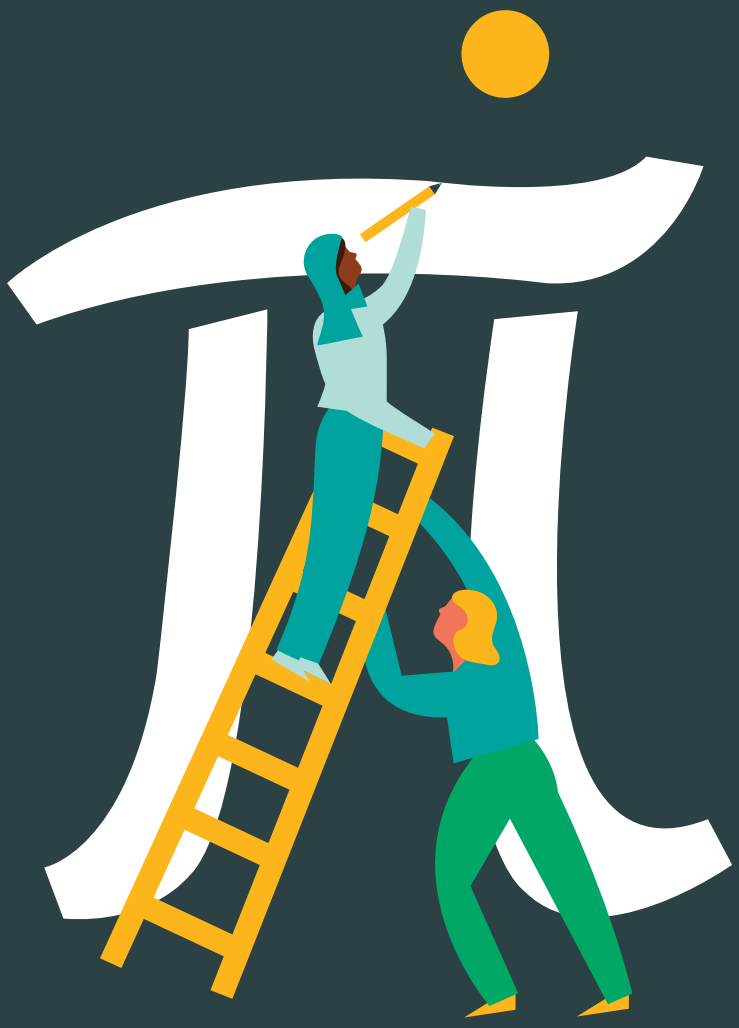
Pearson

MyLab Math for Developmental Math

Efficacy Research Report

April 3 2018



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The corpus of research for this product includes research conducted by our in-house researchers in partnership with customers, and research conducted by third party researchers. All research included in this report meets the standards we have set out for our own efficacy research. These are informed by and aligned with guidance on educational research quality provided by organisations such as the American Educational Research Association and the What Works Clearinghouse.

Efficacy statements in this report are subject to independent assurance by PricewaterhouseCoopers LLP (PwC). The PwC assurance report is on page 24 and further details can be found in the Pearson Efficacy Reporting Framework dated April 3 2018.

Introduction

In 2013, Pearson made a commitment to efficacy: to identify the outcomes that matter most to students and educators, and to have a greater impact on improving them. Our aspiration is to put learners at the heart of the Pearson strategy; our goal, to help more learners, learn more. Part of our commitment was to publish research regarding the impact of the use of our products on outcomes, and to have the outcomes subject to independent audit. We call this efficacy reporting. There is no rulebook for how to do this, no model to follow. We've had to learn fast during this journey, we've sought guidance from others including external expertise, and we are now some, but not yet all of the way there.

The road taken and the milestone reached

In a first for the education sector, we have published audited efficacy reports on some of our most widely used products. Together, these products represent 18 million learners. This Research Report includes independently audited efficacy statements that have been prepared using the Pearson Efficacy Reporting Framework dated April 3 2018 — which we have used consistently for the Pearson products we are reporting on.

We have sought to use the efficacy reporting process to amplify existing non-Pearson peer reviewed research about our products. We've also sought to foster innovation in efficacy research by conducting new research and placing value on a range of research methods — including implementation studies, correlational and causal designs — ensuring data is collected, analyzed and presented to agreed standards at the appropriate stages in each product's lifecycle. The research conducted for this report, and the efficacy statements produced as a result, are designed based on international best practices such as those set out by the American Education Research Association and the What Works Clearinghouse. We have synthesized these into a set of standards we hold ourselves accountable for in our research and reporting. These are set out in the Pearson Efficacy Reporting Framework dated April 3 2018.

Furthermore, we adhere to the same peer-review processes as other high quality research in the education sector. Our work was independently reviewed and validated by SRI International, a well-known non-profit research center, and shared for discussion at research conferences organized by, among others, the American Education Research Association.

Our body of research contains evidence of statistically significant relationships between the use of our products and learner outcomes like student achievement. We want to be clear, though, that efficacy is not a quality a digital product can possess in and of itself. We recognize that implementation — the way a product is integrated into teaching and learning — also has a significant impact on the outcomes that can be achieved. Our reports do not yet capture the full range of intended product outcomes, nor the variety of different ways of implementing our products. What we do know is that the more we can engage with our customers about best practices that can support the integration of learning technologies into their teaching, the more likely they will be to achieve their desired outcomes.

We have commissioned PricewaterhouseCoopers LLP ('PwC') to audit the efficacy statements set out in our Research Reports. This is to demonstrate that the statements accurately reflect the research that has been carried out. PwC's audit report can be found at the end of this document.

The journey ahead

Delivering on our reporting commitment has never been our ultimate goal; what matters most to us is helping more learners, learn more. Our aspiration is to explore what works, for whom, and why; and to encourage discussion about questions such as: What outcomes matter most to students? What should teaching and learning look like? What evidence should we apply to its design? And how should we evaluate impact?

