MyLab / Mastering
Science and Engineering
Data-supported evidence of Mastering’s positive impact on teaching and learning
2013
What Instructors Are Saying

Student Success Rates

“In both courses the drop/fail/withdraw rate decreased significantly and the total number of students earning As and Bs increased.”

—Bruce Fisher, Roane State Community College (p. 10)

“The results show a six to eight percentage point increase in exam grades as I added required MasteringBiology assignments, increased the grade weight applied to MasteringBiology, and included the program’s study-area content on my exams.”

—Sandra Connelly, Rochester Institute of Technology (p. 14)

“Because students are utilizing these resources to gain a deeper understanding of the course content, they are doing better in the course and on the ACS exams, which will help set them up for success as they continue on their educational path.”

—Steven Socol, McHenry County College (p. 30)

Assessment and Diagnostics

“I used to have a preconceived notion of what students find difficult and what I should focus on in class. I’m learning now that the concepts that one group finds difficult are not the same semester to semester, or class to class. MasteringBiology has helped me see that, and I know I am a more efficient teacher as a result.”

—Andrea Aspbury, Texas State University (p. 20)

“I felt that the students who were using the homework to learn and reinforce the concepts were doing better in the course, but having this confirmed through the data is very beneficial.”

—Malia Rose, Ventura College (p. 38)

“Assigning tutorial problems weekly is a positive incentive to students, and instant access to students’ progress is a good way for me to identify less-motivated students.”

—Catherine Dobson, University of Hull (p. 50)

“Assigning tutorial problems weekly is a positive incentive to students, and instant access to students’ progress is a good way for me to identify less-motivated students.”

—Catherine Dobson, University of Hull (p. 50)

“Because students get tutored while doing MasteringChemistry homework, they come to class better prepared and ask much better questions.”

—David V. Dearden, Brigham Young University (p. 36)

Mastering Resources and Tutorials

“MasteringBiology’s online assignments offer students the flexibility to learn in their own space, at their own pace, and in a visual or 3D way that isn’t possible from traditional textbooks.”

—Louise Beard, University of Essex (p. 22)

“Our analysis showed that students overwhelmingly spend more time on for-credit work than on not-for-credit work—and that those students who spend more time on MasteringPhysics homework perform better in the course.”

—Eric Murray and Martin Jarrio, Georgia Institute of Technology (p. 68)

“Assigning tutorial problems weekly is a positive incentive to students, and instant access to students’ progress is a good way for me to identify less-motivated students.”

—Catherine Dobson, University of Hull (p. 50)

“Assigning tutorial problems weekly is a positive incentive to students, and instant access to students’ progress is a good way for me to identify less-motivated students.”

—Catherine Dobson, University of Hull (p. 50)

Student Engagement

“Since implementing the pre- and postlecture MasteringA&P assignments, students are coming to class more prepared and are more engaged in learning.”

—Abigail Goosie, Walters State Community College (p. 6)

“After adopting MasteringGeography, I saw both student interest and retention improve, along with course grades.”

—Christopher Sutton, Western Illinois University (p. 54)

Increased Active Learning

“My students appreciate that I tailor the class sessions to meet their needs. I appreciate having more time for active learning exercises.”

—Eileen Gregory, Rollins College (p. 18)
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• Newly added or updated data

ES Abstracts from experimental studies on Mastering’s effectiveness. Studies were conducted independently or in partnership with Pearson and have been published in peer-reviewed journals and/or presented at educational conferences. Extensive data mining and statistical analysis was used to derive conclusions.
Solutions-based List of Case Studies

Although each institution, course, and classroom is unique, instructors in higher education today face a series of common teaching and learning challenges. To enable quick and easy identification of Mastering case studies that address your challenges, we've categorized them below by common goal.

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Pearson Standards for Efficacy Research

What Pearson Means by efficacy and effectiveness

• Efficacy describes whether a product or intervention has a positive effect on learning, such as reducing wrong answers, increasing retention rates, or raising final exam scores.

• Effectiveness measures the size of the educational improvement from a product or educational intervention.

Why Pearson Is Interested in Efficacy Studies

To deliver the best educational experience for students, we need to understand how Pearson’s content is performing and verify learning gains associated with the use of our products. Toward that goal, we actively seek out educators who wish to explore educational research questions and investigate the efficacy of MyLab / Mastering products.

Pearson’s Efficacy Research Team

Our research team includes Ph.D.-level statisticians who provide practical advice about tracking and analyzing student data when redesigning a course to incorporate technology. Our research team also includes experts in psychometrics, educational statistics, and journal publications. These individuals support instructors who want to run an efficacy study, provide our editorial staff with detailed reports on the quality of our online content, and advise our software engineers of new methodologies for collecting and processing student learning data within MyLab / Mastering products.

How Pearson and Instructors Work Together

Every research project is unique. The process takes time—generally a semester or longer. Instructors interested in conducting a study should expect an interactive and rewarding partnership.

How Pearson Can Help Instructors Get Started

Pearson can provide templates, guidelines, checklists, and samples on course redesign, efficacy studies, data collection, and more. In order to maintain objectivity, Pearson does not offer compensation for data or participation in efficacy studies.

Research Standards

Pearson adheres to the Software & Information Industry Association (SIIA) guidelines for evaluating educational technology products. The key guidelines are:

• Ask the Right Question
• Support the Implementation of the Product or Service
• Plan a Study of Sufficient Size and Duration to Demonstrate an Effect
• Plan for Plausible Causal Claims
• Avoid (the Appearance of) Conflicts of Interest
• Provide a Comprehensive and Detailed Research Report
• Make the Research Findings Widely Available
• Accurately Translate Research for Customers

Contact your Pearson representative for more information.
Welcome to the most comprehensive compendium of data-supported Mastering case studies to date. This year’s report presents firsthand background, data, and results from some of the most successful Mastering implementations at institutions throughout the United States, Canada, England, and Australia.

It is with particular pride that we present this issue, because we recognize the increasing challenges faced by today’s higher education instructors, the rising financial stakes for institutions looking toward change, and the far-reaching implications of changing students’ lives through learning.

We’re delighted, but not surprised, by the report’s growth. Educational technology such as Mastering is no longer a tool only for technology early adopters. Its importance is supported by a growing body of research on the effectiveness of technology-enhanced learning.

A meta-analysis of this research by the U.S. Department of Education1 reports that students in courses with online components outperformed students in face-to-face courses by a statistically significant amount. The authors point out, however, that their findings “almost certainly do not represent a pure effect of technology.” They state what we, too, have repeatedly found and what is illustrated throughout this report: the strategic integration of technology and teaching and learning best practices consistently yields the best results.

Contributors to this report each implemented some of the following recognized best practices.

- **Track data over time.** Driven by budget constraints, state and federal mandates, and accreditation requirements, instructors are being called to quantify learning outcomes. Tracking student gains enables an institution to fulfill those requirements and make informed decisions regarding accreditation, funding, and merit raises. In the classroom, measurable data enable instructors to accurately assess the efficacy of programmatic shifts and the impact made by even the tiniest curricular tweak.

- **Require homework for at least 10 percent of the course grade.** Study after study confirms the significant increase in homework completion rates and student understanding when online homework is required and contributes to at least 10 percent of the final course grade. Instructors at Georgia Institute of Technology report that students overwhelmingly spend more time on for-credit work than on not-for-credit work (p. 68). By increasing the value of required homework from 5 percent to 15 percent, an instructor at Rochester Institute of Technology saw a seven-percentage-point increase in average exam grades (p. 14).

- **Increase student time on task.** One of Chickering and Gamson’s renowned seven principles for good practice in undergraduate education,2 it bears repeating for its significantly positive correlation with achievement: “Time plus energy equals learning.” A Georgia Institute of Technology study confirms that students who spend more time and effort on homework perform better on quizzes and the final exam, and they earn higher course grades (p. 68).

- **Deliver content outside the classroom.** Sometimes referred to as “flipping the classroom,” engaging students in prelecture learning and formative assessment activities results in students who are more prepared for class and promotes more active learning during class time. At Texas A&M, the inclusion of self-guided, interactive learning before lecture contributed to increased student engagement and the ability to decrease lecture and increase active learning such as via small-group projects and discussions. The model bore fruit: more than 99 percent of students who completed the prelecture assignments with averages of 80 percent or higher completed the course with final course grades of A, B, or C (p. 52). Similarly, after shifting to a prelecture homework format, students at Rollins College earned significantly higher exam scores than when homework was assigned to be done after the lecture (p. 18).

By publishing these experiences, Pearson aims to inspire innovation and cultivate a culture of sharing within the higher education community. We deeply appreciate such collaboration with contributors and offer our support to quantify your efforts. Submit your Mastering experience for publication in our next report by sending your measurable results to Mastering Efficacy Manager Betsy Nixon at betsy.nixon@pearson.com.

Key Results

Use of MasteringA&P’s interactive features enhanced student enjoyment in the course and increased student understanding of course concepts. In addition, there was significant correlation between performance with the program and final course grades.

Text

*Fundamentals of Anatomy and Physiology, 8e, Frederic H. Martini and Judi L. Nath*

Implementation

Anatomy and Physiology is a traditional face-to-face course for first-year Sport and Exercise Science students. It comprises 36 hours of contact time over a 10-week period.

I introduced MasteringA&P in spring 2011 to encourage interactive online learning. I used the program as a visual, active-learning resource to complement the lectures. Students were encouraged to access the online tutorials, eBook, interactive activities, podcasts, animations, and self-study resources.

I also created three short, online assignments using multiple-choice questions from the MasteringA&P database. Assignments were required and contributed towards their cumulative grade. Students were informed of the dates to complete the online assessments and there was no time limit for completion. The assignments were automatically graded, and scores, completion time, and question difficulty were exported into an Excel document. The individual assignments took an hour on average to complete, although time spent online ranged from three minutes to more than three hours.

From January to June 2011, students had online access to all MasteringA&P resources, and assignments could be repeated for practice, but not regraded.

Results and Data

- Aggregate scores of the three MasteringA&P assignments ranged from 23.3 to 91.1 percent.
- More than 80 percent of students completed the three MasteringA&P assignments with an average aggregate score of 65.1% ± 14.2.
- There was a significant relationship between performance in the MasteringA&P multiple-choice questions and overall module grades achieved.

From the student perspective:

- 95.2 percent enjoyed completing the online assignments and found them “interesting and helpful.”
- 92.1 percent said they would recommend MasteringA&P to a fellow student.
- 85.5 percent felt their understanding of the course material increased as a result of using MasteringA&P.
- 75 percent said they would prefer to learn this way in the future.
- 60.3 percent reported that they learned more through the online assignments than lectures alone.
- The most popular features were the Interactive Physiology option and postlecture quizzes.

Conclusion

Use of MasteringA&P enhanced students’ understanding of the topic and complemented my face-to-face lectures. Students consistently referred to the enjoyment they experienced from a more interactive, hands-on approach to learning.

From a facilitator’s point of view, MasteringA&P was user-friendly, easy to manage, and comprehensible. Having access to a sizeable bank of questions ensured I could tailor the assessments to reflect the lecture content. It also provided an accessible-on-demand study tool for students and an alternative teaching and learning method that effectively accommodated different student learning needs.

