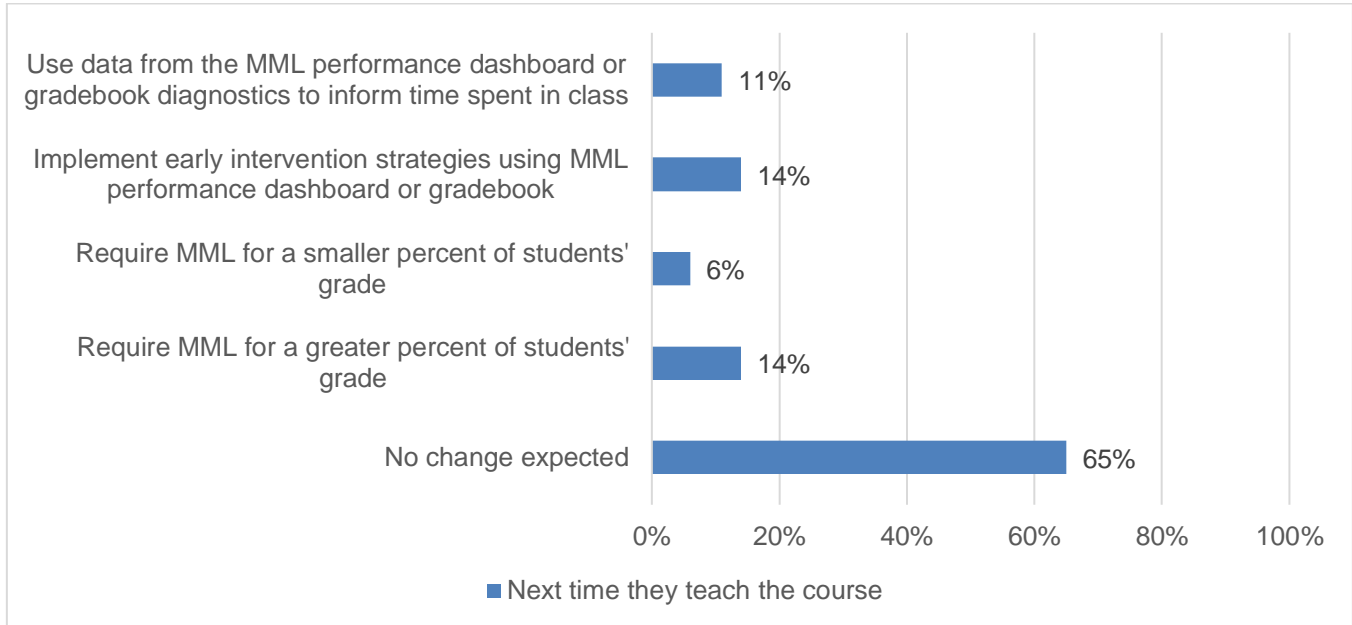
Although not reflective of MyMathLab specifically, information on which practices instructors rated as either Important or Very Important for their students sheds light on their priorities for the developmental Math courses they teach. Almost all instructors rated the following practices as Very Important or Important: participate or ask questions in class, access other support on campus, and come to class having completed readings. Figure 5 shows these percentages as well as the percentages for additional practices.

Figure 5: On a scale of Not Important (1) to Very Important (4), percentage of instructors who indicated it is Important (3) or Very Important (4) for students to do the following (number of respondents=62-63)

Category	Percent
Work with other students on projects	39%
Explain materials to other students	40%
Ask another student help in understanding	54%
Access other supports on campus	95%
Come to class having completed readings	92%
Ask questions or particpate in class	97%

■ Percent who Indicated Important or Very Important
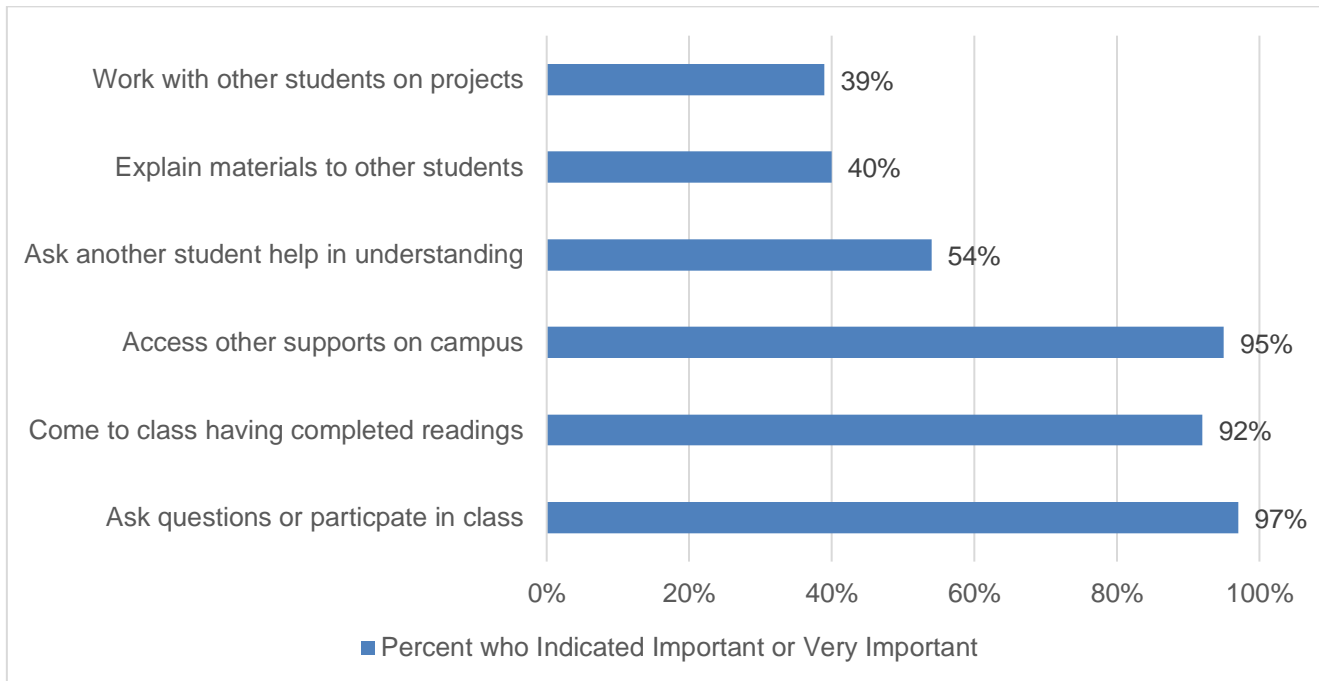
Student Characteristics

As shown in Figure 6, most students in this study were female. Non-white students also made up a majority. Just under half were enrolled at their institution before Fall 2015, and a similar proportion were registered as full-time students in Fall 2015. A relatively small percentage of them majored in a STEM field.