We are excited to continue partnering with educators and others in the field in order to better understand how interactions between educators, students and learning technology can enhance outcomes. We have also been energized to see others in the education sector begin to focus on efficacy and research — though we recognize that their application in education is still nascent. In order to accelerate the emergence of its full potential we are already developing new ways of partnering with educators, researchers and institutions so we can advance this work together. In doing so, we will continue to advocate for the need to apply rigorous evidence to improve the outcomes of teaching and learning, while also seeking to ensure that evidence captures customers' experiences and is relevant and useful to educators in their practice.

Special thanks

We want to thank all the educators, students, research institutions and organizations we have collaborated with to date. We are spurred on by the growing number of opportunities for us to learn from others in the sector who are beginning to tackle the same challenges. If you are interested in partnering with us on future efficacy research, have feedback or suggestions for how we can improve, or want to discuss your approach to using or researching our products, we would love to hear from you at efficacy@pearson.com. If we, as a sector, tackle this together, we will help more learners learn more.

Kate Edwards
Senior Vice President,
Efficacy and Research, Pearson
April 3 2018

Findings in brief

Pearson sought to explore whether the use of MyLab Math for Developmental Math, a teaching and learning platform predominantly used in higher education by students who need remediation on foundational math skills, is related to students' course grades and likelihood of passing the course.

This Research Report presents findings from two research studies: one correlational study conducted at Arizona State University, a four-year college, for students enrolled in an introductory mathematics course; and one correlational study conducted at five US higher education institutions where MyLab Math for Developmental Math was used in developmental math courses during the Fall semester of 2015. Our aim in using correlational study designs was to seek out possible relationships between the use of MyLab Math for Developmental Math and students' course grades and likelihood of passing the course, to identify areas of focus for potential future research using more rigorous causal study designs.

The findings appear alongside details of the research studies, including descriptions of the samples studied, methods of analysis, results, limitations and generalizability, and notes on possible future research.

The report also summarizes the context surrounding the findings, including the research that informed the design and development of the product, the history of the product in the market, how educators use the product, and its intended outcomes.

The findings are inseparable from their surrounding context and the design of the study that produced them. To learn more about these elements, follow the links to our Technical Reports in the **Research studies** section.

In the context of the study conducted at Arizona State University, Pearson found that after controlling for selected student background characteristics:

— Mastering more MyLab Math learning objectives was associated with higher course grades and a higher likelihood of passing the course.
— Making more attempts in MyLab Math quizzes and tests was associated with a higher likelihood of passing the course and receiving higher course grades.
— Earning higher average quiz and test scores in MyLab Math was associated with a higher likelihood of passing the course and receiving higher course grades.
— Making more attempts on MyLab Math QuizMe and receiving higher QuizMe scores were related to lower course grades.
— Receiving higher QuizMe scores was related to a lower likelihood of passing the course.

In the context of the study conducted at five higher education institutions in the US, Pearson found that after controlling for certain student and institutional characteristics:

— On average, for students who were newly enrolled in fall 2015, an increase of 18 attempts on MyLab Math homework was associated with a fivefold increase in the probability of passing a developmental math course.
— Higher homework, quiz, and test scores in MyLab Math were related to a higher probability of passing the course (for example, getting at least a C letter grade).

The complete statements are set out in the boxes titled "Efficacy statements" on pages 13 and 18. These statements have been subject to assurance by PwC, whose report can be found at the end of the Research Report.

Product design and development

Product overview

MyLab Math is a teaching and learning platform that combines trusted author content with digital tools and a flexible platform. The MyLab Math product for Developmental Math courses is predominantly used in higher education by students who need remediation on foundational math skills before taking credit-level math courses. This product is also used in K–12 education (branded as MyLab Math for School) for Algebra 1, Algebra 2, Geometry, and dual-enrollment courses. MyLab Math is designed to accompany a number of textbooks written in the math discipline.

MyLab Math for Developmental Math is designed to enhance and improve the following outcomes:

— Provide students with a positive learning experience while helping them develop a positive mindset towards math
— Build on students' existing experience to identify their strengths and weaknesses and provide an individualized learning path to accelerate their achievement
— Help students prepare for the next level of their education

The full list of the outcomes this product is intended to support, accompanied by a brief description, can be found in the appendix to this report.

Foundational research underpinning the design

MyLab Math is aligned with the insights gained from more than 30 years of research into digital tutoring systems (e.g., Ohlsson, 1986; Anderson, Corbett, Koedinger & Pelletier, 1995). In particular, it provides students with extensive and well supported practice. Research has shown that practice is necessary for students to turn knowledge into procedural fluency (Anderson & Schunn, 2000). This process of developing expertise can be supported by:

— Offering immediate feedback
— Providing different kinds of support (i.e., worked examples, hints)
— Helping to focus students' attention on critical elements and to manage the load on their working memory (Sweller & Cooper, 1985).

All of these strategies and features are intended to enable students to succeed, often for the first time, in math, and then begin to develop a positive mindset for mathematics.

The design of MyLab Math incorporates numerous principles from learning science — diverse, transdisciplinary fields that seek to understand how humans learn. What follows is a summary of some specific learning science research that underpins the design of MyLab Math.

Scaffolding with worked examples

It is common in education for instructors to demonstrate how to solve a particular type of problem. Research shows that such demonstrations, or "worked examples", improve learning, particularly when presented alongside practice problems that students complete on their own (Atkinson, Derry, Renkl, & Wortham, 2000).

MyLab Math includes a variety of learner support tools to help students struggling with assessment items (videos, animations, Pearson eText), and students can "ask for help" and get step-by-step support in solving a math problem. This feature is a form of instructional "scaffolding", in which a complex problem or task is given additional structure to make it more accessible to the student. Such scaffolding techniques are known to enhance learning (Reiser, 2004) , and scaffolding in technology-enhanced learning environments has shown particular promise in supporting novice learning (Sharma & Hannafin, 2007).

This feature is designed to accelerate learning.

Feedback

While research into the timing of feedback (i.e., immediate vs. delayed) has produced a wide range of results, there is research suggesting that immediate feedback improves learning of procedural skills in disciplines like mathematics more than feedback presented after a delay (Shute, 2008).