Submitted by Jo Barton
University of Essex
Implementation

This two-course sequence is a study of the structure and function of the human body. Traditional face-to-face and online sections are offered. The majority of students taking these courses are nursing or allied health majors, who are required to take both A&P I and II for completion of their program. A small percent of students will transfer to a four-year institution. The online students who used MasteringA&P during this study were part of the college’s online course program, versus an online degree program. There are lower enrollments in A&P II due to some students not passing A&P I, and others switching majors.

The department realized that many students were struggling in these courses, so we looked at the issues that were impacting student success—including poor time management, a lack of study skills, no course prerequisites, and an increase in nontraditional students who hadn’t been in a classroom in recent years. To address these needs, we redesigned the course with the goal of increasing students’ preparedness, exposure to and engagement with the course materials, and retention and student success.

My MasteringA&P assignments consist of prelecture homework of 15-25 questions for each chapter. I include activities and reading questions, but no testbank questions. These assignments are untimed, and students have two attempts to answer each question, but one attempt at the homework assignment overall. Assignments are designed to take approximately 30 minutes to complete. In addition, I assign a post-lecture, 10-question, 15-minute quiz for each chapter from a pool of testbank questions. Students have one attempt per quiz. Students may rework both homework assignments and quizzes for practice after their due dates.

Assessments

60 percent Lecture tests (five)
20 percent Comprehensive final
20 percent Mastering A&P quizzes and homework

Key Results

Adoption of MasteringA&P increased student engagement in course content outside of the lecture and the lab, students came to class better prepared, and they scored substantially higher on comprehensive final exams.
Results and Data
After my first semester using MasteringA&P in A&P I, I found that As, Bs, and Cs decreased, and Ds, Fs, and withdraws (D/F/W) increased. The results for A&P II showed the opposite—an increase in As, Bs, and Cs, and a decrease in the D/F/W rate (see figures 1 and 2).

I believe the results in A&P I are caused by multiple factors. Many of the students are freshmen and have poor time management and study skills. In addition, there are no prerequisites—many students may need to take (or may be taking) a developmental or remedial course in reading, math, and/or writing at the same time. With MasteringA&P, students need to fully understand the concepts—those who in the past edged into a higher grade by guessing may find they need to work harder to earn the higher grade. The higher grades in A&P II indicate that students who successfully complete A&P I do better in the more advanced course, likely because of an increased depth of knowledge and retention of the concepts.

I also looked at final exam results, as it is a comprehensive test that measures learning gains made throughout the semester. In both A&P I and II, students showed significant, positive increases in their final exam scores (see figure 3).

The Student Experience
In student surveys, more than 50 percent of students report that MasteringA&P helped them improve their test grades, and that the program is an effective learning tool.

"Do you feel online homework/quizzes improved test grades?"
15% Significantly
45% Somewhat
22% Not at all
5% Actually decreased

"The online homework/quizzes..."
34% Were effective learning tools that improved my interest
24% Were effective, but too time consuming
17% Made studying more difficult because of the extra time required
10% Were time consuming and did not correlate well with course content

Conclusion
After implementing the pre- and postlecture MasteringA&P assignments, students are coming to class more prepared and are more engaged in learning. They ask better questions and have a better understanding of what they don’t know. This means that class time can now be spent discussing more-challenging applications and concepts and giving students a better foundation to apply to future courses.

Submitted by Abigail Goosie
Walters State Community College
UNIVERSITY OF NORTH CAROLINA, WILMINGTON

Product Name  MasteringA&P
Course Name  Human Anatomy and Physiology I
Credit Hours  Four

Key Results  MasteringA&P scores positively correlate with exam and course grades, and contribute to improving the overall class grade average and increasing the number of As.

Text
*Human Anatomy and Physiology, 8e*, Elaine N. Marieb and Katja Hoehn

Implementation
This is the first in a two-semester course sequence. It covers seven of the major organ systems that include the human integumentary, skeletal, muscular, circulatory, and respiratory structures and functions as related to health and movement. Students taking this course are primarily in the School of Health and Applied Human Sciences. The course includes a lecture and lab.

In fall 2011, after the first exam I sent an email to all the students in the course asking them to take part in a MasteringA&P pilot study. I offered students an incentive to participate in the pilot: one point added to their final lecture grade if they completed 100 percent of the assignments by the assigned date. Participating students were also required to attend two optional focus groups and complete a series of surveys. The final survey included questions about their experience using the program. By the end of the semester, 20 students—34 percent of the class—were involved. Of those students, 11 completed 100 percent of the assignments.

Assessments
In spring 2012, the semester following the pilot study, I implemented MasteringA&P as a mandatory part of the course using the following assessment.

62.5 percent  Unit exams (five)
25 percent  Lab
12.5 percent  MasteringA&P homework

Results and Data
I looked at the grades from the pilot study semester to see how students who volunteered to use MasteringA&P performed compared to students who did not use it. Thirty-nine students didn’t participate, 14 participated and completed at least half of the assignments, and six participated but did less than half of the assignments. As shown in figure 1, all of the students who completed more than half of the assignments successfully completed the course and had the highest percentage of As. Based on the success of the pilot study, including the positive feedback from the students who used Mastering A&P, I implemented MasteringA&P into my spring 2012 A&P I course.

I assigned MasteringA&P homework—a mix of tutorials and end-of-chapters questions—for each chapter. I also implemented MasteringA&P into my A&P II course starting fall 2012. The results of my first semester fully incorporating MasteringA&P mirrored the pilot study results. The percentage of F grades remained the same between the two groups. A significant (P≤0.001) increase was observed in mean test grades from spring 2011 (71.8±7.8) to spring 2012 (77.9±10.6). The average MasteringA&P scores (82.0±14.3) were significantly (P≤0.01) and positively correlated (r=0.60) with the average test scores (see figure 3). There was a shift in the grade distribution favoring those in the spring 2012 class, such that the percentage of C and D grades decreased, the percentage of Bs increased from 11 percent to 20 percent, and the percentage of As increased from 0 percent to 6 percent (see figure 2).
The Student Experience

Those students who participated in the spring 2012 focus group reported that MasteringA&P content was helpful in learning the material and that it positively impacted their test scores. Some students reported initial registration or login issues during the first evaluative interview, but all feedback in the second interview was positive and included the following:

- “Love it.”
- “Helps me focus on what to study.”
- “Reinforces concepts.”

At the end of the semester, the overall rating for the program was good to excellent. One hundred percent of the students interviewed said they would recommend MasteringA&P to a fellow student.

Conclusion

I adopted MasteringA&P for both A&P I and II after seeing the success of the pilot study and receiving positive student feedback. I’ve continued to see positive results with MasteringA&P after my first semester of full implementation, and I strongly believe that it is an effective elearning tool that helps students learn more and do better in the course.

Submitted by Robert Boyce and Kayleen Young
University of North Carolina, Wilmington
Implementation

Anatomy and Physiology (A&P) I is a study of basic biological chemistry, cellular structure and function, histology, and integumentary, skeletal, and nervous systems. A&P II is a study of the anatomy and physiology of the muscular, circulatory, immune, respiratory, digestive, excretory, endocrine and reproductive systems. Both courses are prerequisites for admission to all allied health programs except one, and the grades achieved in these courses are often used as a predictor for student success for admission to those programs.

Because of the importance of these courses, it's critical that students successfully learn the course content. Over the years, I became increasingly frustrated with students who did not read the textbook and then struggled in class. After speaking with colleagues at a conference about ways to motivate students to read, I adopted MasteringA&P. The program enables me to assign prelecture homework and thereby better monitor student reading and comprehension of the material. The required homework consists of end-of-chapter questions and tutorials, and I use the diagnostics to better understand where students are struggling.

I also have added my own essay review questions to the MasteringA&P homework in order to mirror questions on my exams. I develop complex content questions which may cover multiple modules and promote critical thinking skills. I give feedback on the written homework questions before the exam review period to help students identify those concepts they need to study.

Assessments

70 percent  Exams (five) and MasteringA&P homework (equal to one exam grade)
30 percent  Lab

Results and Data

To determine if the changes implemented in the course were having a positive impact, I analyzed the data for both A&P I and II before and after adopting MasteringA&P. I found that in both courses the drop/fail/withdraw (D/F/W) rate decreased significantly, and the total number of students earning As and Bs increased. See figures 1 and 2.

In both courses the drop/fail/withdraw rate decreased significantly, and the total number of students earning As and Bs increased.

In addition, I compared the lecture average grade, which includes the MasteringA&P homework, to the course grade since the lab portion did not change. The results in both A&P I and II showed that students achieved a higher lecture average after using MasteringA&P. See figure 3.
The Student Experience

MasteringA&P gives students more confidence to ask questions because they have a better understanding of what they don’t know. Student questions are more focused on the content they need the most help with based on their MasteringA&P results. They know where to focus their efforts when studying, and are therefore better prepared for the exams.

Conclusion

I have been teaching for 38 years and have found that students often will not ask for help when they need it—usually because they don’t know what to ask. MasteringA&P gives the feedback students need to more efficiently focus their efforts and achieve higher levels of success.
Key Results
MasteringAstronomy provides a wide range of activities that cater to diverse learning styles. As a result, both online and on-campus students spend more time on class material and, most important, stay in class. Retention rates for both populations have increased an average of 10 percent.

Text
Essential Cosmic Perspective, 5e, Jeffrey O. Bennett, Megan Donahue, Nicholas Schneider, Mark Voit

Implementation
Both Astronomy 10 and Astronomy 20 are lecture/discussion courses with class sizes of approximately 50 students, and either held on campus in a planetarium or offered completely online with no required meetings. Neither have prerequisites, both qualify for general education credit in physical sciences, and both are typically taken in the first or second semester of a student’s freshman year. Astronomy is one of the top two classes taken at Chabot College by nonmajors interested in transfer. Approximately 20–25 percent of students in the course also take remedial courses in mathematics and English, and a similar population of students are ESL students. Reading skills for some students are significantly limited.

Online homework assignments include a wide variety of MasteringAstronomy resources in an attempt to provide for our students’ diverse learning styles. They’re designed to last one hour or less, based on MasteringAstronomy’s average student time statistics, and include ranking tasks, visual quizzes, tutorial problems, and animated tutorials. Assignments include five to eight questions, plus extra credit opportunities. The animated tutorials are typically allocated more credit as each takes between 10–15 minutes. I also include relevant media links in the assignments. Students are encouraged to suggest additional clips that they think may enhance the assigned questions. Students are not penalized for opening hints in the skill-building and self-paced tutorial questions, and they are given multiple chances at correct answers for every question.

Online reading quizzes for each chapter of our book are created from the available testbank questions and are offered with two chances at each question. Quizzes have 20–25 questions and are designed to take 30–45 minutes. All MasteringAstronomy assignments are available 24/7, and have relatively gentle late penalties to encourage students to learn—even if they aren’t able to complete the work by the deadlines.

Gradebook statistics for homework assignments are used in two ways.

1. I review the results on the day the assignment is due, and problems that have been missed most often, and/or reveal common misconceptions, are then clarified in lecture. I show the statistics to the students (without names) to reinforce that many in a class often make similar mistakes.

2. I use the results to modify the questions—add feedback, hints, or clarifying messages using MasteringAstronomy’s editor—for assignment in subsequent semesters.