Figure 6: Student characteristics from transcript data
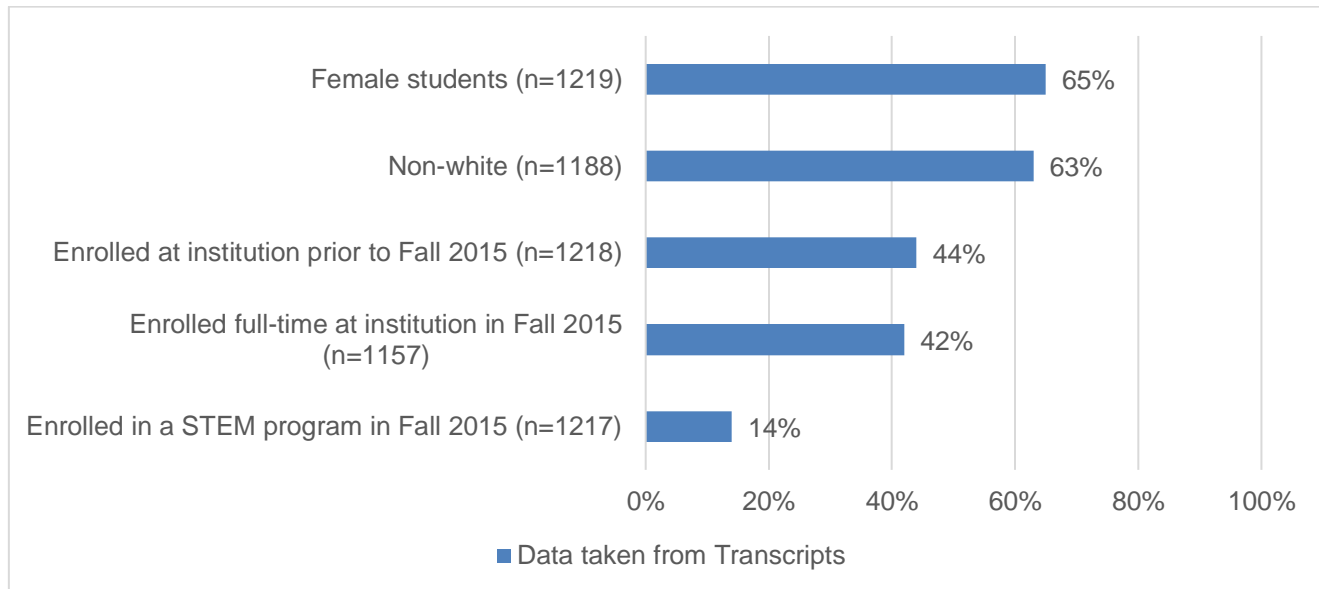
MyMathLab Usage Behavior

The average total time that students (N = 3,361) spent across all assignment types in MyMathLab was 29 hours. Among all different types of assignments (homework, test, quiz, Quizme, lecture, review and survey), homework showed the longest use. Figure 7 shows the time spent and number of attempts for the different types of assignments in MyMathLab.

Figure 7: MyMathLab usage by type of assignment
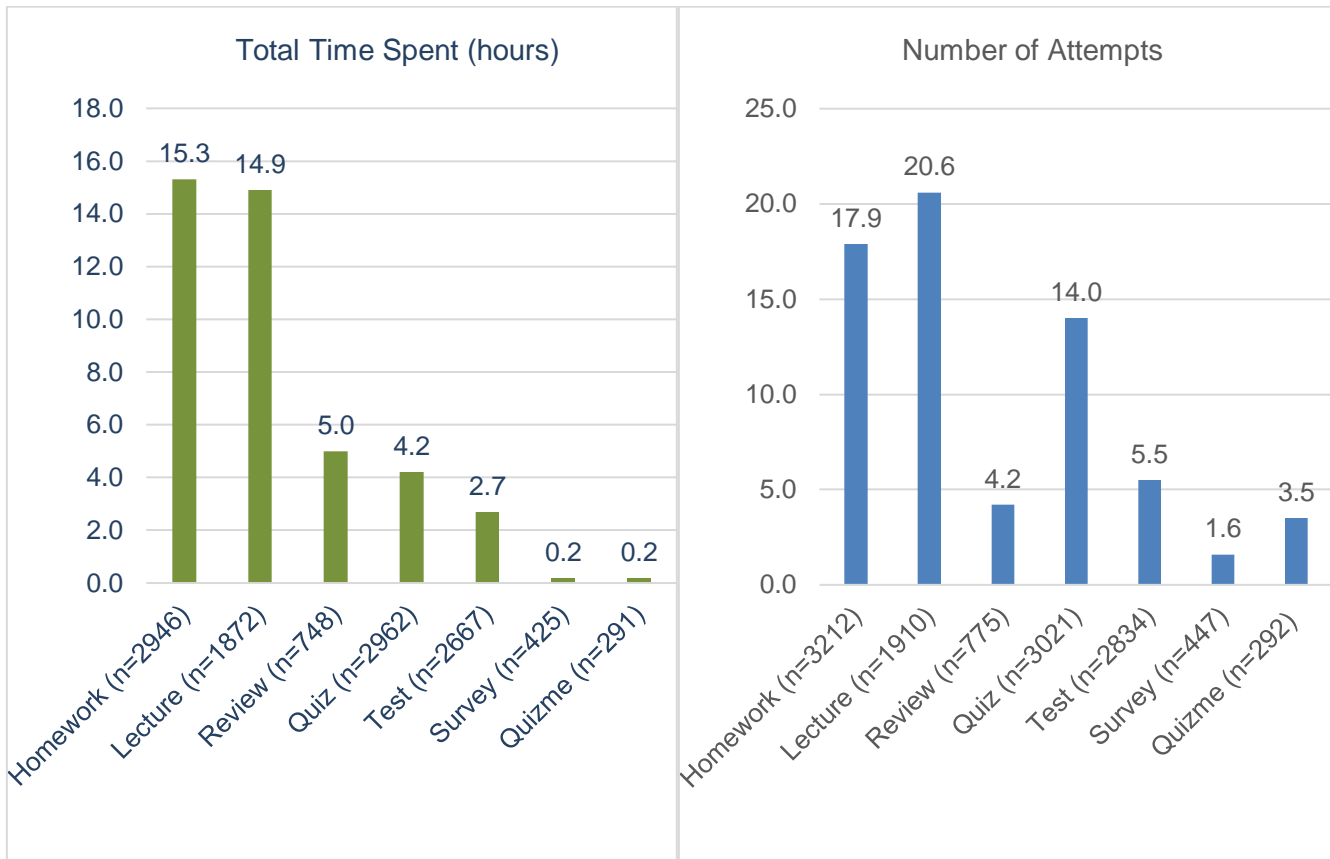
Student Pass Rate

