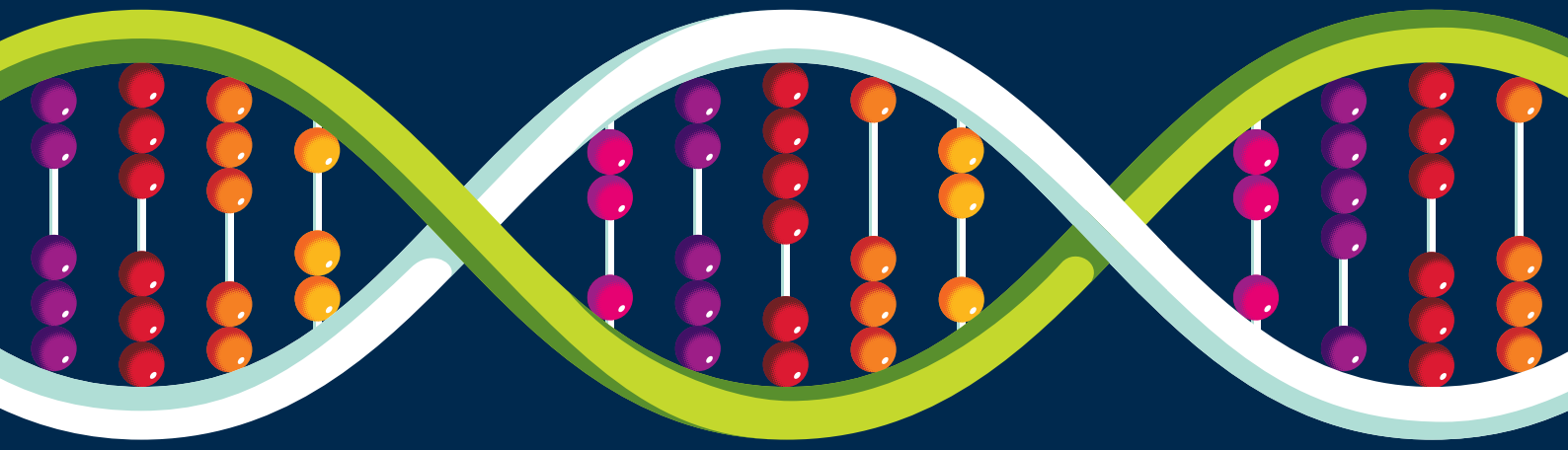
Pearson

Mastering Biology

Efficacy Research Report

April 13 2018



Contents

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 16 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.

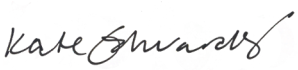
The journey ahead

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 Mastering Biology, an online tutorial system used in higher education general introductory courses, is related to students' exam results.

This Research Report presents findings from one research study: a correlational study we conducted at a North American state-related, land-grant, doctoral university, where students were using Mastering Biology in the Spring 2017 semester for a foundational biology course. Our aim in using a correlational study design was to seek out possible relationships between the use of Mastering Biology and exam results to identify areas of focus for potential future research using more rigorous causal study designs.

The findings appear alongside details of the research study, including a description of the sample studied, method 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 the North American university, Pearson found that:

— Averaging at least 90% or better on Mastering Biology homework assignments is associated with a 9% increase in exam scores.

The complete statements are set out in the box titled "Efficacy statements" on page 12. These statements have been subject to assurance by PwC, whose report can be found at the end of this Research Report.

Product design and development

Product overview

Mastering Biology is an online tutorial system designed to help students achieve mastery of biology concepts and develop critical reasoning and problem-solving skills. It is a further development of Cybertutor, an early tutorial system for biology instruction (Morote, Kokorowski, & Pritchard, 2002). Tutorials feature hints and targeted wrong-answer feedback that emulate a human tutor and help students with tough concepts in order to achieve proficiency quickly. Mastering Biology is designed to accompany a number of textbooks written in the biology discipline.