Assessments
Students are graded on four elements: online homework, online reading quizzes for each chapter of the textbook, weekly participation discussion/research assignments, and two essay exams. The online homework and reading quizzes are required and administered with MasteringAstronomy.

Results and Data
Since I’ve used MasteringAstronomy, I’ve increased both the length of online homework assignments and the breadth of questions selected for those assignments in response to students’ comments that these resources help them learn. Students are definitely working harder, spending more time on their homework and on the quizzes, in addition to the weekly discussion topics. Before using MasteringAstronomy, I used class time for reading quizzes in the on-campus classes, had shorter homework assignments, and assigned animated tutorials on an “all or nothing” credit basis. Now, I have more time for lecture and discussion, have the students doing even more work engaging in key concepts, and have a better sense of what
they still don’t understand through analysis of the program’s statistics. Course completion rates (retention rates) in both my online and on-campus classes have increased approximately 10 percent (see figure 1).

The Student Experience

- “Fun! These interactive tutorials are very helpful.”
- “The tutorials are interesting and I like doing them. I would rather do them than just read and study the book. They add another level to learning Astronomy and I think they are something that should continue to be used.”
- “The explanations after solving each question are very useful!”
- “The hints are very useful [to coach me] step-by-step [on] how to approach [problems] and help guide me to get the correct answer.”

Conclusion

Students in both on-campus and online classes report that the animated tutorials tracked and scored in MasteringAstronomy are the single most effective media resources they use in the class, and that they like those resources even more than they do lectures. Students say that they routinely share the tutorials with friends and family members as they complete the weekly discussion assignments.

Students also report that having two attempts at quiz-question answers helps them to focus on learning by removing much of the stress of a traditional on-campus quiz. They spend time on the quizzes (averaging about 40–50 minutes based on MasteringAstronomy’s usage statistics), undoubtedly in open-book mode searching for answers.

Any learning tool that students use and appreciate, that engages them in science outside of the classroom, and that provides me with one-click insight into their learning and misconceptions is a tool I’ll continue to use.

Submitted by Scott Hildreth
Chabot College
Implementation

This is the second course in a three-quarter (10 week) sequence. It is a fundamental biology course designed for non-biology majors, who have a science requirement. The course is a broad approach to the field of biology, with this session focusing on an introduction to anatomy and physiology of plants and animals. Approximately 350 students per year take the course, which includes both lecture and lab components.

To enhance the lecture I’ve incorporated active learning into the course, including MasteringBiology, iClickers, worksheets, “think-pair-share,” and group activities. In academic year 2009/10, the first year I used MasteringBiology, I provided optional practice assignments that students could earn extra credit by completing. Starting in fall 2010, each quarter I required five to eight MasteringBiology assignments, which accounted for five percent of the students’ final course grade.

When I noticed the impact MasteringBiology was having on student learning, I made additional course changes, including requiring one MasteringBiology homework assignment each week. I increased the weight of the assignments to 15 percent of the final course grade in 2011, and to 25 percent in fall 2012. In addition, up to 25 percent of the exam questions are pulled directly from the MasteringBiology study area.

Assessments (AY 2011/12)

70 percent Exams (four, the lowest is dropped)
15 percent MasteringBiology homework (10, the lowest is dropped)
15 percent Written homework (three)

Results and Data

When I assigned MasteringBiology for bonus credit, few completed the assignments. When polled, they stated it was because “the assignments were optional.” The following year, I required MasteringBiology assignments—and almost every student who completed the assignment earned 100 percent. But I still found that approximately 20 percent of the students didn’t complete any of the assignments, and that less than 10 percent used MasteringBiology’s other study resources.

In AY 2011/12, I changed my assignment design. In the previous years (2009 and 2010), students had unlimited time and three chances to get each question correct. Statistically, with three attempts and four answer options, students are highly likely to earn 100 percent simply by process of elimination—not by learning. When I allowed two attempts with unlimited time, the MasteringBiology grades averaged 88–93 percent, and, with the additional grade weight of the assignments, more students completed them. When polled, more than 40 percent of students reported also using the study area and eText on a regular basis. More than 70 percent of students said they used the study area and eText at least once during a given quarter.

To learn how MasteringBiology facilitates student learning, I evaluated the results of two exams: plant physiology and animal anatomy—often the most predictive of the students’ final performance for the second course in general biology, and which include concepts that are built upon in the third course.

The results show a six to eight percentage point increase in exam grades as I required MasteringBiology assignments, increased the value applied to them, and included the program’s study-area content on my exams—a significant difference in a student’s final course grade (see figures 1 and 2). In addition to a general trend of increasing exam scores, another interesting change is a tightening of the exam scores and final averages, even with a wide range of student majors from across campus.
“The results show a six to eight percentage point increase in exam grades as I required MasteringBiology assignments, increased the value applied to them, and included the program’s study-area content on my exams.”

The Student Experience
Students like to review lecture content in a visual format, use MasteringBiology tutorials to practice the concepts, and appreciate the convenience of the study area resources and eText. Students spend more time in MasteringBiology after the first exam, and office hour questions are often based on content they are working in MasteringBiology, which makes office visits more efficient. Comments from students in written evaluations include:

- “I wish our exams were as interactive as MasteringBiology. I love learning that way.”
- “The videos helped me grasp the materials. I wouldn’t have done as well on the test without MasteringBiology.”
- “I enjoy doing my MasteringBiology assignments, and prefer them to written homework.”
- “More MasteringBiology—’nuf said!”

Conclusion
MasteringBiology is a great addition to my course because of the benefits both my students and I experience. There has been an increase in exam averages every year, a tightening of scores, and an increased understanding of the materials—conceptually and through application. Students are more likely to ask questions, even in the large lecture hall, as they identify cumbersome topics. This, in turn, helps increase interest in and retention of the materials between courses. From an instructor viewpoint, MasteringBiology frees time I formerly spent grading multipage written homework and enables me to work directly with my students. What’s more, because students come to class better prepared, I’m able to implement more active learning in the classroom—and make learning in a large lecture setting more engaging, more effective, and more fun.

Submitted by Sandra J. Connelly
Rochester Institute of Technology
Key Results

In a study conducted over two semesters, students who used MasteringBiology consistently outperformed students who were not using MasteringBiology.

Text

Biology, 8e, Neil A. Campbell and Jane B. Reece

Implementation

Georgia Institute of Technology offers two sections of Biological Principles each fall. Both sections comprise approximately 185 students, are co-taught by the same team of instructors, use the same syllabus, and use identical exams. Course content is organized into five modules: Evolution, Ecology, Metabolism, Genetics, and Molecular Medicine. The first four modules conclude with a one-hour exam. We use a mix of interactive tutorials, activities, and test bank questions for homework assignments.

In fall 2009, we conducted a study to test the effects of various interventions and learning enhancements. We repeated the study in fall 2010 and received nearly identical results.

For the study, students in both sections of Biological Principles were assigned MasteringBiology homework worth a total of up to five percent of their course grades. Students in the first section were assigned MasteringBiology homework for modules 1 and 3; students in the second section were assigned MasteringBiology homework for modules 2 and 4. At the end of the semester, we compared the mean exam scores of each section to determine whether the section with MasteringBiology assignments for a given module outperformed the section not given MasteringBiology assignments.

Assessments

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Component</th>
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<tbody>
<tr>
<td>40 percent</td>
<td>In-class exams</td>
</tr>
<tr>
<td>25 percent</td>
<td>Final exam</td>
</tr>
<tr>
<td>25 percent</td>
<td>Laboratory</td>
</tr>
<tr>
<td>10 percent</td>
<td>Group activities</td>
</tr>
<tr>
<td>5 percent</td>
<td>MasteringBiology (extra credit)</td>
</tr>
</tbody>
</table>

Results and Data

There was no significant difference in overall midterm exam score averages between the two fall 2009 sections ($p = 0.248$). However, the section that was assigned MasteringBiology homework consistently outperformed the section that was not assigned MasteringBiology homework in each of the four modules. This outperformance resulted in a small (2.65 points per module), but significant effect of MasteringBiology assignments on mean exam scores ($p < 0.001$). See figures 1 and 2.

Repeating the experiment in fall 2010 yielded similar results. See figures 3 and 4.

The Student Experience

In a fall 2009 survey ($n = 232$), 90 percent of the students surveyed reported that MasteringBiology “increased my understanding of the course material.” Furthermore, 84 percent of the students surveyed reported that “MasteringBiology positively impacted my exam scores,” and that they “would recommend it to other students taking this course.”

Student comments included the following:

- “I wish every class had this type of study aid.”
- “[MasteringBiology] provided sound reinforcement to concepts out of the book and set up a good base for me to understand deeper concepts in lecture.”
- “MasteringBiology provided the tools I needed to get a better grasp on more-difficult concepts. I could actually see the processes happening in videos and activities.”
“We adopted MasteringBiology as a way to engage students and motivate them to work harder. One of the benefits that we most appreciated was the program’s ability to automatically grade homework and provide instant feedback.”

Conclusion
We have fully integrated MasteringBiology into the Biological Principles course beginning with the fall 2011 semester. We’ve adopted a “flipped” classroom model, which motivates students to engage in the content outside of the classroom, thereby enabling richer discussion and activities during class time.

Submitted by Jung Choi, Tonya Shearer, and David Garton
Georgia Institute of Technology
Implementation

General Biology I is the first of a two-course sequence for biology, biochemistry/molecular biology, and marine biology majors. It is a traditional course taught on campus and incorporates a course management system, MasteringBiology, lecture recordings, and online quizzing.

When I first started using MasteringBiology, all assignments were completed post-lecture. I noticed a slight improvement on exam and quiz scores, and the students reported that they enjoyed using the program. However, I assign homework to ensure that students have done the assigned reading and are prepared for class discussions and activities. Giving homework on material already covered in class didn’t accomplish that, so I experimented with requiring that assignments be completed before lecture.

Today, a short (no more than 20-minute) assignment comprising tutorials and activities is due before every class, except when an exam is scheduled. To successfully complete the assignments, students must have done the reading and watched the animations and tutorial videos. Students now come to class with a basic understanding of the concepts and can work efficiently in groups utilizing this knowledge to solve problems posed in class.

I always consult the MasteringBiology diagnostics before class—not only to see what the students got wrong, but also to determine what misconceptions likely led to their incorrect answers. I often walk into class and say, “I saw your Mastering homework, and you all appear to understand concept x. Is that right?” If no one raises a question, we move on. I have eliminated material from my class because student performance on the homework showed they already understood the material. Conversely, when the Mastering diagnostics indicate misconceptions or misunderstandings, I spend more time in class on those concepts until I am confident that the students have gained a stronger understanding.

Assessments

61 percent Quizzes (10), unit exams (three), and a comprehensive final
19 percent Partial lab papers and research papers
10 percent Pre- and post-lab assignments
10 percent MasteringBiology homework

"My students appreciate that I tailor the class sessions to meet their needs. I appreciate having more time for active learning exercises."