MyLab Math enables students to check frequently on their understanding and receive immediate feedback. Feedback provided in association with practice activities in MyLab Math is specific, clear, concise, and timely. Instructors see basic student performance (e.g., number of items correct/incorrect, number of items attempted) on assignments, and students can see detailed performance on specific learning objectives.

This feature is designed to accelerate learning.

Supporting student success

Research has found a number of factors may be limiting students in achieving their potential. For example, some students may suffer from anxiety (Maloney & Beilock, 2012), or lack foundational study skills or information about the kinds of behaviors that will help them to succeed in certain academic settings.

Factors that research has found to promote student success include self-regulated learning (e.g., Mega, Ronconi, & De Beni, 2014) and adopting a "growth mindset": a belief that their abilities will improve with effort and practice (e.g., Dweck, 1996).

Most MyLab Math courses include Student Success Resources that aim to provide additional support in these areas. By helping students manage anxiety, and by providing training on study skills and test-taking strategies, among other topics, MyLab Math is designed to put students on a path towards more self-regulated learning.

In addition, students have access to materials that have been designed, in consultation with leading researchers in the field, to help instill a "growth mindset".

These features are designed to help students achieve their potential and so prepare for the next level of their education.

Cognitive load

In cognitive psychology, cognitive load refers to the total amount of mental effort being used in working memory. This includes extraneous cognitive load, which is the mental effort spent focusing on elements that are not directly relevant to the learning.

Research shows that if you can reduce extraneous cognitive load for students when they are reading or studying, you can improve the effectiveness of learning (Sweller, 1988). Put simply, if you remove distractions, learning is more likely to occur.

In MyLab Math, the following approaches aim to reduce extraneous cognitive load: topics and subtopics are organized coherently into manageable chunks; assessments are presented in a clean display that aims to help students focus on the task at hand; and the eText is readily available.

The overall aim of these approaches is to accelerate learning and provide students with a positive learning experience.

Adaptive and personalized learning

Research has found that well-designed adaptive systems can be as effective as human tutors (VanLehn, 2006, 2011), and identified two prevalent types of adaptivity in learning technologies. One type relates to adaptive responses to students (i.e., feedback), and, as described under **Feedback**, MyLab Math provides immediate feedback to learners as they practice.

The other mode of adaptivity relates to adapting a learning sequence based on an understanding of a student's current proficiency. This "Knowledge Tracing" has been used to great effect in educational research efforts (e.g., Corbett & Anderson, 1995).

MyLab Math offers a number of options that adjust based on the learner, including Personalized Homework, Skill Builder, and the Companion Study Plan. For example, the Companion Study Plan presents students with instructional materials and practice problems that target the concepts and skills they are struggling with. Students can study these materials before testing their mastery through the QuizMe feature, which allows the instructor to set quiz difficulty as well as the performance threshold for demonstrating mastery. A student who does not demonstrate mastery through QuizMe is taken back to the Companion Study Plan for additional targeted study and practice before attempting the QuizMe again.

Features such as these present students with content they have yet to master fully, offer homework and practice opportunities on corresponding skills, and can provide rich scaffolding and feedback. Instructors have the flexibility to incorporate the style and approach of adaptive and personalized learning that best suits their course structure and students' needs.

These adaptive features are designed to accelerate learning.

History and reach of MyLab Math

Pearson MyLab Math launched in July 2001 under the name MyMathLab. The underlying product that enables the homework in MyLab Math, called MathXL, launched in the mid-1990s and continues to be an integral part of MyLab Math today.

In fall 2016, it was rebranded as Pearson MyLab Math. New iterations (feature enhancements added to MyLab Math) are released to the public for use twice annually (typically in June and December), resulting in continual improvement of the system with new capabilities that support learning and teaching.

MyLab Math is used primarily in the United States market, with around 3 million student registrations annually. This research report relates to the the most significant of the MyLab Math suite, MyLab Math for Developmental Math courses, which has 1 million users per year.

Intended product implementation

We aim to keep MyLab Math flexible enough to allow our customers to make their own choices on how they want to implement it, and to allow them to tweak their practice over time to improve the experience and outcomes.

Over the past 10 years, educator studies completed by Pearson's customers have reported a variety of approaches to the implementation of MyLab Math within blended instruction, emporium model, and hybrid programs.

Customers using blended instruction models have told us they have seen a greater impact when students:

— Use MyLab Math to complete assigned homework prior to class lectures
— Complete chapter quizzes that account for between 10% and 60% of their course grade

Customers using an emporium model of instruction have told us they have seen greater impact when students progress at their own pace and receive one-on-one assistance when they encounter difficulties. Customers using hybrid programs say they have seen better results when students combine self-paced and guided instruction to complete online assignments and assessments.

While educators who have used each of these implementation approaches have reported success with the use of MyLab Math in developmental math courses, more rigorous studies, such as those reported later in this document, indicate that these different approaches must be aligned to the specific skill levels and needs of the students.

Product research

Given the alignment of MyLab Math with the learning science principles discussed in the **Product design and development** section above, we hypothesize that usage of MyLab Math will have a positive relationship with the intended outcomes, particularly in terms of course completion (see Appendix for the full list of learner outcomes). The purpose of the research done to date was to explore the relationship between MyLab Math for Developmental Math usage and students' level of competence and standard of achievement.

Specifically, the activities in MyLab Math and the testing effects that those activities support, combined with the benefits of scaffolding, feedback, reducing extraneous cognitive load, and supporting knowledge retention, should enhance student learning such that we should observe that students' usage and performance in MyLab Math for Developmental Math correlates with achievement on independently administered course exams.

For this first phase of our efficacy journey, we mainly focused on exploring correlational rather than causal relationships between our products and learner outcomes. Demonstrating causation is complex and requires significant investment; our correlational studies identify relationships that may be worth investigating further with causal study designs in future research.