Mastering Biology is designed to enhance and improve the following outcomes:

— Student engagement and learning experiences
— Critical reasoning and problem solving skills that can be applied to everyday applications and later courses
— Student achievement e.g., in homework assignments and end of course examination results

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

Mastering Biology is an online tutorial system designed to support students as they learn biology concepts and skills. These kinds of systems serve a number of the same functions that human tutors perform, including presenting problems, providing guidance (e.g., hints), evaluating students' responses, providing detailed feedback, and choosing content appropriate for a student's current level of understanding. Research has demonstrated the efficacy of a number of tutorial systems, suggesting that well-designed systems can be as effective as human tutors (VanLehn, 2011).

The design of Mastering Biology incorporates numerous principles from learning science, with the goal of helping all students achieve mastery of core biology knowledge and skills. What follows is a summary of some specific learning science research that underpins the design of Mastering Biology.

Adaptivity

Adaptive learning tools are defined as "technology-based artifacts that interact with students and vary presentation based upon that interaction" (Murray & Perez, 2015). Research has identified two categories of adaptivity in learning technologies (Van Lehn, 2006). Mastering Biology uses elements of both kinds of adaptivity to deliver a personalized learning experience for each student.

One type relates to adaptive responses to student inputs, such as immediate feedback that is specific to the student's attempt. When students make an error on tutorial problems in Mastering Biology, they often receive immediate wrong-answer specific feedback to address that particular error (see **Feedback** below).

The other type of adaptivity relates to modifying a learning sequence based on the student's current proficiency. One way in which this can be done is by estimating mastery based on student performance, and ensuring that students receive enough practice to achieve fluency with the content. This "Knowledge Tracing" has been used to great effect in educational research (e.g., Corbett & Anderson, 1995).

Adaptive Follow-Up assignments offer Mastering Biology users additional graded practice in areas in which they are still struggling. These homework assignments are dynamically created by Mastering Biology, based on the student's performance on an assignment.

Dynamic Study Modules also give students further opportunities to practice topics they are struggling with. In the modules, students answer questions and indicate their level of confidence in their responses. By answering one question correctly and confidently, students can demonstrate mastery of topics they already understand, and where they are incorrect or uncertain, they receive extra practice and targeted narrative. This feature enables continuous assessment of performance and activity, then uses data and analytics to provide personalized content in real-time to reinforce concepts that target each student's particular strengths and weaknesses.

All the adaptive Mastering Biology features described above aim to enhance achievement.

Active, constructive, and interactive learning

Mastering Biology problems and associated features embody what are known as *active, constructive,* and *interactive* approaches to learning (Chi, 2009). Each of these approaches has been shown to be more effective for learning than passive approaches, in which students' sole activity is the intake of information (e.g., listening to a lecture).

Active learning is characterized by doing something during learning, and it ranges widely from taking notes during a lecture, to searching a textbook for information, or answering questions that test memory of facts.

Constructive learning refers to activities in which a student produces a novel idea or other output that goes beyond previously encountered information, for example, the solution to a new problem.

Interactive learning involves a back-and-forth interaction between the student and another individual, such as a human or digital tutor.

Research demonstrates that, on average, each of these approaches to learning is more effective than passive approaches, with efficacy increasing as learning activities progress from active to constructive to interactive forms (Chi, 2009).

Mastering Biology generally supports students to go beyond passive activities, with many problems supporting active, constructive and interactive learning.

Active, constructive, and interactive activities can be integrated into the classroom through use of Learning Catalytics. This classroom engagement tool uses the devices students already bring to class — smartphones, tablets, or laptops — to pose questions and engage them in a variety of tasks. Instructors receive real-time analytics that they can use to generate discussion to assess students' performance in real-time.

One way Mastering Biology encourages constructive learning is with simulations. Simulations require students to apply their learning by critically evaluating information, deciding on next steps to take, and solving novel problems. This feature aims to develop critical reasoning and problem solving skills.

Many Mastering Biology items are accompanied by optional hints that students can access for additional help. These hints are intended to help students successfully complete an item when they might not be able to otherwise. Declarative hints provide advice on how to approach the problem, guiding students to the final answer, and Socratic hints break a problem down into smaller sub-problems. This interactive feature aims to enhance achievement by helping students successfully complete items that they might struggle with otherwise.

The hints, feedback, Dynamic Study Modules, and Adaptive Follow-Up assignments all provide opportunities for a more interactive learning experience.