Results and Data

Figure 1 illustrates consistent improvement in exam scores since MasteringBiology was implemented in 2008, and supports the hypothesis that MasteringBiology improves student learning. The improvement is most noticeable when the homework is assigned prelecture (2010–12). Note that the final exam for this class is a secure exam that changes very little from year to year.
The Student Experience
MasteringBiology helps my students to work more efficiently. I utilize the drag-and-drop and sorting questions in the program as much as possible because they require that students analyze and evaluate information. In this way, they may be studying the same amount of time as other students, but their time is being used more effectively.

I conducted a student survey in 2009, the first year I used MasteringBiology. I administered the same survey again in 2011 when prelecture homework was part of the course assessment. The survey results indicate that the majority of students strongly agree or agree that the use of MasteringBiology enhanced their learning and should continue to be utilized in the course. See table 1.

Conclusion
MasteringBiology enables me to lecture less and teach more—I'm more efficient now at helping my students learn. It appeals to the students and enhances their learning. They actually tell me they want more homework! Anything that helps them do more biology and enjoy it is great in my book.

Submitted by Eileen Gregory
Rollins College

Table 1. Student Survey Results, 2009 and 2011
Organismal Biology students who completed prelecture quizzes in MasteringBiology receive significantly higher exam scores than those students who do not complete them. In addition, requiring prequizzes has resulted in record-low D/F/W rates for the course.

Text

*Biological Science, 3e*, Scott Freeman

Implementation

Organismal Biology is a traditional lecture class taught on campus. There are two to three sections of the course per semester, each with about 230 students.

Each week before the first lecture, I administer a MasteringBiology reading quiz, which includes 5–10 multiple-choice questions. After each of the seven major units, students complete an assignment that involves the tutorials and activities based on that unit—questions span material from more than one chapter. The assignment is due at the end of the week that the last set of material covers.

MasteringBiology has changed the way I run my class. Now I can check the gradebook data—especially the quizzes taken before lecture—and if there is an area of common student misconception, I spend more time on that in my lecture. I also base my in-class pop quizzes on the content with which students are having trouble. Because classes are fairly large, I have students work in small groups on the in-class assignments. In these groups, students may work together on questions in an open-book, open-note, open-discussion environment. Questions are on those topics that students need more time on, as indicated by the gradebook statistics.

I use approximately 90 percent of MasteringBiology’s tutorials and activities. The remaining 10 percent of my questions are topics I’ve modified to best fit my course.

For more involved activities, I assign from four to eight items, designed to take about two hours. Students are made aware of this in advance, told that the assignment is due on a particular date, and instructed to dedicate time to it in order to do well and derive the greatest benefit.

Assessments

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>70 percent</td>
<td>Lecture exams</td>
</tr>
<tr>
<td>20 percent</td>
<td>MasteringBiology homework and quizzes</td>
</tr>
<tr>
<td>10 percent</td>
<td>In-class pop quiz, collaborative work, attendance, and participation</td>
</tr>
</tbody>
</table>
“Gradebook statistics show me that students who complete the MasteringBiology assignments are better prepared—even those who aren’t the best students.”

Results and Data
Students are definitely working harder. This course has required MasteringBiology long enough now those students who took it in prior years advise present students that if they dedicate time to MasteringBiology, they’ll do better in the course.

Gradebook statistics show me that students who complete the MasteringBiology assignments are better prepared—even those who aren’t the best students.

The most significant improvement occurred when I started assigning prelecture assessments (see figure 1). Students who both did and did not use MasteringBiology showed no significant difference in final exam scores before I started assigning prelecture quizzes. However, final exam scores improved significantly once I implemented the prelecture assignments.

In addition, the course D/F/W rate has also dropped to a record low of 32 percent.

Conclusion
I see two primary benefits from using MasteringBiology:

- Students read the textbook prior to attending lecture. This enables me to spend more time making the material’s conceptual connections.
- Using the gradebook diagnostics, I can quickly identify the concepts that students struggled with in the reading and spend more time on them in lecture.

I used to have a preconceived notion of what students find difficult and what I should focus on in class. I’m learning now that the concepts that one group finds difficult are not the same semester to semester, or class to class. MasteringBiology has helped me see that, and I know I am a more efficient teacher as a result.

Submitted by Andrea Aspbury
Texas State University
Implementation

Molecular Cell Biology is a first-year, first-semester course. The course is taught as a large, mostly noninteractive, group lecture—as such, some students simply don’t attend. I found that students didn’t regularly read the textbook and probably didn’t review the course material until studying for exams. In fall 2009, I adopted MasteringBiology with the goal of motivating students to read the textbook and interact with the lecture material in a format that was more familiar to them, thereby making their learning more effective and enjoyable.

My MasteringBiology homework consists of assignments that open each lecture day and close one week later. Assignments comprise mostly activities and tutorials, and are designed to review what was covered in lecture in a more interactive way. Students may not view hints or answers until after the assignment due date, and there is no time limit on the assignment.

Each question is assigned a point value related to the number of minutes a student should take to complete it (e.g., 10 minutes = 10 points). I try to get each assignment to equal 30 points. I monitor the gradebook when the assignments are open and e-mail and communicate with students through our institutional LMS 24 hours before the deadline to remind them of it. Once the deadline has passed, students who have not completed the assignment are given a 24-hour extension, and a reduced grade.

At the end of the term, I create no-credit, review assignments for each topic using multiple-choice testbank and end-of-chapter questions. Students may make multiple attempts and answers may be viewed. Once the assessment is completed, the original assignments are available to use for additional practice.

Assessments

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Assessment Type</th>
</tr>
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<tbody>
<tr>
<td>33 percent</td>
<td>Written final exam</td>
</tr>
<tr>
<td>33 percent</td>
<td>Multiple-choice exam</td>
</tr>
<tr>
<td>25.5 percent</td>
<td>Lab worksheet homework</td>
</tr>
<tr>
<td>8.5 percent</td>
<td>MasteringBiology homework</td>
</tr>
</tbody>
</table>

Results and Data

MasteringBiology has enabled the students to engage with the course materials and has had a positive impact on my students’ learning in the course. Since using the program, I’ve seen an increase in the homework and course mean grades. In addition, both the multiple-choice and written, final exams have shown grade increases over the last two years using MasteringBiology. With no other changes to teaching or assessment, the mean course grade has increased by more than six percent since implementing MasteringBiology. See figure 1.

“Since using the program, I’ve seen an increase in the homework and course mean grades.”

I also have found that making the MasteringBiology assignments required—as summative assessments—is the best way to get the students to engage with the course material. At least 90 percent of students regularly complete a required assignment; usually only 30–60 percent of students complete an optional, extra-practice assignment.
The Student Experience

I survey students about MasteringBiology by writing my own questions and adding them to the last required assignment in the program. Responses reveal that most students enjoy the work and find it helpful. Many admit that they probably would not have completed as many assignments if they hadn’t been required. They also use some of the other study resources, such as the eText and self-study resources.

Some of the comments I received from students include:

- “At first I was skeptical about having to buy the book new and paying full price. But I’ve just done the first three questions and have learned so much already.”

- “The online assessments are a fun and interactive way to learn biology.”

- “I found [MasteringBiology] helpful. I can now remember the majority of the functions and names without looking at the book.”

Conclusion

Students want to be engaged in the subject matter, and they welcome new technologies. Because modern students grew up with computers, some find books alien. We need to embrace this shift, rather than try to revert back to the old-school way of learning. MasteringBiology’s online assignments offer students the flexibility to learn in their own space, at their own pace, and in a visual or 3D way that isn’t possible from traditional textbooks.
### Study Design

In 2008 students were assigned weekly MasteringBiology homework consisting of tutorials, multiple-choice questions, and selected readings in preparation for the lecture. A 15-minute open-book quiz was then given in Blackboard within 36 hours of the lecture. The quiz scores were compared with the year 2007, in which MasteringBiology had not been used in a similar course with the same instructor. Sequence, quiz length, question types and degree of difficulty, and time allowed for a quiz were the same in 2008 with MasteringBiology to enable a fair comparison to 2007, when MasteringBiology was not used.

The final exams in both years were identical; students repeating the course were not included. Furthermore, entering students did not differ in any substantial way as judged by the university’s entrance rankings (75.1 in 2007 as opposed to 75.0 in 2008). The number of students in the course for each year is about 600.

### Results and Data

For each of the 12 weekly quizzes, students who used MasteringBiology outperformed those who did not use it in the previous year. The average quiz score gain was $6.4 \pm 3.3$ (95% confidence interval). Students who used MasteringBiology placed at the 62nd percentile on average in the final exam, which corresponds to an effect size of 0.3. See figure 1.

![Figure 1](https://example.com/figure1.png)

With acknowledgment to Prof. Gerry Rayner, Monash University.

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### Conclusion

The consistency in score gains for those students who used MasteringBiology in comparison to those who did not—across all of the quizzes and hence, across many concept domains in biology—is an educationally significant result. (For more details, see G. Rayner, Evaluation and student perception of MasteringBiology as a learning and formative assessment tool in a first year Biology subject, Proceedings of the 2008 Australian Technology Network Assessment Conference.)
Study Design
The students were assigned weekly MasteringChemistry homework and were given a paper-based final examination at the end of the semester. MasteringChemistry data for 204 students was applied to develop a two-parameter item response model for answers scored dichotomously based on whether or not a student obtained the correct answer to a given part of an item on the first attempt without requesting help from the program.

Results and Data
The application of the item response model predicts the paper-based final exam score with a correlation of about 0.68. The correlation implies that about 46% of the variance in the final exam scores is explained by the regression line. The statistical uncertainty in the correlation is between 0.57 and 0.74 with high confidence.

Conclusion
The predictive ability of the Mastering platforms aids instructors in confidently assessing students at risk of failing the course and provides the necessary remediation. “[Given the fact that a student is being assessed] over the course of the semester over several hundreds of problems with many variables that directly correlate with [the student’s] skill, it gives [a] better way to deal fairly with a student’s actual skill. This eliminates the high-stakes nature of a final exam. Given such assessment capabilities, teachers could confidently determine a student’s skill without worrying about the one who miraculously passed, deserved to pass, or failed, just because of some ‘bad luck.” 1

Key Results
Research has shown that the Mastering system data can predict students’ final exam scores with a correlation of over 0.6.1 This predictive ability provides instructors with the opportunity to provide personalized instruction for students at risk of failing the course.

Figure 1. Correlation between the predicted versus the actual final exam score for 204 students at Louisiana State University in fall 2007 using MasteringChemistry.

1 D. E. Pritchard and R. Warnakulasooriya, Data from a Web-based homework tutor can predict student’s final exam score, ED MEDIA 2005: World Conference on Educational Multimedia, Hypermedia & Telecommunications, pp. 2523–2529.

With acknowledgments to Prof. Randall W. Hall and Prof. Leslie G. Butler, Louisiana State University.
LOUISIANA STATE UNIVERSITY

Product Name: MasteringChemistry
Course Name: Introductory Chemistry, Fall 2007

Key Results: Students demonstrated learning and knowledge transfer, as illustrated by decreasing problem difficulty relative to a problem’s position in the assignment.

Study Design
The students were assigned weekly MasteringChemistry homework. Twelve regular homework assignments were given (except the introductory assignment to MasteringChemistry) to the class, which consisted of about 260 students. The regular homework assignments had about 15 problems on average per assignment and the end-of-chapter (EOC) problems were always assigned after the tutorial problems within an assignment. A two-parameter item response model was fitted to the data scored dichotomously based on whether or not a student obtained the correct answer to a given part of a problem on the first attempt without requesting any help from MasteringChemistry, hence obtaining the difficulty and the discrimination parameters of the problem.