Existing research

In 2018 Pearson researchers completed a systematic search and review of research articles published since 2012 that assessed the impact of MyLab Math on learner outcomes. Our criteria for the review and inclusion of existing published research on our products were designed based on US Department for Education What Works Clearinghouse guidance. Based on these guidelines, in order for research to be included in this Efficacy Report on MyLab Math it needed to meet a number of criteria, including that the study was published in the past five years, examined at least one intended learner outcome category, and reported results in enough detail that the research could be properly evaluated. For more information on this see the Pearson Efficacy Reporting Framework dated April 3 2018.

In our initial screening, we discovered 91 studies. After an initial review we found that 10 contained information relevant to MyLab Math for Developmental Math. Following an in-depth review, we discovered that no existing published studies met the necessary criteria to be included in this Efficacy Report. For the initial screening list and a list of the subset of studies that contained information relevant to MyLab Math for Developmental Math but did not meet the criteria to be included here see the Pearson Efficacy Reporting Framework dated April 3 2018.

Research studies

There are two new studies, conducted by SRI International (Study 1) and Pearson (Study 2), that form the basis of the Efficacy Report for MyLab Math. The research questions and findings for each study are set out in detail below, including the efficacy statements generated by those studies.

Study 1

Study citation	An analysis of the relation between student usage and course outcomes for MyLab Math and MyLab Foundational Skills[1] — SRI International — March 2018
Research study contributors	*SRI International* Louise Yarnall Jared Boyce Tallie Wetzel Erica Snow *Other contributors* Robert Murphy
Research questions	1. What were the trends in the students' use of and performance in the courseware? 2. Controlling for student demographic and prior achievement variables, is student courseware use and performance associated with course outcomes?
Related intended outcomes category	Level of competence and standard of achievement
Study design	Relational (correlational, not predictive) This was a follow-up to a 2016 study on the Adaptive Learning Market Acceleration Program (ALMAP)[2]. In the 2016 study (Yarnall, Means, & Wetzel, 2016), researchers gathered quasi-experimental evidence on course outcomes, cost data, and both instructors' and students' experiences of ALMAP courseware. The evidence gathered did not include the titles of the course texts used with MyLab Math. One notable gap in this original ALMAP study was the lack of access to and analysis of the data on student product usage and performance generated by the courseware. In 2016, to further understand the usage of its own courseware products in the ALMAP courses, Pearson hired SRI International, the same external research institute that conducted the original ALMAP study, to further examine how students' use of, and performance in, MyLab Math related to course outcomes.
Metrics studied	— Course grades — Passing the course
Description of sample	SRI International examined MyLab Math usage and course outcome data collected in 2014 and 2015 from Arizona State University (ASU), a four-year college that was part of the original ALMAP study. ASU integrated Pearson's MyLab Math into an introductory mathematics course offered at three campuses. The ASU students in the sample were evenly split between men (46%) and women (54%), were mostly White and Asian (61%), were full-time students (95%), and less than a third relied on Pell grant financial aid.

[1] Though this study focused on both MyLab Math and MyLab Foundational Skills, only the MyLab Math findings are reported here.

[2] The Bill & Melinda Gates Foundation initiated ALMAP to advance evidence-based understanding of how adaptive learning technologies such as adaptive courseware could improve opportunities for low-income adults to learn and to complete postsecondary credentials.

Sample size	2,144 students (original sample); 1,570 students (analytic sample) To be included in the analytic sample for this study, a student record from the original ALMAP study had to meet several requirements: 1. The students had to be unique, meaning SRI only included data from a single term. If a student appeared in more than one term, only the student's first term was used. 2. The records had to have a complete set of Pearson usage variables (no missing data). 3. A complete set of demographic, prior achievement (i.e., pretest proxy data), and course outcome variables had to be available (i.e., no missing data). The sample in this study was smaller than the sample in the original ALMAP study since, for these analyses, researchers needed to match students in the original ALMAP sample with their Pearson courseware usage data. For a variety of reasons, it was not possible to match data in many cases.
Analysis	Students' usage of MyLab Math was measured by number of attempts made across different types of MyLab Math activities (e.g., tests, quizzes, QuizMe). Students' performance was measured by mean achievement scores across each of the activities and learning objectives mastered. Pearson provided usage data for MyLab Math at ASU, and ASU provided Pearson and SRI with student identifiers to connect the ALMAP study data to the Pearson usage data. Pearson's usage data captured students' engagement with specific MyLab Math activities, including quizzes, tests, and QuizMe. Pearson usage data also examined how many learning objectives students mastered. Statistical models were developed to explore the extent to which MyLab Math usage and performance data were associated with students' course outcomes — specifically course completion and course grades at a four-year college. The models controlled for student background characteristics, including gender, ethnicity, Pell status, enrollment status (full-time or part-time), and measures of student prior achievement or a proxy, when available. In exploring the usage data, SRI discovered many high correlations and multicollinearity issues that prevented full use of all activity types and usage metrics. Specifically, owing to multicollinearity issues, SRI was unable to include both hours spent using MyLab Math and attempts made in MyLab Math activities. Therefore, in consultation with Pearson, SRI chose to include attempts as the preferred usage variable. SRI included all activity types except homework because approximately two thirds of the students did not attempt any homework activities in the courseware.

Results

After controlling for student background characteristics, usage of MyLab Math and performance in quizzes and tests were significantly and positively associated with the two course outcomes: course grades and completion. However, use and performance on QuizMe was negatively associated with course grades.

Increased attempts in quizzes and tests, increased average scores on quizzes and tests, and mastering a higher number of learning objectives were associated with statistically significant higher course grades.

However, having a greater number of MyLab Math QuizMe attempts and achieving better scores in QuizMe activities were associated with statistically significant lower course grades, when controlling for student-level background characteristics. A possible explanation could be that lower-skilled learners were repeating QuizMe activities until they achieved a score greater than 80%, but that they never fully mastered the concepts.

Increased attempts in quizzes and tests, increased average scores on quizzes and tests, and increased learning objectives mastered were associated with increased likelihood of students completing a course. However, increases in the average QuizMe scores were negatively associated with completing the course.