Testing effect

Being tested on information improves learning and memory more so than simply re-studying that same information. This *testing effect* is a well-established psychological phenomenon, having been demonstrated in a large number of laboratory and classroom settings (Roediger & Karpicke, 2006). Testing is believed to support learning by requiring retrieval of information from memory, thereby strengthening the ability to recall that information again later.

When using Mastering Physics, students engage in retrieval practice whenever they recall information in order to answer questions in homework, Adaptive Follow-Up assignments, or Dynamic Study Modules. Research suggests that retrieval practice contributes both to long-term retention and to learning in a way that can flexibly transfer to help solve new problems (Carpenter, 2012; Roediger & Butler, 2011).
It is worth noting that research on the testing effect has found that it is not only successful retrieval of correct information that helps learning. Even if a student does not get the problem correct on the first try, when a student is given feedback, testing is still found to be more beneficial than passive studying (Roediger & Butler, 2011). In addition, most courses using Mastering Biology allow students to make multiple attempts; there is a benefit for memory when successfully retrieving correct information on a re-attempt of a question, particularly if that retrieval is strenuous (Pyc & Rawon, 2009).

Scaffolding

Research has found that novices learn and process information in fundamentally different ways to those with more background knowledge (Chi, Feltovich, & Glaser, 1981). Specifically, novices lack a body of relevant knowledge and strategies to draw upon to help them solve new problems or learn new information. As such, it is critically important to provide novice learners with *scaffolds*, or supports, to help them achieve learning outcomes that might otherwise be out of reach.

Scaffolding can support learning by helping students structure complex tasks and by highlighting aspects of problems that require special attention (Reiser, 2004). And scaffolding in technology-enhanced learning environments has shown particular promise in supporting novice learning (Sharma & Hannafin, 2007).

Mastering Biology provides scaffolds alongside assessment items. In many items, struggling students can access optional hints, similar to what they might receive from an instructor. These hints are a form of scaffolding in which students are provided with support that allows them to achieve tasks that they might otherwise struggle with or fail to achieve. Mastering Biology hints do this by breaking down problems into smaller steps and by helping students recognize specific concepts or issues they must consider to solve the problem. This approach is aligned to research showing that studying step-by-step examples of expert problem-solving helps develop problem-solving skills (Atkinson, Derry, Renkl, & Wortham, 2000).

Feedback

Learning is enhanced when students are provided with regular feedback on their performance. Research on computer-based feedback systems have shown that feedback that explains or otherwise elaborates on the correctness of a response is more effective than feedback that only indicates whether the response was right or wrong (Van der Kleij, Feskens, & Eggen, 2015).

Research on feedback timing (i.e., immediate vs. delayed) has produced a wide range of results, but findings generally indicate that immediate feedback is appropriate when students are learning new, difficult tasks (Shute, 2008).

Mastering Biology provides students with immediate feedback on problems they attempt. Feedback always indicates whether the student's response was correct, and for many problems the feedback also explains why an answer is correct (in the event of a correct response) or addresses a specific mistake or misunderstanding (in the event of an incorrect response).

History and reach of Mastering Biology

The Mastering product line, of which Mastering Biology is a part, launched more than 15 years ago. In that time the various products under the Mastering umbrella have been used by more than 20 million students.

First launched in 2008, Mastering Biology has been used in general introductory courses for majors and non-majors, and it has grown to support courses in human biology, genetics, cell and molecular biology, and ecology.

Mastering Biology is currently used by 570,000 students per year at the higher education level. The platform is used in United States, Canada, Australia, Netherlands, UK, South Africa and New Zealand, and serves students from a broad range of backgrounds.

Intended product implementation

Scaffolding

We aim to keep Mastering Biology 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.

Customers have told us that they have seen a greater impact when Mastering Biology is:

— Required
— Assigned for at least 10% credit
— Assigned with due dates to help keep students on schedule
— Used as a formative assessment tool to prepare students for summative assessments (this includes fading away supports such as learning aids over time so that students are better prepared for assessments that don't use them)

Mastering Biology provides a range of tools and content that can be used to gauge students' understanding of the material in pre- and post-class activities. In addition, Mastering Biology provides tools and activities for in-class work.