The learner outcome examined in this study is achievement, measured by whether a student passed or failed the course. Pass/fail status was determined from the course grade data provided by the instructors at the end of the course. As shown in Figure 8, the overall pass rate was 84% across all institutions and courses, with considerable variability across institutions (ranging from 57% to 98%).

Figure 8: Pass rate for White House Project developmental Math courses by institution
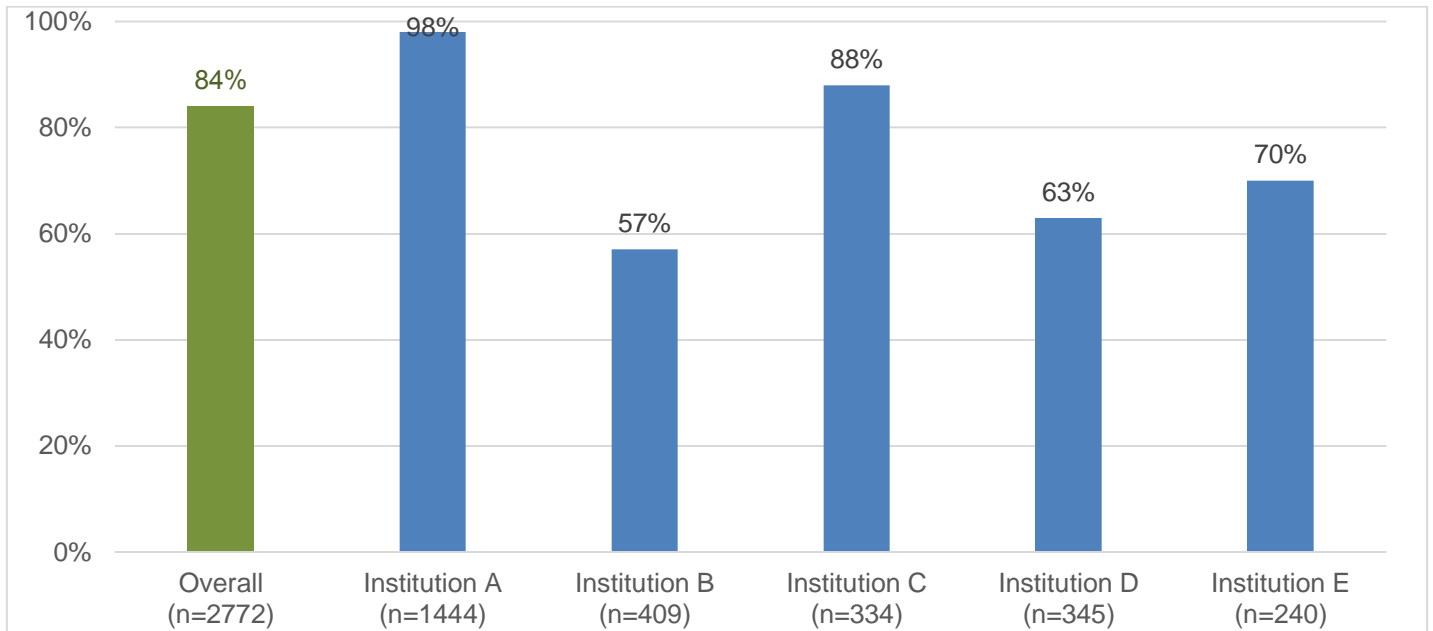
Relationship between MyMathLab Factors and Probability of Passing

Hierarchical Generalized Linear Modeling (HGLM) was used to analyze student achievement. This method was chosen for two reasons: (i) generalized linear models are appropriate for modeling dichotomous outcomes (e.g., pass versus fail), and (ii) hierarchical models can account for clustering that occurs due to the nature of the sample (e.g., institution effects, such as overall higher or lower pass rates in courses at some institutions relative to others).

At the institution level, we controlled for whether the institution was located in a city (urbane locale). In addition, each institution varied in the type of instruction it used with MyMathLab – emporium or blended. The type of instruction used with MyMathLab was also controlled for in the analysis model.

HGLM results

Three HGLM analysis models5 were initially analyzed to assess the relationship between MyMathLab assignments and students passing their developmental Math course. Each of the three models considered a

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[5] Logit link function was used for HGLM.

different type of MyMathLab assignment in the analysis, using the full sample of students who participated in the study6. These analyses addressed the first two research questions:

1. What is the contribution of the following factors to students passing the developmental Math course?

    a. Students' usage behaviors with MyMathLab – number of attempts made and amount of time spent on homework, quizzes and tests.

    b. Students' homework, quiz and test grades.

    c. The number of MyMathLab learning objectives mastered.

2. Is the contribution of these factors to students passing the course similar across the three types of assignments – homework, tests and quizzes?