Efficacy statements

In the context of this study, conducted at Arizona State University for students enrolled in an introductory mathematics course, Pearson is able to make the following relational (correlational, not predictive) statements about the efficacy of MyLab Math:

- Mastering more MyLab Math learning objectives is associated with higher course grades and a higher likelihood of passing the course.
  - Each additional learning objective mastered was associated with a 19% increase in a student's odds of passing the course.
- Making more attempts in MyLab Math quizzes and tests was associated with a higher likelihood of passing the course and receiving higher course grades.
  - Each additional quiz attempt was associated with an increase of 3% in a student's odds of passing the course.
- Earning higher average quiz and test scores in MyLab Math was associated with a higher likelihood of passing the course and receiving higher course grades.
  - Each standard deviation increase in a student's average quiz score was associated with an increase of 88% in that student's odds of passing the course.
  - A one standard deviation increase in a student's test scores was associated with that student's increased odds of passing the course by a factor of 36.
- Making more attempts on MyLab Math QuizMe and receiving higher QuizMe scores were related to lower course grades.
- Receiving higher QuizMe scores was related to a lower likelihood of passing the course.
  - A one standard deviation increase in QuizMe scores was associated with a decrease of 69% in students' odds of passing the course.

It should be noted that these statements reflect a relationship between MyLab Math and performance above and beyond students' prior achievement. Therefore, it is not simply the case that high-achieving students tend to perform well on multiple aspects of the course. The relationships expressed above were calculated across all students in the sample and capture the contribution of MyLab Math to course performance once prior achievement has already been accounted for.

Limitations and generalizability	*Results are correlational and not causal:* SRI attempted to control for any bias that could be introduced by students' background characteristics and prior skill level by including measures of student background characteristics and incoming skill level. Despite these controls, these measures likely do not capture all the possible confounding factors that might influence product use and course outcomes, such as student motivation, family support, and prior learning experiences with technology. We are, therefore, not able to rule out the influence of all the confounding factors on students' achievement in the course. *The generalizability of the study:* The study made use of data at only one institution. Replication of findings at other institutions would be needed to be able to generalize the findings. *The implementation of QuizMe:* As MyLab Math for Developmental Math is designed to be flexible, information about how QuizMe was implemented by teachers is required to determine how use of, and performance on, QuizMe resulted in lower course grades and a lower probability of students passing the course. For example, instructors can choose the number of questions on QuizMe for each chapter. If instructors only required students to answer one or two questions per chapter, it is possible that students could score highly on QuizMe without having mastered all of the objectives required to pass the course. Unfortunately, implementation information was not available for this study.
Future research	Future research could examine students' learning experiences in MyLab Math, as well as whether MyLab Math plays a role in helping students progress at a higher rate through the course, to the next course and to credit-bearing courses. We could also explore whether these findings can be replicated at other schools so we can understand more about what works, when, where, how, for whom and why. Future research could make use of more rigorous research designs. For example, an experimental or quasi-experimental research design could assess whether use of MyLab Math leads to higher exam scores — that is, whether the relationships we observed were causal in nature.

Read about this research in more detail in our Technical Report

Study 2

Study citation	A study on the White House Project Initiative for MyMathLab[3] — Pearson — March 2018
Research study contributors	Faculty at participating institutions
Research questions	1. What is the relationship between the following factors from MyLab Math and students' probability of passing the course? a. Students' usage behaviors with MyLab Math, specifically 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 MyLab Math objectives mastered 2. Is the relationship between factors from MyLab Math and students' probability of passing the course similar across the three types of assignments — homework, tests, and quizzes? 3. Is the relationship between factors from MyLab Math and students' probability of passing the course similar across groups of students — students enrolled prior to the Fall of 2015 and students who were newly enrolled in the Fall of 2015?
Related intended outcomes categories	Timeliness and completion Level of competence and standard of achievement Specifically: Learners complete the course at first attempt Learners achieve a pass overall *These outcomes are the common outcomes across the five institutions that allowed for the aggregation of student data for analysis.*
Study design	Relational (correlational, not predictive) Pearson researchers completed this study in 2016, in collaboration with faculty at five higher education institutions (three community colleges, one technical college and one state university) in the US where MyLab Math was used in the Fall 2015 Developmental Math course. Each college used different course texts with MyLab Math. These included: — *Introductory & Intermediate Algebra*, 5th edition, Margaret L. Lial — *Algebra: A Modular Approach*, Custom Edition — *LEAP Log Workbook*, Pearson Education, Inc. — *Algebra Foundations*, 1st edition, Elayn Martin-Gay — *Prealgebra & Introductory Algebra*, 4th edition, Elayn Martin-Gay — *Intermediate Algebra*, 12th edition, Marvin L. Bittinger — *Geometry,* Student Edition 2011, Prentice Hall
Metrics studied	— Homework assignments — Course grades — Passing the course

[3] When this study was carried out, MyLab Math was known as MyMathLab. In our discussion of this study, we refer to the product as MyLab Math for consistency.