Product research

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

Specifically, the activities in Mastering Biology and the testing effects those activities support, combined with the benefits of scaffolding and elaborated feedback, should enhance student learning. As a result, we should observe that students' usage of and performance in Mastering Biology 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 rigorous 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 Mastering Biology on learner outcomes. Our criteria for the review and inclusion of existing published research on our products was 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 Mastering Biology 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 111 studies. After an initial review, we found that two contained information relevant to Mastering Biology. 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 Mastering Biology but did not meet our criteria to be included here, see the Pearson Efficacy Reporting Framework dated April 3 2018.

Research studies

There is one new study, conducted by Pearson, that forms the basis of the Efficacy Report for Mastering Biology. The research questions and findings for the study are set out in detail below, including the efficacy statement generated by this study.

Study 1

Study citation	A study of Mastering Biology use in a foundational biology course (March 2018) — Pearson Global Product Organization Efficacy and Research — Impact Evaluation
Research study contributors	Christine Leow and Kenneth Lee (in collaboration with the instructor at the institution who provided the study data)
Research questions	1. What are the student factors (e.g., prior achievement, full-time status, STEM major, test anxiety and confidence in course, parent education, Mastering Biology usage patterns) that are related to student achievement? 2. To what extent are Mastering Biology usage patterns throughout the course (e.g., time spent, use of hints, progress in homework assignments, etc.) related to student achievement? Is the relationship robust after controlling for student characteristics?

Related intended outcomes category	Standard of achievement or level of competence
Study design	Relational (correlational, not predictive) This study examined the association between the use of Mastering Biology with *Biological Science*, by Freeman et al. 2016 (6th edn., Pearson), and students' achievement on their course exams in a biology course taught by a single instructor focused on Mendelian and population genetics, evolution, and ecology. The instructor in this study used Mastering Biology for homework assignments. We measured students' performance by their homework assignment scores, and their use of Mastering Biology by the number of hints used and the total time spent using the product.
Metrics studied	Achievement in course exams
Description of sample	This study was limited to participants at one school: a North American state-related, land-grant, doctoral university. The institution asked to remain anonymous in our efficacy reports. The study sample included students who were enrolled in the Spring 2017 semester in a foundational biology course. Only students who agreed to participate and for whom data were available were used in the study.
Sample size	The analytic sample included 106 students (class enrollment was approximately 230 but only about 150 students consented to be a part of the study)
Analysis	A set of ordinary least squares (OLS) regressions were conducted to assess the relationship between Mastering Biology use and performance, and student achievement (as measured by performance on course exams). In order to better assess the relationship between Mastering Biology and exam scores, and because students' homework scores showed restriction in range (i.e., all but one student earned average homework scores of 60% correct or higher), two different specifications of performance on Mastering Biology were used. The first model used a continuous specification of platform score, while the second model classified students into different categories based on their platform average scores to explore potential non-linear relations between Mastering Biology and achievement. Additionally, to account for student factors that can influence this relationship, student demographic information and psychosocial characteristics including prior achievement, parental level of education, full-time enrollment status, whether the student was a freshman, whether a student was a STEM major, and the student's level of comfort with technology, were included in the regression models.

Results

Averaging at least a 90% or better on Mastering Biology homework assignments was associated with a 9% increase in exam scores. This relationship was non-linear. That is, only averaging 90% or better on Mastering Biology homework assignments was associated with increased exam scores.

This non-linear relationship can perhaps be attributed to how the instructor implemented Mastering Biology in the course. Because the instructor afforded students multiple chances to reach the correct answer on homework assignments, and did not penalize students when they requested hints, the focus of the homework was practice, rather than performance. As such, although most students were ultimately able to attain relatively high homework scores, they may not have fully mastered the material. In other words, students who did not score at least a 90% on the homework assignments may not have achieved a level of mastery that would be beneficial to their performance on exams.

No significant relationships were found between total time spent using Mastering Biology and exam scores, or between the number of hints used and exam scores.

Efficacy statements

In the context of this study, conducted at a North American state-related, land-grant, doctoral university, for students enrolled in the foundational biology course, Pearson is able to make the following relational (correlational, not predictive) statement about the efficacy of Mastering Biology:

— Averaging at least 90% or better on Mastering Biology homework assignments was associated with a 9% increase in exam scores.