Homework variables from the platform data were considered in the first model, test variables were considered in the second model, and quiz variables were considered in the third. These three types of assignments were the most frequently used types of assignment and hence, most students had data on homework, test, or quiz assignments than on other types of assignment. However, it does not necessarily mean that most students would attempt all three types of assignment. Hence, separate models for the different assignments were conducted. Since separate models were conducted, multiple comparison adjustment using Bonferroni correction was used, resulting in a significant level threshold of 0.017 (i.e. 0.05/3). Tables 2 to 4 present the results of the variables used in the analysis models.

Table 2: HGLM results when MyMathLab homework variables were included in the model for the full analytic sample of students enrolled before and during Fall 2015

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.3008	3.4262	2	0.09	0.9380
Student level					
Female	0.07548	0.2921	684	0.26	0.7962
White	-0.1806	0.3620	684	-0.50	0.6180

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[6] When viewing these results, one should keep in mind the sample size. Although 1,282 students had transcript data available, after joining the transcript data to the other forms of data available, the sample size was reduced to 861 participants due to students missing data for some of the data sources.

Enrolled full-time at institution	0.2507	0.3372	684	0.74	0.4574
STEM major	-0.3325	0.4410	684	-0.75	0.4512
Enrolled before Fall 2015	-0.3873	0.2931	684	-1.32	0.1869
Total time spent (standardized hours) in MyMathLab homework	-1.1758	0.2328	684	-5.05	<.0001
Total number of homework attempts (standardized) in MyMathLab	1.5072	0.3273	684	4.60	<.0001
Student MyMathLab homework grade (standardized)	0.6590	0.1542	684	4.27	<.0001
Number of unique MyMathLab objectives mastered (standardized)	0.6836	0.2143	684	3.19	0.0015
Institution level					
Urban locale	3.9322	2.8599	684	1.37	0.1696
Blended instruction used	-1.0982	2.5104	684	-0.44	0.6619

(versus emporium)					

Note: n=698 in HGLM analysis

Table 3: HGLM results when MyMathLab test variables were included in the model for the full analytic sample of students enrolled before and during Fall 2015

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	4.0882	3.2060	2	1.28	0.3303
Student level					
Female	-0.1941	0.3485	701	-0.56	0.5777
White	-0.3696	0.4212	701	-0.88	0.3806
Enrolled full-time at institution	-0.04324	0.3740	701	-0.12	0.9080
STEM major	-0.3928	0.4564	701	-0.86	0.3897
Enrolled before Fall 2015	-0.09823	0.3396	701	-0.29	0.7725
Total time spent (standardized hours) in MyMathLab test	0.5559	0.3314	701	1.68	0.0939
Total number of test attempts (standardized) in MyMathLab	0.1482	0.3698	701	0.40	0.6888
Student MyMathLab	2.3525	0.3039	701	7.74	<.0001

test grade (standardized)					
Number of unique MyMathLab objectives mastered (standardized)	0.3770	0.2368	701	1.59	0.1119
Institution level					
Urban locale	1.2486	2.6256	701	0.48	0.6345
Blended instruction used (versus emporium)	-2.1390	2.3575	701	-0.91	0.3646

Note: n=715 in HGLM analysis

Table 4: HGLM results when MyMathLab quiz variables were included in the model for the full analytic sample of students enrolled before and during Fall 2015

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.08884	1.6043	2	0.06	0.9609
Student level					
Female	-0.1649	0.3021	722	-0.55	0.5854
White	0.1320	0.3670	722	0.36	0.7191
Enrolled full-time at institution	-0.04156	0.3363	722	-0.12	0.9017
STEM major	0.3093	0.4466	722	0.69	0.4888

Enrolled before Fall 2015	-0.3367	0.3033	722	-1.11	0.2673
Total time spent (standardized hours) in MyMathLab quiz	0.04831	0.3453	722	0.14	0.8888
Total number of quiz attempts (standardized) in MyMathLab	2.5163	0.8498	722	2.96	0.0032
Student MyMathLab quiz grade (standardized)	1.6203	0.2528	722	6.41	<.0001
Number of unique MyMathLab objectives mastered (standardized)	0.6334	0.2054	722	3.08	0.0021
Institution level					
Urban locale	3.9465	1.3562	722	2.91	0.0037
Blended instruction used (versus emporium)	1.4222	1.1730	722	1.21	0.2258

Note: n=736 in HGLM analysis

Across the three models, significant results were found for the platform variables, especially in the homework model and the quiz model.

These models suggested that the number of homework and quiz attempts made, the grades obtained in these assignments, and the number of unique objectives mastered were all positively and significantly related to the probability of passing the course. This means that, as students attempted more assignments, obtained higher assignment grades, and mastered more unique objectives in MyMathLab, the probability of passing the course increased, even after controlling for their demographic characteristics. It should be noted that time spent in homework was found to be significantly and negatively related to the probability of passing the course. This is not surprising, as struggling students could be spending more time in their homework assignments or they could leave the homework assignment opened without actively working on it.

The test model had only one positive and significant finding, which was the test assignment grade. When students obtained higher test grades, they were more likely to pass the course.

To further examine these findings, subgroup analyses were also conducted. The students were spilt into whether they enrolled before or during Fall 2015, with Tables 5 to 8 showing results for students who enrolled before Fall 2015. (See Appendix 2 for tables of results for students who were newly enrolled in Fall 2015.)

The remainder of the analyses address the third and final research question:

3. Is the contribution of these factors to students passing the course similar across groups of students – those enrolled before Fall 2015 and students newly enrolled in Fall 2015?