Description of sample	The study sample were students enrolled in the Fall 2015 semester in developmental math courses at the five participating institutions. Only students who agreed to participate and for whom data was available were included in the analytic sample for the study. The majority of students in the study sample were female. Students from underrepresented minority groups (which in this sample included all students of non-White backgrounds) also made up a majority. Just under half of the students in the sample were enrolled at their institution prior to Fall 2015, and a similar proportion were registered as newly enrolled full-time students in Fall 2015. A relatively small percentage of them majored in a STEM (science, technology, engineering and mathematics) field.
Sample size	— 1,282 students were enrolled in the developmental math courses — 861 students consented to participate in the study Multiple procedures were used to collect the data used in the study, including the primary outcome of interest (whether students passed the course), the primary study variables (students' usage of and performance in the platform), and a range of factors known to have a potential influence on student achievement. These data collection procedures included: — *For the primary outcome of interest*: course grade data requested from the institution — *For the primary study variables*: MyLab Math platform data — *For prior achievement and other demographic factors*: student transcripts requested from the institution — *For implementation factors*: an instructor survey at the end of the semester and an interview with each course instructor Despite this robust data collection strategy, many students were missing one or more of these critical data sources and were excluded from the final analysis.
Analysis	Not all forms of problems available in MyLab Math were assigned in all courses, so in order to examine the relationship between components of MyLab Math and students' probability of passing the course, separate Hierarchical Generalized Linear Modeling (HGLM) analyses were conducted according to: — The type of assignment — homework, tests, or quizzes — in MyLab Math — The group of students — those who were newly enrolled in the Fall 2015 semester or those enrolling prior to Fall 2015 (and who may have already completed and failed a previous developmental math course) The analyses were also run using the entire sample of students (not disaggregated by year of enrollment). We adjust for available student background characteristics that might have an unintended impact on the findings of our research. Potential confounding factors we adjusted for in this analysis were: — Students' enrollment year status (full vs. part-time) — Years of enrollment in the institution — Major — Race — Gender — The instructional format used in the developmental course (blended vs. emporium) — School characteristics, such as whether it is in an urban setting

Results

Making more homework attempts on MyLab Math homework assignments was associated with a higher probability of passing the course. That is, students who returned to work on homework problems until they got them right tended to pass the course at higher rates. Differences in the probabilities of passing the course were found for students newly enrolled in Fall 2015 and students that had enrolled prior to Fall 2015.

For example, for students newly enrolled in Fall 2015, an increase of 18 additional homework attempts made over the course of the semester using MyLab Math was associated with an increase in probability of passing the course from 9.8% to 53%[4]. However, for students enrolled prior to Fall 2015, the same increase in number of homework attempts using MyLab Math was associated with a more modest increase in probability of passing the course, from 72% to 87%.

The differences in baseline probabilities between these two groups may be attributed to the fact that 69% of the students who were enrolled at the institutions prior to Fall 2015 had already taken part of the developmental math course sequence or a college-level math course at the institution. So in Fall 2015 they began with a greater foundation in math than newly enrolled students and had less room for improvement.

Obtaining higher grades in MyLab Math homework, quiz, or test assignments is associated with a higher probability of passing the course. This finding is not surprising as most assignment grades accounted for a portion of the final course grade.

The mastery of unique objectives assessed in MyLab Math homework and quizzes matters for students newly enrolled in Fall 2015 but not for students enrolled prior to Fall 2015. Mastering an objective might not matter for students who had prior college experience or who completed previous developmental math courses where they had already mastered some of the objectives.

Specifically, for newly enrolled students with average homework usage, mastering more unique objectives was related to an increased probability of passing the course from 9.8% to 24%. There is no corresponding increase in probability of passing the course for a typical student enrolled prior to Fall 2015. These possibilities suggest there may be room for more investigation.

While the number of attempts made on MyLab Math homework assignments were related to all students' probability of passing the course, time spent on the homework assignments was negatively related to the probability of passing the course (that is, students who spent more time on homework assignments had a lower probability of passing the course).

This could be because students who are struggling to master topics may take longer on homework assignments than those who are more able. We were also not able to differentiate between the times when students were actively engaged when logged in to MyLab Math, and the times when students were logged in but not engaged. This negative association was true for time spent on homework assignments. On the other hand, for quizzes and tests, time spent on the assignment was generally unrelated to the probability of passing the course.

See Figure 1 for visual representation of findings

[4] This increase was based on the student group who were male, from underrepresented minority groups, part-time, non-STEM majors, with data available for average time spent, attempts, scores on homework and average objective mastery, in non-urban locales using the emporium model.

Figure 1: Overview of findings from Study 2

		Types of assignments		
MyLab Math factor	**Student group**	**Homework**	**Test**	**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	↑	⊘	⊘
Grades	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 the course)

Efficacy statements

In the context of this study, conducted at five higher education institutions in the US where MyLab Math was used in the Fall 2015 Developmental Math course, Pearson is able to make the following relational (correlational, not predictive) statements about the efficacy of MyLab Math:

— On average, for students who were newly enrolled in fall 2015, an increase of 18 attempts on MyLab Math homework was associated with a fivefold increase in the probability of passing a developmental math course.

— Evidence showed that higher homework, quiz, and test scores in MyLab Math were related to a higher probability of passing the course (for example, getting at least a C letter grade).

It should be noted that these statements reflect a relationship between MyLab Math and performance above and beyond students' prior achievement. Therefore, it is not simply the case that high-achieving students tend to perform well on multiple aspects of the course. The relationships expressed above were calculated across all students in the sample and capture the contribution of MyLab Math to course performance once prior achievement has already been accounted for.

Limitations and generalizability

Results are correlational and not causal:
The research design does not allow us to determine whether using MyLab Math contributes to students' successful completion of a developmental math course. The number of meaningful student and institutional variables we were able to control for was limited, and not all instructors participated in the instructor survey, so we are not able to rule out all confounding factors that might influence students' achievement in the course.

No comparison group:
All the students in this study were MyLab Math users, and there was no comparison group of non-users. This limits the study to correlational findings.

Relationships between variables:
Some of the metrics studied — homework assignments and passing the course — were related, because grades from MyLab Math homework would contribute to passing the course. Ideally in a study, variables used to measure the product should not be related to variables used to measure the outcome in this way. In the case of this study it was impossible to avoid, because some participating institutions do not give final exams in the Developmental Math course, only a pass or fail grade indicating whether students met the minimum proficiency.

Separate analyses for different assignments:
Because different instructors used the different assignment types (i.e., homework, tests, and quizzes) in different ways, we could not combine all the assignment types into a single regression model. The correlations found for each assignment type should not be misinterpreted as independent or in any way additive.

The generalizability of the study:
Because not all types of data were available for all students, the results discussed may not fully generalize, or apply, to the 1,282 students who were the original focus of the study.

Future research

Future research could examine specific aspects of MyLab Math usage in more detail.