It should be noted that this statement reflects a relationship between Mastering Biology and performance above and beyond students' prior achievement. Therefore, it is not simply the case that high-achieving students tend to perform well on this aspect of the course. The relationship expressed above was calculated across all students in the sample and captures the contribution of Mastering Biology to course performance once prior achievement has already been accounted for.

Limitations and generalizability

Results are correlational and not causal:
Our study design does not allow us to determine whether higher achievement in Mastering Biology homework assignments would actually lead students to improve their achievement in their course exams or whether another factor is at play. 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 school. Replication of findings at other schools would be needed to be able to generalize about the findings.

Future research

Future research could 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 studies could also investigate student engagement and learning experience within Mastering Biology, and whether use of Mastering Biology leads to better critical reasoning and problem solving, as well as higher performance on course exams.

Such studies would need to make use of more rigorous research designs. For example, an experimental or quasi-experimental research design could assess whether use of Mastering Biology leads to higher course performance — 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 use Mastering Biology without or with little technical support.

Mastering Biology is designed to be easy for students to use, from course registration to working on and submitting assignments.

Intended outcome 2

Learners can access the learning content/subject matter.

Mastering Biology functions with standard operating systems and hardware so that students are able to access it from their home or lab computer or mobile device.

Intended outcome 3

Learners are engaged and have a positive learning experience and see the value of Mastering Biology activities.

Mastering Biology has a range of tools and content designed to fully engage students, from interactive pre-lecture videos and activities that provide an introduction to key topics, to challenging summative items that help students master concepts and skills and apply their knowledge to new situations. An additional key feature is a classroom engagement tool, *Learning Catalytics*, which augments lectures by providing guiding questions for in-class discussion that encourage student participation and foster a positive learning experience.

Intended outcome 4

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

Mastering Biology is designed to be accessed on any device, anywhere and at any time.

Outcomes related to timeliness and completion

Intended outcome 5

Learners complete assignments.

Mastering Biology supports students with a range of activity types, immediate feedback, and a menu of hints. These support features make it more likely that students will stay engaged and complete assignments.

Intended outcome 6

Learners attend class.

Mastering Biology students benefit from self-paced tutorials featuring specific, wrong-answer feedback and hints that emulate a human tutor with the aim of making students more likely to complete assignments on time.

Intended outcome 7

Learners complete the course.

All of the resources in Mastering Biology are intended to support students to persist to completion of individual assignments and of the course as a whole.

Intended outcome 8

Learners complete the course the first time.

Mastering Biology is designed to provide guidance and support that helps students master content and gain the skills necessary to pass the course first time.

Outcomes related to standard of achievement or level of competence

We have evidence related to this category of intended outcomes for Mastering Biology.
Find it under "Product Research".

Intended outcome 9

Learners pass the course.

Mastering Biology is designed to help students improve their knowledge of biology. Relevant, thoughtful activities keep students engaged with the content, and immediate feedback and hints support students as they learn. Adaptive Follow Up assignments provide additional practice, personalized for the specific concepts and skills a given student struggles with.

Intended outcome 10

Learners pass assignments grade.

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

Intended outcome 11

Learners gain critical and scientific reasoning skills that can be applied to everyday situations and later courses.

Mastering Biology is intended to instill in students an understanding of core scientific principles. Many activities focus on the process of science, asking students to evaluate hypotheses, analyze data and experiment results, and predict how outcomes would change if certain parameters were adjusted.

Outcomes related to learner progress

Intended outcome 12

Majors: Learners progress/choose next level bio courses.

Students are taught skills in the context of scientific principles that relate to more advanced courses. Knowledge gained while studying with Mastering Biology should encourage students to progress to the next course in the biology major.

Intended outcome 13

Learners demonstrate increased performance in courses after general bio.

For students studying biology, but not as a major, in addition to completing the general biology course, Mastering Biology aims to help students show success in subsequent courses.

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 Mastering Biology Efficacy Research Report dated April 13 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 Mastering Biology 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 Mastering Biology 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 Mastering Biology efficacy statements, in accordance with the agreement between us dated 9 August 2017. We permit this report to be disclosed on-line[i] at https://www.pearson.com/corporate/efficacy-and-research/efficacy-reports in respect of the Mastering Biology 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
13 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