Table 5: HGLM subgroup analysis of students enrolled before Fall 2015 when MyMathLab homework variables were included in the model

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.9227	3.4167	2	0.27	0.8124
Student level					
Female	-0.3361	0.5319	261	-0.63	0.5281
White	0.1026	0.5902	261	0.17	0.8621
Enrolled full-time at institution	0.07380	0.5118	261	0.14	0.8855
STEM major	-0.5440	0.8569	261	-0.63	0.5260
Number of prior Math	-0.2396	0.2331	261	-1.03	0.3049

courses taken at institution					
Prior GPA	0.3025	0.2430	261	1.24	0.2143
Total time spent (standardized hours) in MyMathLab homework	-1.5242	0.4534	261	-3.36	0.0009
Total number of homework attempts (standardized) in MyMathLab	0.9657	0.3957	261	2.44	0.0153
Student MyMathLab homework grade (standardized)	1.1017	0.3306	261	3.33	0.0010
Number of unique MyMathLab objectives mastered (standardized)	0.03896	0.3257	261	0.12	0.9049
Institution level					
Urban locale	2.4297	2.7845	261	0.87	0.3837
Blended instruction used (versus emporium)	-1.4693	2.5376	261	-0.58	0.5631

Note: n=276 in HGLM analysis

Table 6: HGLM subgroup analysis of students enrolled before Fall 2015 when MyMathLab test variables were included in the model

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
Solution for Fixed Effects					
Intercept	3.8690	2.6992	2	1.43	0.2882
Student level					
Female	0.2756	0.6016	270	0.46	0.6472
White	-0.3676	0.7181	270	-0.51	0.6091
Enrolled full-time at institution	-0.3374	0.6265	270	-0.54	0.5906
STEM major	0.3838	0.9631	270	0.40	0.6906
Number of prior Math courses taken at institution	-0.4858	0.2829	270	-1.72	0.0871
Prior GPA	-0.1551	0.2931	270	-0.53	0.5971
Total time spent (standardized hours) in MyMathLab test	-0.5009	0.5744	270	-0.87	0.3840
Total number of test attempts (standardized) in MyMathLab	0.6100	0.6081	270	1.00	0.3167
Student MyMathLab	2.4483	0.5078	270	4.82	<.0001

test grade (standardized)					
Number of unique MyMathLab objectives mastered (standardized)	-0.4736	0.3942	270	-1.20	0.2306
Institution level					
Urban locale	0.4170	2.1002	270	0.20	0.8428
Blended instruction used (versus emporium)	-0.1808	1.9421	270	-0.09	0.9259

Note: n=285 in HGLM analysis

Table 7: HGLM subgroup analysis of students enrolled before Fall 2015 when MyMathLab quiz variables were included in the model

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	-0.4008	2.5022	2	-0.16	0.8874
Student level					
Female	0.1981	0.5044	283	0.39	0.6948
White	0.09050	0.5619	283	0.16	0.8722
Enrolled full-time at institution	-0.1531	0.5186	283	-0.30	0.7680
STEM major	0.9276	0.8333	283	1.11	0.2666
Number of prior Math	-0.2485	0.1948	283	-1.28	0.2032

courses taken at institution					
Prior GPA	-0.1506	0.2598	283	-0.58	0.5625
Student total time spent (standardized hours) in MyMathLab quiz	-0.3690	0.5079	283	-0.73	0.4682
Student total number of quiz attempts (standardized) in MyMathLab	3.1730	1.4106	283	2.25	0.0253
Student MyMathLab quiz grade (standardized)	1.9675	0.4804	283	4.10	<.0001
Number of unique MyMathLab objectives mastered (standardized)	-0.1815	0.3372	283	-0.54	0.5909
Institution level					
Urban locale	4.8065	2.0686	283	2.32	0.0209
Blended instruction used (vs. emporium)	2.6509	1.8840	283	1.41	0.1605

Note: n=298 in HGLM analysis

Tables 5 to 7 present the results for students who enrolled in the institution before Fall 2015. For this group of students, we were able to control for their achievement in previous courses at the institution using prior GPA

and number of previous Math courses completed. As seen in all three of the models, though the number of unique objectives mastered was no longer significant, the assignment grades obtained were still positively and significantly related to the probability of passing the courses. Thus, higher homework grades, higher quiz grades and higher test grades were all related to a higher probability of passing courses. For the homework model, but not for the test and quiz models, the number of attempts made was also significantly and positively related to the probability of passing courses, signaling that a greater number of attempts on homework assignments was associated with a greater likelihood of passing the courses.

The remaining analyses (see Tables 1A to 3A in Appendix 2) give results for the subgroup of students who were enrolled at the institution in Fall 2015 and had not taken previous courses at the institution. For this subgroup analysis of students, who were only enrolled at the institution during Fall 2015, the variables used in the models nearly matched the variables used in the full sample, as we do not have any previous course achievement data for this group of students.

The significant results found for this subgroup of students were strikingly similar to the full sample results. Thus, results of these models reinforced the findings that the number of attempts made across homework assignments and the grades obtained on all three types of MyMathLab assignments were positively and significantly related to the probability of passing the course. So, higher grades on any of the three types of assignments were related to a higher probability of passing courses, and the number of attempts made for homework was similarly related to a higher probability of passing courses.

Conclusion

The key analyses conducted in this study adjust for student background characteristics – including gender and whether students were non-white, enrolled full-time, and majored in a STEM field – as well as school characteristics (urban locale, and blended or emporium instruction). Addressing the three research questions, our study showed that:

1. When analyzing all students who participated in the study and for whom data was available, the grade level in MyMathLab assignments was consistently found to be associated with probability of passing the developmental Math course, with higher grades corresponding to a greater probability of passing.

2. For both the number of attempts and the number of objectives mastered, the positive association with the probability of passing was only true for homework and quizzes in the full sample. So, for these two types of assignments, a greater number of attempts made and objectives mastered were associated with a higher probability of passing. For tests, on the other hand, both the number of attempts made and number of objectives mastered were unrelated to the probability of passing.

3. Time spent on homework assignments was negatively related to the probability of passing, with students who spent more time having a lower probability of passing the course. For quizzes and tests, however, time spent was generally unrelated to the probability of passing the course.

4. Overall, students enrolled before Fall 2015 and students newly enrolled in Fall 2015 showed almost the same pattern of findings as the group of students as a whole. One notable exception was for number of objectives mastered, which had no association to the probability of passing for students enrolled before Fall 2015 but had a positive association with the probability of passing for students newly enrolled in Fall 2015 – where larger numbers of objectives mastered was associated with a greater probability of passing for both homework and quizzes. Another exception was for time spent on tests, which had no association to the probability of passing except for newly enrolled students in Fall 2015, who had a higher probability of passing if they spent more time on tests.