For example, we found that the number of attempts made and unique objectives mastered in both homework and quizzes were related to passing the course. However, in the context of tests, neither attempts made nor objectives mastered were related to passing the course. This result suggests that homework and quizzes may play a different role than tests in helping students master the material. Future studies may want to focus on the contribution of learner support tools available within homework and quizzes that are generally not available in tests.

As another example, we found that the number of unique objectives mastered mattered only in the sample of newly enrolled students, for whom we were not able to control for prior achievement. To improve our understanding of how mastery of objectives relates to students' prior learning, future studies might want to investigate how students with different levels of prior achievement use Study Plan to master objectives.

Finally, if we were to replicate the study at more institutions, involving more students over more semesters, this would allow the findings to be generalized further.

Future research could also make use of more rigorous research designs. For example, an experimental or quasi-experimental research design could assess whether use of MyLab Math leads to higher exam scores — that is, whether the relationship we observed is causal in nature.

Read about this research in more detail in our Technical Report

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Appendix 1: full list of intended outcomes

Outcomes related to learner access and experience

Intended outcome 1

Learners can successfully register and use MyLab Math with little technical support.

MyLab Math is designed to be accessible at any time via phones and tablets, as a means of increasing engagement in the classroom and beyond.

Intended outcome 2

Learners respond to built-in feedback.

MyLab Math is designed to provide students with immediate feedback on answering a question. This built-in feedback highlights the areas that need extra attention, encouraging students to focus on these topics.

Intended outcome 3

Learners can access digital learning materials from personal computer, tablet or smartphone anytime.

MyLab Math is designed to be accessed remotely and on any device, allowing students to access learning materials from anywhere, at any time.

Intended outcome 4

Learners have a positive learning experience and are motivated to learn.

MyLab Math is designed to provide students with a positive learning experience. A variety of multimedia resources are available as assignment learning aids. Students can link to the ebook, video clips, and animations to improve their understanding of key concepts. All content in MyLab Math is derived from, or correlated to, an author's textbook, thereby building towards a seamless experience in class, in the book, and in MyLab Math.

Intended outcome 5

Learners have a positive mindset to math leading to success.

There are a variety of motivations, beliefs, and attitudes that may prevent students from achieving their potential. Specifically, three areas of importance are: dealing with anxiety, personal relevance, and mindset. These are areas where MyLab Math used in developmental math courses is aiming to help students, and mindset is a key outcome validated by instructors as being of importance to them and their students.

Outcomes related to timeliness and completion

Intended outcome 6

Learners complete the required activities related to their level of understanding and make good progress.

MyLab Math offers a number of options that adjust based on the learner, including the Companion Study Plan, Personalized Homework, and Skillbuilder. These features present students with content they have yet to master fully, offer homework and practice opportunities on those skills, and can provide rich scaffolding and feedback. These support features make it more likely that students complete the activities most relevant for them and ultimately improve their level of understanding.

Intended outcome 7

Learners complete assignments on time.

MyLab Math offers the opportunity to set prerequisites so that required parts of the course must be completed and passed before a student can go onto the next stage in his or her learning. MyLab Math exercises include learning aids, such as guided solutions, sample problems, and extra help at point-of-use, and also offer helpful feedback when students enter incorrect answers. All this is designed to help students complete their assigned work. These learning aids can be activated or deactivated at the instructor's discretion.

Intended outcome 8

Learners complete the course at first attempt.

MyLab Math is designed to guide students towards passing their course, first time. The Companion Study Plan, Personalized Homework, and Skillbuilder features present students with content they have yet to master fully, offer homework and practice opportunities on those skills, and can provide rich scaffolding and feedback. These features help to create an individual learning experience that helps students navigate their course material and make the grade.

— We have evidence about how MyLab Math relates to this intended outcome. Find it under **Product research**.

Intended outcome 9

Learners progress at a higher rate through the course when using MyLab Math.

MyLab Math is designed to build on students' existing experience to identify their strengths and weaknesses and provide an individualized learning path to accelerate their learning.

Intended outcome 10

Learners participate in the lab.

MyLab Math is designed to identify each student's strengths and weaknesses and create an individual learning path for each student. This means students can receive support at their own level of learning, encouraging them to use MyLab Math to supplement their learning.

Outcomes related to standard of achievement or level of competence

Intended outcome 11

Learners achieve a pass overall.

The most obvious intended outcome for MyLab Math is to help learners improve in their math skills. MyLab Math has features such as Skillbuilder, which personalize learning based on student performance, providing recommendations on what skills students need to master to complete their assignments and improve skills specific to their needs and pass overall. The Companion Study Plan aims to support improved performance on tests by serving as a prerequisite check of all skills needed to do well on that test.

— We have evidence about how MyLab Math relates to this intended outcome. Find it under **Product research**.

Outcomes related to learner progress

Intended outcome 12

Learners achieve college readiness more quickly having used MyLab Math.

In addition to gaining the skills required to go on to complete the Maths course, MyLab Math aims to help students prepare for the next level of their education.

Intended outcome 13

Learners' achievement in assignments.

The instructional content, practice materials, and assessments in MyLab Math cover all of the objectives for students to pass assignments.

Intended outcome 14

Learners achieve course credit.

Students will gain not only an understanding of key math concepts, but an understanding of the skills required to achieve course credit.

Outcomes related to learner progression

Intended outcome 15

Learners progress to the next module.

Students are taught skills in the context of mathematical principles that relate to more advanced concepts. Knowledge gained from MyLab Math should encourage students to progress to the next module.

Intended outcome 16

Learners progress to the next course.

The majority of MyLab Math implementations are in developmental courses, offered at two-year colleges in North America as a course or series of courses starting at basic arithmetic and then progressing through pre-algebra, elementary algebra, and finally intermediate algebra. Students must demonstrate a readiness with these topics before enrolling in a credit-bearing college mathematics course.

Intended outcome 17

Learners progress to credit-bearing courses.

MyLab Math offers comprehensive content that prepares students to achieve higher levels of attainment and ultimately qualify for credit-bearing courses.