Results and Data
The difficulty of the problems against its position in the assignment correlates at -0.32 ± 0.09 on average for 10 homework assignments in which a linear association between problem difficulty and problem order in the assignment can be identified. Thus, the problem difficulty decreases over a given assignment. In other words, problems given later in an assignment are easier than the ones given earlier. See figures 1 and 2.

It is highly plausible that the decrease in problem difficulty is due to an overall effect of learning within a given assignment. The instructor followed the best practice recommendations given in MasteringChemistry and selected a roughly equal number of tutorials and EOCs as much as feasible within an assignment. The tutorial and EOC problems were selected so that they covered important parts of each chapter. Although the 1 (easy) through 5 (hard) difficulty scale was not used by the instructor in selecting the problems from the MasteringChemistry’s item library, the problems selected mainly fell in the difficulty range 1–3. Even if the EOC problems (that were assigned at the end of an assignment) were inherently easy, the general negative correlation does not explain the decrease in difficulty we see among the tutorial problems along the order.

Since the instructor did not consciously select problems in decreasing order of difficulty within an assignment, it is reasonable to infer that on average we see a learning effect from one problem to the next within an assignment. The average decrease in difficulty per problem within an assignment is -0.26 ± 0.13. Thus, the difficulty of the next problem within an assignment effectively decreases by about 0.26 standard deviations. Since the student skill and the problem difficulty are placed on the same standard deviation scale in an item response model, this also suggests that the increase in skill from one problem to the next within an assignment is about 0.26 standard deviations.
Conclusion

In 10 of the 12 regular assignments given in MasteringChemistry, a linear decrease in problem difficulty occurs, with the earlier problems in an assignment being more difficult than the later problems. The average correlation between the problem difficulty and its order within an assignment is $-0.32 \pm 0.09$ while the decrease in difficulty from one problem to the next is $-0.26 \pm 0.13$ standard deviations. Hence, the learning effect attributable to a problem is about 0.26 standard deviations.

Figure 1. The difficulty of the problems decrease along the order in the assignment: Chapter 1 of Brown/LeMay/Bursten (Introduction: Matter and Measurement). The problem difficulty is reported on a standard deviation scale. A single-part problem with difficulty -1 means that a student who is one standard deviation below average in skill has a 50% chance in successfully answering the problem on first attempt.

Figure 2. The difficulty of the problems decrease along the order in the assignment: Chapter 11 of Brown/LeMay/Bursten (Intermolecular Forces, Liquids, and Solids). The problem difficulty is reported on a standard deviation scale. A single-part problem with difficulty -1 means that a student who is one standard deviation below average in skill has a 50% chance in successfully answering the problem on first attempt.

With acknowledgments to Prof. Randall W. Hall and Prof. Leslie G. Butler, Louisiana State University.
Key Results
Assigning MasteringChemistry had a significant, positive impact on student performance as measured by exam scores. The improvement was seen for students at each of the score quartiles.

Study Design
In the years 2004–07 online homework was not used in General Chemistry courses. In fall 2008 MasteringChemistry was introduced for credit for online homework in the course. Historical comparisons were feasible since the course coverage and instructional components were comparable over the years. Fall semester final exam scores for the years 2004, 2005, 2007 (without MasteringChemistry), and 2008 (with MasteringChemistry) were compared for students who completed the course within a given semester. The number of students in the course in a given year ranged from 912 to 1,125.

Results and Data
Students who used MasteringChemistry in fall 2008 showed an improvement of 0.5 in effect size in the final exam in comparison to the years 2004, 2005, and 2007, in which MasteringChemistry was not used. The average student who used MasteringChemistry in 2008 is at the 69th percentile. In terms of percentile points, there is a 19-percentile-point improvement in the final exam score, on average, when students were assigned homework in MasteringChemistry.

More remarkable, students at each of the score quartiles (25th, 50th, and 75th percentiles) were positively affected by the use of MasteringChemistry in fall 2008 relative to the previous years. In particular, the probability that a student at the 25th percentile of the class would obtain a final exam score of 50 or above is 81%. That probability is less than 50% in the previous years (42% in 2004, 26% in 2005, and 17% in 2007) in which MasteringChemistry was not used. See figures 2–4.

Figure 1. The final exam score (historical) comparisons of students who did not use MasteringChemistry in the years 2004, 2005, and 2007 to students who used MasteringChemistry in 2008. The errors shown are the 95% confidence interval of the standard error of the mean. The final exam scores are scaled to a maximum of 100%.

1 The difficulty levels of the final exams across the years were assumed to be comparable. This is a reasonable assumption though it cannot be rigorously proven. The fall 2006 final exam scores were lower by about 0.6 standard deviations compared with the other non-MasteringChemistry years 2004, 2005, and 2007, and hence are not included in the analysis. According to the instructor, this may be due to an ice storm that hit the campus area on the day of the first exam, which led to its cancellation. This also deprived students from study for about two weeks. Though the ice storm did not occur during the final exam, it may have had a ripple effect as reflected in the low final exam scores. The lower scores in 2006 may further support the argument that the final exams had comparable difficulties, since an easier exam to compensate for the ice storm would not have resulted in such a decrease.

2 It is difficult to adjust the observed effect size (0.5) for individual teacher influences in 2008 over and above teacher effects for the years 2004, 2005, and 2007. According to some research findings an effect size of about 0.2 is attributable to the teacher in a traditional classroom setting, while various other teacher influences such as reinforcement, peer tutoring, class environment, and questioning would result in an average effect size of about 0.4 (Ref: Influences on student learning, J. Hattie, Inaugural Professional Lecture, University of Auckland). Thus, if the latter teaching methodologies were employed in 2008 in addition to the traditional settings in the previous years the teacher effect would account for 0.2 of the observed effect size. The resulting effect size attributable to MasteringChemistry would then be about 0.3, which would place the average student at the 62nd percentile.
Figure 2. The final exam score (probability) distributions for a student at the 25th percentile. The probability that a student at the 25th percentile of the MasteringChemistry class in 2008 would obtain a score of 50 or above is 81%. That probability is less than 50% in the previous years (42% in 2004, 26% in 2005, and 17% in 2007) in which MasteringChemistry was not used. Graph legend: MasteringChemistry (2008) is on the far right. The remaining years (2004, 2005, and 2007) are on the left.

Figure 3. The final exam score (probability) distributions for a student at the 50th percentile. The probability that a student at the 50th percentile of the MasteringChemistry class in 2008 would obtain a score of 70 or above is 23%. That probability is less than 10% in the previous years (3% in 2004, 2% in 2005, and 2% in 2007) in which MasteringChemistry was not used. Graph legend: MasteringChemistry (2008) is on the far right. The remaining years (2004, 2005, and 2007) are on the left.

Figure 4. The final exam score (probability) distributions for a student at the 75th percentile. The probability that a student at the 75th percentile of the MasteringChemistry class in 2008 would obtain a score of 85 or above is 3%. That probability is three times as less in the previous years (1% in 2004, 0.5% in 2005, and 1% in 2007) in which MasteringChemistry was not used. Graph legend: MasteringChemistry (2008) is on the far right. The remaining years (2004, 2005, and 2007) are on the left.

Conclusion
The use of MasteringChemistry in the General Chemistry course in fall 2008 resulted in 0.5 effect size score gains in the final exam. The average student who used MasteringChemistry can be placed at the 69th percentile in relation to the previous years’ score distributions in which MasteringChemistry was not used. Through an observational study, the attribution of score improvements to MasteringChemistry is supported by the observation that the final exam score distributions (mean and variance) remained stable in the years 2004, 2005, and 2007 in which MasteringChemistry was not used. Students at each score quartile were positively affected by the use of MasteringChemistry. For example, the probability that a student at the 25th percentile of the class would earn a final exam score of 50 or above is 81%. That probability is less than 50% in the previous years in which MasteringChemistry was not used. Thus, students who were less skillful or were at risk of failing the course were positively affected by the use of MasteringChemistry. Similarly, a student at the 75th percentile who has used MasteringChemistry has three times as much chance of scoring above 85 than a student at the same percentile level who did not use MasteringChemistry.

With acknowledgment to Prof. Valerie Frerichs, University at Buffalo, State University of New York.
General Chemistry II is a continuation of General Chemistry I and is primarily taken by science and engineering majors who plan to transfer to a four-year school. Topics covered include solution chemistry, thermodynamics, kinetics, acids and bases, chemical equilibrium, electrochemistry, nuclear reactions, and coordination chemistry. Laboratory experiments are designed to correlate with lecture material. I administer the national American Chemical Society (ACS) second semester (ST) and the full term (GC) examinations as the final examination for the course.

I’ve found issues with giving paper-and-pencil homework, such as students copying the answers from the solutions manual or being unsure how to start a problem so they don’t attempt it. I adopted MasteringChemistry to provide homework with guided help, hints, and instant feedback so students would know how they are doing and where they need to focus their efforts.

My MasteringChemistry homework is a mix of tutorials and end-of-chapter problems. I divide the lecture for a chapter into two class periods and give one homework assignment at the beginning of a chapter and an additional homework assignment to cover the end of the chapter. I’m able to assign problems of various levels of difficulty and offer harder problems for extra credit, which enables stronger students to advance their skills.

Assessments

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Component</th>
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<td>22.5 percent</td>
<td>Quizzes</td>
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<td>20 percent</td>
<td>Final exams</td>
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<tr>
<td>13 percent</td>
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<tr>
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Results and Data

Since implementing MasteringChemistry in 2010, I’ve seen positive results in several areas. Our success rate (A/B/C) from 2001 to 2009 in General Chemistry II averaged 62 percent. During the three years we’ve been using MasteringChemistry, the success rate has increased to 74 percent (see figure 1).

In addition, scores on the both of the ACS standardized exams have increased, resulting in students achieving a much higher exam percentile in 2011 and in 2012 (see figures 2 and 3).

I also compared the average student grade point average to the ACS exam percentile achieved, and discovered that the ACS exam-percentile increases have outpaced average student-GPA increases over the same period (see figure 4).

Key Results

Students are able to tackle more-complex problems using MasteringChemistry. This, in turn, helps them to achieve higher rates of success both on ACS standardized exams and in the course.

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**Text**

*Chemistry, 5e*, John E. McMurry and Robert C. Fay

**Implementation**

General Chemistry II is a continuation of General Chemistry I and is primarily taken by science and engineering majors who plan to transfer to a four-year school. Topics covered include solution chemistry, thermodynamics, kinetics, acids and bases, chemical equilibrium, electrochemistry, nuclear reactions, and coordination chemistry. Laboratory experiments are designed to correlate with lecture material. I administer the national American Chemical Society (ACS) second semester (ST) and the full term (GC) examinations as the final examination for the course.

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**Key Results**

Students are able to tackle more-complex problems using MasteringChemistry. This, in turn, helps them to achieve higher rates of success both on ACS standardized exams and in the course.
The Student Experience

Students believe that MasteringChemistry helps them to succeed in the course. Some of the feedback I have received includes:

- “I really enjoyed [MasteringChemistry]. It seemed like there was a natural progression to the ideas presented that made going from one problem into the next less daunting. It made partial problems out of the steps in calculation so I always felt I was on the right track.”