Discussion

Data for this analysis came from five institutions that participated in this study by providing us with the necessary data. Based on this sample of five institutions, the findings are as follows:

Number of Attempts Made in Homework Assignments. This was a consistent finding for both the full sample and the sub-group samples. More attempts the students made in homework were related to a higher probability of passing the course. Hence, based on this finding, students who work on homework assignments in MyMathLab do matter. To translate the results more concretely, take, for example, the subgroup of students who were newly enrolled in Fall 2015 (since the fixed effects coefficient for this subgroup is the largest). On average, an increase of 18 homework attempts (i.e. one standard deviation increase in homework attempts) was found to be associated with a fivefold increase in the probability[7] of passing the course from 9.8% to 53%.

MyMathLab Homework, Quiz, and Test Grades. Similar to the finding for the number of attempts, this was a consistent finding in both the full and sub-group samples. Higher grades for homework, quiz or test assignments were related to a higher probability of passing the course. This finding is not too surprising as most assignment grades account for a certain portion of the final course grade.

Number of MyMathLab Unique Objectives Mastered on Homework and Quizzes. A significant, positive association was only found in the homework and quiz models for the full sample and one of the sub-group samples (i.e. students who were only enrolled in Fall 2015). It was not found in the sub-group sample of students enrolled before Fall 2015, where their previous course achievement was controlled for. The implication may be that reaching new objectives in MyMathLab might not make a difference to course results for students who had completed courses before, but this needs further investigation.

In summary, after controlling for student demographics and institutional characteristics, there are still some aspects of MyMathLab that were found to be significantly related to the probability of passing the course. For certain characteristics, however, the findings depended on the type of assignment and on the group of students.

The grades that a student obtained in the assignments made a difference to the likelihood of passing the course across all types of assignments, for students overall and for the Fall and pre-Fall sub-groups. Among students as a whole and students newly enrolled in Fall 2015, those who made more homework assignment attempts had a higher probability of passing the course, but this was not found for tests and quizzes. For time spent on homework assignments, across both groups of students and students as a whole, more time spent

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[7] The fixed effects coefficients were converted to predicted probability by $[\exp(x)/(1 + \exp(x))]$

corresponded to a lower probability of passing. However, for tests among students who were newly enrolled in 2015, more time spent corresponded to a higher probability of passing.

Limitations and Future Research

There are limitations to this study. First, the research design only allows us to make correlational claims and not causal claims about MyMathLab and achievement. In this study, all students were MyMathLab users and there was no comparison group of non-users. Hence this limits the findings from this study to correlational. Future research could address this limitation by using a more rigorous experimental design that either randomly assign students to users and non-users or matching users to non-users on prior achievement and other demographic variables. A second limitation is that the outcome in this study is passing the course, which is correlated to the platform variables. As mentioned earlier, using passing the course as the outcome was necessitated as some participating institutions do not give final exams in a developmental course. Only a pass or fail grade was given to indicate if the students met the minimum proficiency before enrolling in full-credit courses. However, this puts a limitation to our study since grades from MyMathLab homework, tests and quizzes would contribute to passing the course. Ideally, in a study, the platform variables should not be correlated to the outcome but this is impossible in our study.

Across the different institutions and across the different instructors for the different courses within each institution, there is variation in which type of assignments the instructors used for the course. Hence, not all courses have the same pattern of designated assignments for students to complete. This limits the analyses since it is not possible to combine all assignments (i.e. homework, tests, and quizzes) into a single regression model. It is possible that students who completed one type of assignment might tend to complete other types of assignments. Hence a single model could account for the potential relationship between the different assignment types. However, since there is variation in course assignments, this study could only examine each assignment type in separate regression models. Caution should be taken not to interpret the individual effects for the different assignment types as independent of each other and additive in some way.

In addition, there was a limited number of meaningful student variables (such as gender, race, STEM major, full-time status) and institutional variables (such as urban locale and use of blended instruction) that we have access to and were able to control for. Hence, we are not able to rule out all confounding factors that might influence students' achievement in the course. This is limited partly due to the data that the participating institutions were able to provide. The courses in this study were developmental, gateway courses and were mostly offered to students before they enroll in full-credit courses. Hence, the institutions might not have full record on these students. Figure 2 shows the sample sizes of students from the various data sources and Figure 6 describes the students based on the transcript data. As some students had missing data, the results discussed may not fully generalize, or apply, to the 1,282 students who were the original focus of the study. In addition, replicating the study at other institutions that would involve more students and over more semesters would be needed to allow for further generalization of findings.

Another limitation is that not all instructors participated in the instructor survey which would have otherwise allowed us to determine if there were any instructor variables that might influence student achievement in the course. If more student, instructor, and institutional variables could have been included in the analysis, it might give us a fuller picture of the impact of MyMathLab.

Findings from this study point to the need to examine the different aspects of MyMathLab in more detail. We found that the number of unique objectives mastered that could be assessed in Study Plan (which is a separate activity type from homework, quiz, or test) matter only in the full sample and the sample of students enrolled in Fall 2015 for homework and test assignments but not the sample of students who were enrolled prior to Fall 2015 and for whom we were able to control for prior achievement. Hence, to further understand how mastery of objectives affects learning, we might want to investigate the different kinds of objectives in MyMathLab and the relation to learning.

Worth noting is that the number of attempts made in MyMathLab was not related to the probability of passing the course for tests and quizzes but was for homework. The research cited in this report speaks to the benefits of learner support tools offered by MyMathLab, including scaffolding with worked examples (Sharma & Hannafin, 2007) and feedback on performance on assignments (Hattie 2009, 2012). However, homework may play a different role than that of tests and quizzes. Future research may want to focus on the contribution of these learner support tools specifically related to homework as opposed to tests and quizzes.

References

Anderson, J. R., Corbett, A., Koedinger, K. R., & Pelletier, R. (1995) Cognitive tutors: Lessons learned. *Journal of the Learning Sciences, 4*(2), 167-207.

Anderson, J. R. & Schunn, C. D. (2000). Implications of the ACTR learning theory: No magic bullets. In R. Glaser, (Ed.), *Advances in instructional psychology: Educational design and cognitive science* (Volume 5), pp. 134. Mahwah, NJ: Lawrence Erlbaum Associates.