Intended outcome 18

Learners gain certification.

The library of multimedia lessons and assessments in MyLab Math cover all of the objectives to assist students to go on to achieve a certification.

Intended outcome 19

Learners accelerate to the next course.

In addition to completing the Developmental Math course, MyLab Math aims to help learners succeed in subsequent collegiate level courses with offerings from College Algebra to Differential Equations.

Independent limited assurance report to the directors of Pearson plc

The directors of Pearson plc ("Pearson") engaged us to provide limited assurance over the efficacy statements clearly identified by the box titled 'Efficacy statements', including reference to the study design type, in the Pearson MyLab Math for Developmental Math Efficacy Research Report dated April 3 2018 ("Research Report").

Our conclusion

Based on the procedures we have performed and the evidence we have obtained, nothing has come to our attention that causes us to believe that the efficacy statements set out in the Pearson MyLab Math for Developmental Math Research Report have not been prepared and reported, in all material respects, in accordance with the Pearson Efficacy Reporting Framework dated April 3 2018.

This conclusion is to be read in the context of what we say in the remainder of our report.

Efficacy statements

The scope of our work was limited to assurance over the efficacy statements clearly identified by the box titled 'Efficacy statements', including reference to the study design type, in the MyLab Math for Developmental Math Research Report. Our assurance does not extend to other information presented in the Research Report.

Professional standards applied and level of assurance

We performed a limited assurance engagement in accordance with International Standard on Assurance Engagements 3000 (Revised) *Assurance Engagements other than Audits and Reviews of Historical Financial Information*, issued by the International Auditing and Assurance Standards board. A limited assurance engagement is substantially less in scope than a reasonable assurance engagement in relation to both the risk assessment procedures, including an understanding of internal controls, and the procedures performed in response to the assessed risks.

Our independence and quality control

We applied the Institute of Chartered Accountants in England and Wales (ICAEW) Code of Ethics, which includes independence and other requirements founded on fundamental principles of integrity, objectivity, professional competence and due care, confidentiality and professional behaviour.

We apply International Standard on Quality Control (UK) 1 and accordingly maintain a comprehensive system of quality control including documented policies and procedures regarding compliance with ethical requirements, professional standards and applicable legal and regulatory requirements.

Our work was carried out by an independent and multi-disciplinary team including educators, statisticians, and experts in reporting and assurance.

Reporting and measurement methodologies

The efficacy statements need to be read and understood together with the Pearson Efficacy Reporting Framework dated April 3 2018 (the "Framework"), available on Pearson's website[i] at https://www.pearson.com/efficacy-reporting-framework. The absence of a fully comprehensive set of generally accepted rules for identifying learner outcomes and defining, assessing and reporting the efficacy of educational products allows for different, but acceptable, ways of measuring product efficacy and reporting findings as efficacy statements. This could affect comparability between Pearson's efficacy reporting and that of other organisations.

Work done

We are required to plan and perform our work in order to consider the risk of material misstatement of the efficacy statements. A material misstatement would be an efficacy statement that does not reflect the study design and quality of underlying research or the omission of key information from a relevant study.

In doing so, we:

- made enquiries of relevant Pearson management;
- evaluated the design of the Framework including key structures, systems, processes and controls for managing, generating and reporting the efficacy statements;
- tested all 19 controls across the 8 stages of the Framework;
- confirmed that all management reviews were performed by at least two members of Pearson's Efficacy & Research team;
- performed substantive testing on a sample basis of the data that underpins the research studies and the resulting efficacy statements, and the controls over the completeness and accuracy of that data (supported by Pearson Internal Audit in those instances where student data was subject to confidentiality restrictions);
- assessed the quality and conclusions of the underlying research studies;
- inspected the statistical analysis to assess whether the efficacy statements are valid, supportable and consistent with the underlying research studies;
- independently re-performed screening of relevant external public research studies and compared to that done by Pearson;
- assessed the efficacy statements and underlying Technical Report(s) for consistency with the Framework; and
- reviewed the product's efficacy web page, Research Report, and Technical Report(s) for alignment of research studies and efficacy statements.

Pearson responsibilities

The directors of Pearson are responsible for:

- designing, implementing and maintaining internal controls over information relevant to the preparation of efficacy statements that are free from material misstatement, whether due to fraud or error;
- establishing an objective framework for preparing and reporting efficacy statements;
- preparing and reporting efficacy statements in accordance with the Framework; and
- the overall content of the Framework and the Research Report.

Our responsibilities

We are responsible for:

- planning and performing the engagement to obtain limited assurance about whether the efficacy statements are free from material misstatement, whether due to fraud or error;
- forming an independent conclusion, based on the procedures we have performed and the evidence we have obtained; and
- reporting our conclusion to the directors of Pearson.

Inherent limitations

Efficacy research, and the resulting efficacy statements, reflect the implementation and use of a product in a particular context. It would not be appropriate to assume a product would always generate similar outcomes in other contexts and/or in the future.

Intended users and purpose

This report, including our conclusions, has been prepared solely for the board of directors of Pearson in accordance with the agreement between us, to assist the directors in reporting Pearson MyLab Math for Developmental Math efficacy statements, in accordance with the agreement between us dated 9 August 2017. We permit this report to be disclosed online[i] at https://www.pearson.com/corporate/efficacy-and-research/efficacy-reports in respect of the MyLab Math for Developmental Math Research Report to assist the directors in responding to their governance responsibilities by obtaining an independent assurance report in connection with the efficacy statements. To the fullest extent permitted by law, we do not accept or assume responsibility to anyone other than the board of directors and Pearson for our work or this report except where terms are expressly agreed between us in writing.

PricewaterhouseCoopers LLP

PricewaterhouseCoopers LLP
Chartered Accountants
London
3 April 2018

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i The maintenance and integrity of Pearson's website is the responsibility of the directors; the work carried out by us does not involve consideration of these matters and, accordingly, we accept no responsibility for any changes that may have occurred to the reported efficacy statements or the Framework when presented on Pearson's website.

Pearson