- “I actually really liked it! The homework allowed me to better understand the lecture material, and the program’s repetition proved beneficial when I was trying to master concepts.”

Conclusion

MasteringChemistry helps students grasp the more-complex problems and concepts they’ll need in an advanced general chemistry course. Students like how the program walks them through complex problems and offers help when and where they need it. Because students utilize these resources to gain a deeper understanding of course content they do better both in the course and on the ACS exams, which helps set them up for success as they continue on their educational path.

Submitted by Steven Socol
McHenry County College
Key Results
The class average ACS exam score increased from the 64th percentile to the 76th percentile after requiring MasteringChemistry. Students cite MasteringChemistry as the most significant contributing factor to their success.

Text
Chemistry: The Central Science, 11e, Theodore E. Brown, H. Eugene H LeMay, Bruce E. Bursten, Catherine Murphy, Patrick Woodward

Implementation
General Chemistry is a traditional course taught on campus. It consists of four lecture hours and three lab hours per week over the course of a 15-week semester. MasteringChemistry is a huge part of my course—I spend a minimum of one hour a night designing lessons, monitoring student work, and interacting with students, so I classify the course as hybrid.

I'm what you’d call a power user of MasteringChemistry. I've been a MasteringChemistry disciple since I beta tested the program for its 2007 release. It's the best technology implementation I've used in all of my 38 years of teaching.

I want my students to use their textbook, so I cover material in the order that it's presented in class. For every section covered, there's an assignment that clearly directs students to a corresponding textbook section. I try to keep my assignments to 10 problems or fewer and one hour or less per textbook section. Because MasteringChemistry has an amazing database that gives median time-on-task and relative difficulty level based on actual student usage, it's easy to see the time required to complete the assignment. Considering that I cover about 10 chapters per semester, and each chapter has about eight sections that require mastery, my students do about 800 problems per semester. To keep the students on task, I give them two days to complete the assignment without penalty. After that, they lose 25 percent each day they're late.

My assignments begin with tutorials that contain hints and a Socratic approach to helping students who need extra help. Important: I encourage students to use hints! I tell them that outright, and I neither give them extra credit nor penalize them for using or not using hints. This is contrary to the default setting, but it makes a huge difference to do it my way. Tutorials are followed by several end-of-chapter (EOC) problems with randomization and unit features turned on when available. I give EOC problems for which the answers are not given in the textbook, and I no longer make solution manuals available in the bookstore.

Every night I check the gradebook and look for the students who are struggling, so I can talk to them one-on-one and encourage them to get additional help, ideally from me. When a student comes to me for help, whether during a live office hour or during my evening “office hours,” I immediately refer to that student’s MasteringChemistry work to make sure that the student has used the hints and to identify his/her misconceptions. The program’s diagnostic tools make for much more effective and efficient office hours.

I also look at the class average on a given assignment. If the average falls below 90 percent mastery, I rethink my approach and often reinforce the concept the next day with different examples or graphics.

Another feature I use is the new learning outcomes feature. This is a powerful (and nearly effortless) way to document student mastery of skills that transcend chapters.

Assessments
80 percent Exams (five)
16 percent MasteringChemistry homework
4 percent Lab

The MasteringChemistry portion is enough credit to motivate students, but not enough to inflate their overall course grade. Almost all students will earn the same course grade with the MasteringChemistry grade included as they would based on exams alone. A few will earn half a grade higher due to the MasteringChemistry grade.
Results and Data

I've collected significant qualitative and quantitative data on MasteringChemistry's impact on American Chemical Society (ACS) exam scores, as well as on my students' perception of MasteringChemistry's effect. I give the ACS standardized exam in General Chemistry as my final exam at the end of the second semester of the course. Since adopting MasteringChemistry, my class average has increased from the 64th percentile in 2007 to the 76th percentile in 2010 (see figure 1).

In a student survey that asked students to rate 20 factors that had the greatest impact on their success in the course, students rated MasteringChemistry as the most significant factor (see figure 2). Students definitely recognize that the program has a positive impact on both study habits and performance.

Conclusion

MasteringChemistry's impact on my course is best illustrated by my favorite success story: A student dropped the class (and would have failed had she not dropped) the year before I used MasteringChemistry. She retook the class the first year I used the program—and earned an A! I had never experienced that kind of turnaround in repeat student performance, and it would not have happened without MasteringChemistry.

Submitted by Robert Pribush
Butler University
Implementation
This is a traditional face-to-face class with a lecture and lab. Nearly all science majors and a large portion of engineering students take this course. As a result, classes are a melting pot of experiences and attitudes—from chemistry majors to students who dread chemistry.

In 2007, my first semester teaching the course and my first semester using MasteringChemistry, I gave students 8 percent credit for MasteringChemistry homework. In 2009, I increased the course credit for MasteringChemistry to 10 percent. I give one MasteringChemistry homework assignment each week and specifically choose tutorial-type questions, since I want struggling students to see the homework assignments as instructive and real practice. (Plus, some of them are fun!) Students don’t lose points for hints, but can earn bonus points if they answer a question correctly without using hints.

From 2007 to 2009, I received complaints after the first midterm. Students said they did well on the homework assignments and did the practice exam, but didn’t do well on the midterm. Looking over their midterms, I saw that these students lost significant points because they ran out of time. They hadn’t learned time management as it pertains to testing versus studying and were unaware of how long it took them to complete a question.

I reviewed the MasteringChemistry time diagnostics with my students. Some were shocked to find out that they sometimes spent more than 20 minutes on a single problem (that other students finished in less than 10 minutes). Students were studying hard, but weren’t taking into account the ticking-clock factor of timed tasks like the midterm.

In fall 2010, I changed the grading system on midterms and the final exam. I now use a “one-point-per-minute” rubric to indicate to students how they should budget their time. For example, a five-point problem should take the average student about five minutes to complete. For an 80-minute midterm, I assign 50 points to allow plenty of extra time for slower students or to review and revise answers. I also changed from giving three midterm exams to giving two.

My final change was introducing a MasteringChemistry timed quiz, approximately one and a half weeks before the first midterm. I simulate a dry-run for the test by selecting three problems from the end-of-chapter questions. Students have exactly 30 minutes to complete the quiz, which is made available for 24 hours on a predetermined date. I use the time diagnostic in MasteringChemistry to ensure that the average student can feasibly finish within that time frame.

I implemented the first timed quiz in October 2010. Student comments on the very next day were exactly as predicted—overwhelmingly, it was an eye-opening experience for them. The class average on the quiz was only 45.3 percent, with most completing the first question but getting only about halfway through the second. In 2011 in response to popular demand from students, I added a second timed quiz before the second midterm. This second quiz was treated like a real practice run for the second midterm.

Assessments
30 percent Final Exam
30 percent Midterms
25 percent Lab
10 percent MasteringChemistry homework and quizzes
5 percent Participation

Key Results
By completing MasteringChemistry tutorial homework assignments and timed end-of-chapter quizzes, students learned course content and improved their test-taking skills, resulting in an increase in As, Bs, and Cs.
Results and Data
The combination of tutorial and timed end-of-chapter questions helps students learn, understand, and practice the course materials. The timed quizzes allow students to simulate actual test conditions and better prepare for the midterms and the final exam.

In analyzing the results from fall 2011, when students had both assigned MasteringChemistry homework and a timed MasteringChemistry quiz prior to each midterm, I found that the correlation of their MasteringChemistry grade to the final course grade was stronger than in prior years (see figures 1 and 2). In addition, during this period of time, I saw an increase in As, Bs, and Cs—a seven percentage-point increase in success rates, and a decrease in Ds, Es, Fs, and incompletes (see figure 3).

The Student Experience
MasteringChemistry is an integral part of a course that is indispensable to my students. Student evaluation comments are largely positive towards the program—they mention its ease of use, the availability of hints, and the step-by-step breakdown of the questions. Their comments include:

- “MasteringChemistry assignments were quite helpful since they were a step-by-step way to go through all the subject matter during the week. The assignments were challenging enough, but not too strict in terms of marks.”

- “The timed MasteringChemistry quiz was a major wake-up call! I had no idea how long I was taking to solve problems. It really opened my eyes and helped me prepare for exams.”

Conclusion
When I was hired to teach the course, MasteringChemistry was already in use by other faculty so I chose to “play along” and use it in my sections, as well. I quickly realized the value of the program.

I care deeply about my students’ performance and want each of them to succeed, but increasing class sizes make it impossible to have meaningful one-on-one contact with every single one. The most beneficial aspect of MasteringChemistry is its tutorial nature—students can read, learn, practice course problems, and seek help via hints when they are struggling. It’s as close as a computer program can get to me sitting beside them while they’re studying.

Submitted by Kathy-Sarah Focsaneanu
University of Ottawa
Key Results
MasteringChemistry’s hallmark advantages of immediate feedback and personalized learning facilitate greater student learning, as evidenced by increased exam scores; and time previously spent grading homework can be spent on hands-on teaching and research.

Text
Chemistry: The Central Science, Theodore E. Brown, H. Eugene LeMay, Bruce E. Bursten, Catherine Murphy, Patrick Woodward

Implementation
Each year, more than 2,500 students in sections of 250 take General Chemistry. Even with TA support, it is impossible to grade that amount of paper homework. In 2007 we adopted MasteringChemistry to ease the burden of grading. Today everything the students complete is automatically graded. What’s more, students receive tutoring with hints and answer-specific feedback while they do their work, so it’s both more efficient and more effective.

My MasteringChemistry assignments have evolved over the years, from traditional end-of-chapter problems in the beginning, to tutorial problems that offer hints and answer-specific feedback. Tutorial problems are a strength of the program. In addition, we follow an atoms-first approach and tend to skip around the book a bit. The program’s authoring tools enable us to put in a few problems of our own.

I use MasteringChemistry’s national database of problem length and relative difficulty to build homework assignments of approximately 60–90 minutes per assignment. It means I no longer field complaints about homework that takes too long to complete. Throughout the semester, I review MasteringChemistry’s diagnostic tools to see how well students are learning—and how well I’m teaching—particular concepts.

Assessments
70 percent  Exams (three midterms and a final)
10 percent  MasteringChemistry homework
7.5 percent  In-class clicker quizzes
7.5 percent  Recitation sections (in-class work)
5 percent  Weekly online exams

Results and Data
I believe that MasteringChemistry has improved our students’ understanding of general chemistry. When I gave my students the same exam that I had given the semester before I implemented MasteringChemistry, their scores increased and the improvement in scores increased as the term progressed. That experience has been repeated every time we used duplicate exams. Today the exams are modified, but scores continue to be high. See figure 1.

What I find most compelling is MasteringChemistry’s impact on students’ perception of the course. This is a general education course—a service course—that nonmajors take. These students are a reluctant audience: they don’t like chemistry, and they see it as a barrier. Using MasteringChemistry helps them to feel that they have a fair chance of learning it—that’s a big part of the battle.