Bangert-Drowns, R. L., Kulik, C.L. C., Kulik, J. A., & Morgan, M. (1991). The Instructional effect of feedback in test-like events. *Review of Educational Research, 61*(2), 213-238.

Corbett, A., & Anderson, J. R. (1995). *Knowledge tracing: Modeling the acquisition of procedural knowledge. User Modeling and User-Adapted Interaction, 4*(4), 253-278.

Diener, C. I. & Dweck, C. S. (1978). An analysis of learned helplessness: Continuous changes in performance, strategy, and achievement cognitions following failure. *Journal of Personality and Social Psychology, 36*(5), 451-462.

Dweck, C. S. (1996). Implicit theories as organizers of goals and behavior. In P. M. Gollwitzer & J. A. Bargh (Eds.), *The psychology of action: Linking cognition and motivation to behavior* (pp. 6990). New York: Guilford Press.

Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. New York, NY: Routledge.

Hattie. J. (2012). *Visible learning for teachers: Maximizing impact on learning*. New York, NY: Routledge.

Hattie, J., & Timperley, H. (2007). The power of feedback. *Review of Educational Research, 77*(1), 81-112.

Hulleman, C. S., Godes, O., Hendricks, B. L., & Harackiewicz, J. M. (2010). Enhancing interest and performance with a utility value intervention. *Journal of Educational Psychology, 102*(4), 880-895.

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Science, 16*(8), 404-406.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81-97.

Ohlsson, S. (1986). Some principles of intelligent tutoring. *Instructional Science, 14*(3), 293-326.

Sadler, R. (1989). Formative assessment and the design of instructional systems. I*nstructional Science, 18*,119--144.

Sharma, P., & Hannafin, M. J. (2007). Scaffolding in technology-enhanced learning environments. *Interactive Learning Environments, 15*(1), 27-46.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257-285.

VanLehn, K. (2011). The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems. *Educational Psychologist, 46*(4), 197-221.

Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that personal characteristics can be developed. *Educational Psychologist, 47*(4), 302-314.

Appendix 1: Instructor Survey

END OF SEMESTER SURVEY FOR INSTRUCTORS

1. In an average 7-day week, about how many hours do you EXPECT the typical student to spend preparing for your course (studying, reading, writing, doing homework, etc.)?

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ More than 10 hours

2. In an average 7-day week, about how many hours do you think the typical student ACTUALLY spends preparing for your course (studying, reading, writing, doing homework, etc.)?

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ More than 10 hours

* 3. In an average 7-day week, about how many hours do you think the typical student in your course spends doing each of the following?

	0 hours	1-5	6-10	11-15	16-20	21-25	26-30	More than 30 hours
Attending class	○	○	○	○	○	○	○	○
Providing care for dependents (children, siblings, parents, etc.)	○	○	○	○	○	○	○	○
Traveling to class (driving, walking, etc.)	○	○	○	○	○	○	○	○
Participating in school activities (clubs, residence duties, athletics, community service, etc.)	○	○	○	○	○	○	○	○
Working on campus	○	○	○	○	○	○	○	○
Working off campus (restaurant, retail, etc.)	○	○	○	○	○	○	○	○
Doing community service or volunteer work	○	○	○	○	○	○	○	○
Relaxing/socializing (time with friends, video games, TV, online chatting, etc.)	○	○	○	○	○	○	○	○
Exercising	○	○	○	○	○	○	○	○

4. In your course, how important is it to you that the typical student do the following?

	Not important	Somewhat important	Important	Very important
Ask questions or participate in class discussions.	○	○	○	○
Come to class having completed readings and assignments.	○	○	○	○
Ask another student for help understanding course material.	○	○	○	○
Explain course material to other students.	○	○	○	○
Work with other students on projects.	○	○	○	○
Access other supports available to them on campus (tutoring, advising, first-year experience groups, etc.)	○	○	○	○

* 5. In your course, about what percentage of class time is spent on the following?

	0%	1-9%	10-19%	20-29%	30-39%	40-49%	50-59%	60-74%	75% or more
Lecture	○	○	○	○	○	○	○	○	○
Discussion	○	○	○	○	○	○	○	○	○
Student presentations	○	○	○	○	○	○	○	○	○
Small-group activities	○	○	○	○	○	○	○	○	○
Independent student work (writing, discussion boards, etc)	○	○	○	○	○	○	○	○	○
Videos, music, movies, etc. (not including media or performances produced by students)	○	○	○	○	○	○	○	○	○
Assessing student learning (tests, quizzes, surveys, polls, etc.)	○	○	○	○	○	○	○	○	○
Experiential activities (labs, field work)	○	○	○	○	○	○	○	○	○
Using a classroom response system (clickers)	○	○	○	○	○	○	○	○	○

* 6. What kind of training on the Pearson product, if any, did you participate in before teaching this course?

* 7. How has the Pearson product impacted how you teach this course?

* 8. To what extent do you agree or disagree with the following statements.

	Strongly disagree	Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree	Strongly agree
The Pearson product is easy to use	◯	◯	◯	◯	◯	◯	◯
Students came to class better prepared with the Pearson product	◯	◯	◯	◯	◯	◯	◯
Students completed assignments before class with the Pearson product	◯	◯	◯	◯	◯	◯	◯
Students were more engaged in the course with the Pearson product	◯	◯	◯	◯	◯	◯	◯
Students performed better on summative assessments (high stakes exams, final projects, etc.) with the Pearson product	◯	◯	◯	◯	◯	◯	◯
Students have improved their performance in the course overall with the Pearson product	◯	◯	◯	◯	◯	◯	◯

* 9. What is one "best practice" you would share with instructors who have a high population of students who enter college unprepared to complete college-level math, writing or science courses?

* 10. What have been the benefits to you of using the Pearson product?

* 11. What have been the challenges (if any) in using the Pearson product?

[   ]

* 12. How likely is it that you would recommend the Pearson product you used in this course to a friend or colleague?

[1=Not likely at all; 10=Very likely]

○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10

* 13. Do you expect your implementation of the Pearson product to change next time you teach this course? If yes, how? (select all that apply)

☐ Require the Pearson product for a greater percentage of students' grade.

☐ Require the Pearson product for a smaller percentage of students' grade.