I survey students every semester—I ask them which course components are the most helpful to their learning of general chemistry. Students rate each component on a scale of 1–5, with 1 being Not Very Helpful and 5 being Extremely Helpful. I’ve done this every semester over the 4 or 5 years I have taught the course. MasteringChemistry always ranks at or near the top—better than my lectures and better than the quizzes and the text (see figure 2). The only components that come close are the recorded lectures, which students access online, and the weekly microquizzes, which they can take as many times as they want and are somewhat modeled after the MasteringChemistry tutorial problems.
Conclusion

Students who use MasteringChemistry are more likely to do their homework—they know it counts toward their final grade and they receive immediate feedback from it, including specifically where they made mistakes. And because students get tutored while doing MasteringChemistry homework, they come to class better prepared and ask much better questions. This enables me to be more flexible in lecture.

We recently completed a textbook adoption cycle during which we reviewed other homework systems. One of the reasons we remained with the Pearson text is that we believe MasteringChemistry is the best of all the online homework systems we explored. Although other systems may approach parity with the program, MasteringChemistry is ahead of the curve for two reasons: 1) the tutorial problems and the way the students are coached, and 2) the gradebook and better diagnostics data.

In short, I’m a believer. I definitely like this way of teaching—it enables me to spend more time doing research and helping students instead of grading homework.

Submitted by David V. Dearden
Brigham Young University
Implementation
This lecture course is an introduction to matter and energy, atomic structure, nomenclature, chemical equations, stoichiometry, gases, thermochemistry, quantum chemistry, bonding, molecular geometry, oxidation-reduction, liquids and solids, and solutions. Its corresponding lab may be taken in conjunction with the course or after course completion. The majority of students who take General Chemistry I also take General Chemistry II.

I started using MasteringChemistry in fall 2010 because I believe the goal of homework is to help students learn and study. In order to master course concepts and problems, students need practice and repetition—and MasteringChemistry provides that. In fall 2011, I modified the course by adding paper-and-pencil quizzes to help students practice writing down their work.

Assessments
Fall 2010
51 percent Exams
27 percent MasteringChemistry homework
22 percent Final exam

Fall 2011
49.5 percent Exams
21 percent MasteringChemistry homework
16 percent Final exam
13.5 percent Quizzes

Results and Data
An analysis of student outcomes without assigned MasteringChemistry (spring 2009) and with assigned MasteringChemistry (fall 2010, fall 2011) indicated the following:

- 96 percent of students who averaged 70 percent or higher on their MasteringChemistry homework successfully completed the class with a grade of A, B, or C. See figure 1.
- Those students who successfully completed the course earned an average score of 73 percent on their MasteringChemistry homework.
- Those students who did not successfully complete the course earned an average score of 37 percent on their MasteringChemistry homework. See figures 2 and 3.
- The drop/fail/withdraw (D/F/W) rate fell from 56 percent without the use of MasteringChemistry homework to an average of 44.5 percent the first two semesters that MasteringChemistry was in use. See figure 1.
- There was an increase in final course grades of A and B for both semesters using MasteringChemistry. See figure 1.
- There is a strong, positive correlation between homework scores in MasteringChemistry and the final course grade for both semesters using MasteringChemistry. See figures 2 and 3.
- There was a moderate, positive correlation between the paper-and-pencil quiz averages and the final course grade.
“Previously, I only suspected that those students who used the homework to learn and to reinforce course concepts did better in the course. Now I have confirmation of it through data analysis.”

The Student Experience
I encourage peer tutoring. My students are forming study groups now and spending more time talking through the MasteringChemistry problems with each other.

Students who do better in the course are those students who use the program’s hints to help them better understand problems and who appreciate the opportunity to rework the problems.

Conclusion
I was very surprised by the extremely high correlation between students who successfully complete the class and score a 70 percent or higher on the MasteringChemistry homework. I felt that the students who were using the homework to learn and reinforce the concepts were doing better in the course, but having this confirmed through the data is very beneficial. I believe that MasteringChemistry will be an extremely helpful resource for a whole generation of students at Ventura College.
Text
Chemistry: A Molecular Approach, 2e, Nivaldo J. Tro

Implementation
General Chemistry I is a traditional lecture and recitation course taught on campus to more than 1,000 students annually. In spring 2012 we changed the format to a buffet-style hybrid course, meaning that all of the testing and homework was completed online using MasteringChemistry.

MasteringChemistry has not changed our approach with respect to lecture or recitation. It has, however, changed student engagement outside of class in that the program provides an additional instructional tool that has proven to be highly effective.

For online homework, we assign a tutoring problem and pair it with one or two end-of-chapter (EOC) problems. The tutoring problems reinforce our philosophy that the primary purpose of homework is to practice. For assessment and self-testing, we use EOC problems because they closely align with exam problems—no hints or feedback.

Practice problems are optional, but the EOC problems are for credit. Students who are struggling with an assessment may go back to the tutoring problems. Although some instructors believe that students won’t do work that is not for credit, that isn’t the case at our school; students who need the tutorials usually use them.

We assign homework after each lecture. Students have only three days to complete their homework—this keeps them constantly engaged and learning.

We also use MasteringChemistry for proctored, 15-minute recitation quizzes. Quizzes typically have five questions, many with multiple parts.

Additionally, students take three-minute, MasteringChemistry-based preparation quizzes before they come to class. These quizzes have three questions, usually on definitions or highlights from the assigned reading.

We continuously monitor the gradebook, using the color coding to analyze student progress and engagement. We capitalize on the gradebook because it is individualized and you can really see where a student is having trouble. As instructors, we can help students analyze what their problems are by looking at their wrong-answer choices and the amount of time they put into a problem.

MasteringChemistry also has helped us change our teaching to better suit our students. Because we are a strong science and engineering school, you might expect our students to perform better than the national average. MasteringChemistry showed us that was not always the case. For example, our students didn’t perform as well as we expected in organic nomenclature as compared to the national average. The gradebook’s statistics made us aware of this information, and that encouraged us to focus more on explaining organic nomenclature and how to name organic molecules.

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<td>Nomenclature exam (first exam)</td>
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<td>5 percent</td>
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Key Results
When using MasteringChemistry, students remain engaged and learning. They use it more than other available assistive-learning technologies, and value it as much as one-on-one personal tutoring.
The Student Experience

We asked students how much time they spend per week using each instructional tool. Figure 1 illustrates their responses regarding the optional, not-for-credit MasteringChemistry practice problems. We also asked about the perceived value of the MasteringChemistry practice problems. More than 80 percent of the students rated them as useful, very useful, or essential (see figure 2).

We offer a variety of assistive instructional tools outside of the scheduled classroom time, such as office hours and student discussion boards. We try to link these tools together so that there are synergistic effects. For example, on the discussion board, we set up threads for every MasteringChemistry homework problem. Students may ask specific questions, and answer with comments. The only comments not allowed are direct answers to the MasteringChemistry problems.

We wanted to understand what types of students prefer which instructional tools for their mastery of chemical concepts. Specifically, we offer nonmandatory, collaborative learning centers under the Missouri S&T campus-wide LEAD (Learning Enhancement Across Disciplines) program. Those students who take advantage of these centers also use the other assistive tools more frequently. For students who participated in the collaborative learning centers, the perceived value of assistive instructional tools was generally significantly higher than for those that did not take advantage of our LEAD centers. The surprising part, however, was that both groups perceived MasteringChemistry as the most valuable tool. It is

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**Figure 1. Hours Per Week Spent On MasteringChemistry Practice Problems**

**Figure 2. Student Rating of MasteringChemistry Practice Problems**
“MasteringChemistry has helped us change our teaching to better suit our students.”

the one instructional tool that both groups valued the highest, and the only one they valued equally as high (see figure 3). Our conclusion is that even students who are not as open to using assistive instructional tools gave MasteringChemistry the highest value—an equal value as those students who use all tools more frequently. This is a very powerful message. With MasteringChemistry, we have found a tool that addresses both groups equally. Originally, we thought our LEAD tutoring, more personal one-on-one help, would earn an equally high value, but students obviously like more—and put more value on—the individualized assistance provided by MasteringChemistry tutoring problems.

Students report the following:

• “MasteringChemistry really helps facilitate learning.”

• “MasteringChemistry was extremely helpful for learning concepts for exams.”

Conclusion

As a general guideline, we follow the Seven Principles for Good Practice in Undergraduate Education, as outlined by Arthur W. Chickering and Zelda F. Gamson.

1. Encourage contact between students and faculty.
2. Develop reciprocity and cooperation among students.
3. Encourage active learning.
4. Give prompt feedback.
5. Emphasize time on task.
6. Communicate high expectations.
7. Respect diverse talents and ways of learning.

MasteringChemistry helps address all of these principles, especially the prompt feedback and time on task principles. Because of the positive impact MasteringChemistry has had on our teaching and on our students’ success, as well as our students’ positive perception of the program’s value, we are partnering with the National Center for Academic Transformation on redesign of our general chemistry education track. As part of it, we’ll be increasing our use of MasteringChemistry.
Implementation
General Chemistry is a traditional lecture course, serving approximately 2,000 students annually, mostly science, math, and engineering majors. Lab is taken concurrently, but as a separate course.

We require students to complete the Introduction to MasteringChemistry assignment, a Math Review assignment using the math tutorials available in the item library, and 10 additional assignments—one for each of the chapters we cover. We use a mix of tutorial and end-of-chapter problems, and we target our chapter assignments to take about three hours to complete, based on the database median time-to-completion statistics. We allow students four attempts for each problem.

We review the available diagnostics, particularly student time, item score, and student score, to monitor student progress and engagement, as well as to identify common misconceptions that may need clarification.

Assessments
60 percent Exams (three)
25 percent Final exam
10 percent MasteringChemistry homework
5 percent Participation (via classroom response system)

Results and Data
Students’ course grade distribution shifted noticeably after we implemented MasteringChemistry. As shown in figure 1, we had a significant increase in the percentage of students earning an A or B, and far fewer Ds and Fs. The drop/fail/withdraw (D/F/W) rate fell dramatically from 41.6 percent before implementation of MasteringChemistry to 30.2 percent after.

Conclusion
I credit the shift in grade distribution and the decrease in the D/F/W rate to three factors: use of MasteringChemistry, adoption of a Pearson textbook, and instructor effort. I believe students are learning more with the new system. We were initially concerned because fewer students were coming to office hours for help, but quickly recognized it was because they were receiving tutorial help from MasteringChemistry. In addition, student comments about the program have been very positive. But perhaps the strongest endorsement is the lack of student complaints.

We’ll be redesigning our general chemistry sequence for the 2012/13 academic year with more emphasis on recitation, but MasteringChemistry will remain 10 percent of the overall course grade.

Figure 1. General Chemistry Grade Distribution and D/F/W rates, 2009–2010

Key Results
Use of MasteringChemistry contributed to a positive shift in grade distribution and significant decrease in D/F/W.
Key Results

The highly reliable assessment (over 90%) of Mastering’s content means that instructors can be confident about the information they obtain from the program, and that they can use that data to effectively plan individual intervention or class instruction.

Study Design

A General Chemistry class was randomly selected from the MasteringChemistry database, the only criterion being that the course comprise at least 300 students and at least 60 assigned tutorial items throughout the semester. The random selection avoided any biases that would be introduced if the study was conducted explicitly to verify the reliability of assessment. The 80 tutorial items given throughout the semester were divided randomly into two sets of 40 items each. The average difficulty of a given set for a student was computed as a linear combination of the average values of time to first correct response, the number of incorrect responses given when feedback is absent (except “try again”), and the number of hint requests. The results were based on 347 students.