☐ Implement early intervention strategies using the Pearson product's performance dashboard or gradebook diagnostics

☐ Use data from the Pearson product's performance dashboard or gradebook diagnostics to inform time spent in class.

☐ No change expected

Other (please specify)

[   ]

SECTION A: ABOUT ME AND MY INSTITUTION

* 14. Please tell us your...

First Name:

Last Name:

School:

City:

State:

* 15. Which of the following best describes your institution?

◯ 2 Year School

◯ 4 Year School

◯ Private Sector (Career College)

16. Which of the following best describes your position at your institution?

◯ Adjunct

◯ Lecturer/Instructor

◯ Tenure-track

◯ Tenured

◯ Administrator

* 17. Prior to the current semester, about how many times had you taught this course?

◯ 0 ◯ 1-2 ◯ 3-4 ◯ 5-9 ◯ 10 or more times

Appendix 2: Technical Tables

Tables from the Model for Students Newly Enrolled in Fall 2015

Table A1: HGLM subgroup analysis of students newly enrolled in Fall 2015 when MyMathLab homework variables were included in the model

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	-2.2187	3.6821	2	-0.60	0.6080
Student level					
Female	0.002229	0.3932	389	0.01	0.9955
White	-0.2284	0.5079	389	-0.45	0.6532
Enrolled full-time at institution	0.4547	0.5125	389	0.89	0.3755
STEM major	-0.4039	0.5613	389	-0.72	0.4723
Total time spent (standardized hours) in MyMathLab homework	-1.1144	0.3327	389	-3.35	0.0009
Total number of homework attempts (standardized) in MyMathLab	2.3230	0.6777	389	3.43	0.0007
Student MyMathLab homework	0.5386	0.1931	389	2.79	0.0055

Effect	Estimate	Standard Error	DF	t Value	Pr > |t|
grade (standardized)					
Number of unique MyMathLab objectives mastered (standardized)	1.0375	0.3463	389	3.00	0.0029
Institution level					
Urban locale	5.7540	3.1121	389	1.85	0.0652
Blended instruction used (versus emporium)	0.6420	2.6713	389	0.24	0.8102

Note: n=402 in HGLM analysis

Table A2: HGLM subgroup analysis of students newly enrolled in Fall 2015 when MyMathLab test variables were included in the model

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	5.5202	3.3647	2	1.64	0.2426
Student level					
Female	-0.4883	0.5003	397	-0.98	0.3297
White	-0.5078	0.6068	397	-0.84	0.4032
Enrolled full-time at institution	-0.1639	0.5579	397	-0.29	0.7691
STEM major	-0.2892	0.6060	397	-0.48	0.6335
Total time spent	1.9221	0.5934	397	3.24	0.0013

(standardized hours) in MyMath Lab test					
Total number of test attempts (standardized) in MyMath Lab	0.6826	0.5853	397	1.17	0.2442
Student MyMath Lab test grade (standardized)	2.4522	0.4717	397	5.20	<.0001
Number of unique MyMath Lab objectives mastered (standardized)	0.5254	0.3864	397	1.36	0.1747
Institution level					
Urban locale	1.8472	2.6514	397	0.70	0.4864
Blended instruction used (versus emporium)	-3.3451	2.5146	397	-1.33	0.1842

Note: n=410 in HGLM analysis

Table A3: HGLM subgroup analysis of students newly enrolled in Fall 2015 when MyMathLab quiz variables were included in the model

Solution for Fixed Effects					
Effect	**Estimate**	**Standard Error**	**DF**	**t Value**	**Pr > |t|**
Intercept	0.08604	1.0381	2	0.08	0.9415
Student level					

Female	-0.6852	0.4110	404	-1.67	0.0963
White	-0.07730	0.4781	404	-0.16	0.8716
Enrolled full-time at institution	-0.4591	0.4189	404	-1.10	0.2737
STEM major	-0.08022	0.5555	404	-0.14	0.8853
Total time spent (standardized hours) in MyMath Lab quiz	0.4940	0.4670	404	1.06	0.2908
Total number of quiz attempts (standardized) in MyMath Lab	2.4348	1.0979	404	2.22	0.0271
Student MyMath Lab quiz grade (standardized)	1.6257	0.3234	404	5.03	<.0001
Number of unique MyMath Lab objectives mastered (standardized)	1.0303	0.2961	404	3.48	0.0006
Institution level					
Urban locale	4.0889	0.8789	404	4.65	<.0001
Blended instruction used (versus emporium)	2.1223	0.7755	404	2.74	0.0065

Note: n=417 in HGLM analysis

Equations and SAS Code for Hierarchical Generalized Linear Models (HGLM)

The data for this study is hierarchical in nature, with students nested in the five institutions. Typically, hierarchical linear modeling is used when the data is nested, but since the outcome of interest in this study is passing the course, which is binary, HGLM were used in the analysis to address the non-normally distributed outcome.

Specifically, our HGLM has two levels – student and institution. The equation at the student level is given by

$$\eta_{ij} = \beta_0 + \Sigma \beta_j \boldsymbol{X_{ij}} \tag{1}$$

where

η_{ij} represents the log odds of passing the course for student i in school j

β_0 represents the average log odds of passing the course at school j

X_{ij} represents the student level variables used in the models

Because the outcome is binary, the model has no error variance at the student level. In our analysis, we only consider a random intercept-only model where the school level model is given by

$$\beta_0 = \gamma_{00} + \Sigma \gamma_0 W_j + u_{0j} \tag{2}$$

where

γ_{00} represents the log odds of passing the course at a typical school

W_j represents the school level variables we controlled for

u_{0j} represents the unique effect associated with school j, that is the school level error term

A sample of the SAS syntax used to estimate the solutions for the fixed effects of student and institutional variables used in the HGLM analysis is shown in Figure A1.

Figure A1: SAS syntax used for the HGLM full sample homework model

```
proc glimmix method=laplace noclprint;

class INST_unitid;

model GRADE_pass (EVENT=LAST) = female white full_time stem_major
before_fall_2015

standardized_total_duration_homework standardized_num_homework_attempts
standardized_homework_grade standardized_num_unique_objmastered

INST_urban_locale INST_blended_instruction

/dist=binary link=logit solution oddsratio;
```