Results and Data

The correlation between the average difficulty of the first item set and the average difficulty of the second item set is about 0.85 yielding a high reliability of about 92%. The high correlation implies that about 72% of the variance is explained by the regression line. (The statistical uncertainty in the correlation is between 0.80 and 0.89 with high confidence, and therefore, we can be fairly confident that we would obtain higher reliability values under repeated measurement under similar conditions.)

Conclusion

Mastering content offers highly reliable assessment (over 90%) as evidenced by a study conducted at Massachusetts Institute of Technology. Such high reliability aids instructors by providing a high level of confidence in Mastering content and assessments in that information provided by Mastering, whether on an individual student or the class as a whole, is validated for further intervention and instruction.
Study Design

Engineering students must possess solid understanding of basic statics concepts in order to succeed in subsequent courses for which Statics is a prerequisite. MasteringEngineering was employed in a study to ascertain the effects of using an online homework system in a Statics course. Students were given a conceptual test, known as the Concept Assessment Tool for Statics (CATS), or the Statics Concept Inventory.\(^1\)

Developed by Frontiers in Education, the CATS was designed to identify student misconceptions in Statics. It contains 27 multiple-choice questions that focus on nine individual concepts\(^2\) (see table 1). The test has been taken by more than 2,500 students at more than 20 universities. It requires students to demonstrate conceptual understanding, but few computational skills are required.

The goal of the study was to examine individual item level difficulty during the pre- and posttests and then compare the differences using an item response model. Students were given the Concept Assessment Tool for Statics test twice during the course: once at the beginning as a pretest and once at the end as a posttest. Although each item was analyzed for the study, this abstract reports only on the findings around the general concepts to which the individual items belong.

Results and Data

When compared to the pretest stage, 93% of the items in the Statics Concept Inventory showed decreased difficulty in the posttest stage—an indication that students experienced learning gains in the concepts assessed via the items by the end of the semester. Figures 1 and 2 show the concept difficulties assessed by an item response model at the pre- and posttest stages. The difficulty is in standard deviation units where 0 means average difficulty and +1, for example, means a difficulty level of one standard deviation above average.

The change of concept-level difficulty from pre- to posttest is presented in table 2 and in figure 3. Negative values indicate that the concepts became easier at the posttest stage as compared to the pretest stage. All concepts, with the exception of friction, showed a reduction of difficulty by the end of the semester compared with students’ understanding at the start of the semester.

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1 For information on the Concept Assessment Tool for Statics, visit http://engineering-education.com/CATS/intro.htm.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FBD</td>
<td>Separating bodies and recognizing forces</td>
</tr>
<tr>
<td></td>
<td>3rd Law</td>
<td>Newton’s third law</td>
</tr>
<tr>
<td></td>
<td>Static Eq.</td>
<td>Static equivalence of force and couple systems</td>
</tr>
<tr>
<td></td>
<td>Roller</td>
<td>Force between a roller and contacting body</td>
</tr>
<tr>
<td></td>
<td>Slot</td>
<td>Force between a pin and body with a slot</td>
</tr>
<tr>
<td></td>
<td>Neg. Fric.</td>
<td>Contacting bodies with negligible friction</td>
</tr>
<tr>
<td></td>
<td>Repres.</td>
<td>Representing forces with variables and vectors</td>
</tr>
<tr>
<td></td>
<td>Friction</td>
<td>Friction force at most equal to slipping limit</td>
</tr>
<tr>
<td></td>
<td>Equil.</td>
<td>Conditions of equilibrium</td>
</tr>
</tbody>
</table>

Table 1. The nine unique statics concepts included in the Statics Concept Inventory.

Figure 1. Concept difficulties at the pretest stage.

Figure 2. Concept difficulties at the posttest stage.
### Table 2: Changes in concept-level difficulty from pre- to posttests in standard deviation units.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Abbreviation</th>
<th>Difficulty Change from Pre- to Posttests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>FBD</td>
<td>-1.30 ± 0.28</td>
</tr>
<tr>
<td>2</td>
<td>3rd Law</td>
<td>-0.79 ± 0.44</td>
</tr>
<tr>
<td>3</td>
<td>Static Eq.</td>
<td>-0.42 ± 0.36</td>
</tr>
<tr>
<td>4</td>
<td>Roller</td>
<td>-1.84 ± 0.29</td>
</tr>
<tr>
<td>5</td>
<td>Slot</td>
<td>-0.82 ± 0.27</td>
</tr>
<tr>
<td>6</td>
<td>Neg. Fric.</td>
<td>-0.95 ± 0.40</td>
</tr>
<tr>
<td>7</td>
<td>Repres.</td>
<td>-2.08 ± 0.30</td>
</tr>
<tr>
<td>8</td>
<td>Friction</td>
<td>0.04 ± 0.28</td>
</tr>
<tr>
<td>9</td>
<td>Equil.</td>
<td>-0.64 ± 0.32</td>
</tr>
</tbody>
</table>

#### Conclusion

From the concept analysis, students showed learning gains in eight of the nine concepts. On average, the difficulty from pre- to posttest decreased about one standard deviation. This also indicates a skill gain of one standard deviation on average by the end of the course.

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**With acknowledgment to Prof. Manohar Arora, Colorado School of Mines.**
**EXPERIMENTAL STUDY: SCORE GAINS**

**COLORADO SCHOOL OF MINES**

Golden, CO

<table>
<thead>
<tr>
<th>Product Name</th>
<th>MasteringEngineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Name</td>
<td>Statics, Fall 2009</td>
</tr>
</tbody>
</table>

**Key Results**

Students who were not required to complete MasteringEngineering homework earned lower final exam scores on average and showed a wider range of scores than students who were required to complete MasteringEngineering homework.

**Study Design**

Prior to 2009, MasteringEngineering was not used in the Statics course. In fall 2009, MasteringEngineering and Hibbeler’s Statics, 12th edition were required for credit for online homework. Historical comparisons are feasible, since the course was taught by the same instructor with the same course goals. In both semesters students were assigned homework. In 2008, traditional homework was hand graded. In 2009, a new textbook and MasteringEngineering were assigned for online homework. The same final was used to compare the 2008 and 2009 results. Furthermore, during both years the final exams were marked by the same teaching assistants.

**Results and Data**

Students who used MasteringEngineering in fall 2009 showed an improvement of 0.7 ± 0.2 in effect size on the final exam when compared to fall 2008, in which MasteringEngineering was not used.¹ A total of 64 students took Statics in 2008 (without MasteringEngineering); a total of 69 students took the course in 2009 (with MasteringEngineering). Students who used MasteringEngineering earned an average score of 79% ± 8% on the final exam. In comparison, students who didn’t use MasteringEngineering earned an average score of 70% ± 16% on the final exam² (see figure 1).

Figure 2 illustrates the distributions of final exam scores with and without the use of MasteringEngineering. The score distribution without MasteringEngineering (dotted line) is left skewed (dragging the mean score down and towards the left) compared to the distribution with MasteringEngineering (solid line). That using MasteringEngineering shifted the mean scores from the left (lower mean scores) to the right (higher mean scores) indicates improvement in the test scores. In addition, the score distribution without MasteringEngineering shows wide variance. In contrast, after the use of MasteringEngineering, the student scores not only show a higher mean, but all students obtained relatively higher scores as indicated by the low variance.

¹ Generally, an effect size of 0.3 or less is considered small, and an effect size of 0.8 or above is considered large.

² Students in 2008 and 2009 were equally prepared for the Statics course. In 2009, students used Hibbeler’s Statics, 12th edition and MasteringEngineering for homework. In 2008, students used a different textbook and did traditional homework that was hand graded.
Conclusion

The use of MasteringEngineering in the fall 2009 Statics course resulted in score gains with an effect size of 0.7. Students who didn’t use MasteringEngineering obtained lower scores on average and showed a wider range of scores (from 30% to 100%). Students who used MasteringEngineering showed improvement not only on average, the entire class scored above 60%. Students who used MasteringEngineering in 2009 showed a 13% score gain on average relative to students who did not use MasteringEngineering in 2008.
### Key Results
MasteringEngineering saves time for the instructor and significantly increases student satisfaction, engagement, learning, and success.

### Text
*Engineering Mechanics: Statics, 13e, Russell C. Hibbeler*

### Implementation
Statics covers a two-semester course sequence that draws a variety of students, often with a wide range of math competency. Student enrollment has increased exponentially in recent years from approximately 60 students to close to 200 currently.

The course format is mainly problem-based learning and was developed when enrollments were smaller. Prior to 2011, there were two or three paper-and-pencil assignments each semester, plus a weekly tutorial session, where it was intended that the students would work on the assigned questions. Tutorial sessions were poorly attended. As a result, the general level of understanding was low, which was reflected in exam and course scores. In 2011, I began giving weekly not-for-credit paper-and-pencil assignments in an effort to increase attendance at the weekly tutorial sessions.

I piloted MasteringEngineering in the 2012 academic year. The previous statics courses had two lectures and one tutorial hour per week. The tutorial hour now takes place in a computer lab, with myself and four teaching assistants.

I had several reasons for adopting MasteringEngineering. First, with nearly 200 students, automated grading saved time. I also wanted students to engage more with the course material and to gain a broader understanding of the subject. In addition, being able to look in the gradebook and see who has and hasn’t done the assignments gives me an immediate snapshot of the engagement of the class. Plus, I wanted to update my teaching, and to have students feel that they were using technology for learning and were getting their money’s worth for tuition paid.

Each week, I assign approximately four, not-for-credit questions in MasteringEngineering, making sure they are relevant to the lecture and include a mix of tutorials to increase understanding and test their knowledge. I often briefly go over each question in the lecture preceding the tutorial, so students know what to expect. The idea is that they start the work in the tutorial session and complete it by the end of the week. It is not mandatory, but I let them know that I check the results. Although these questions don’t contribute toward the course grade, I email individuals who haven’t attempted any. If students demonstrate specific problems with the questions, I work those in class.

For credit, students have online homework consisting of eight questions in MasteringEngineering that they have two weeks to complete, a paper-and-pencil assignment, and one traditional exam.

All of the problems that have been assigned over the year are available to the students until the end of exams. I encourage them to use this and the study area of MasteringEngineering to review for the exam.

### Assessments
- **80 percent** Exam
- **15 percent** Paper-and-pencil homework
- **5 percent** MasteringEngineering homework
Results and Data

Figures 1 and 2 show an improvement in student performance after the implementation of MasteringEngineering, as indicated by an increase in both average course grades and pass rates. What’s more, there was an increase in student enrollment over this same period.

The Student Experience

The students are more engaged with the course content, and appear to be tackling problems much earlier than in previous years. A number of students have commented to me that they found MasteringEngineering to be an extremely useful tool.

Conclusion

MasteringEngineering is an excellent resource to improve student engagement and performance. Assigning tutorial problems weekly is a positive incentive to students, and instant access to students’ progress is a good way for me to identify less-motivated students. In addition, the online assignments are ideal for large courses and make it possible to quickly assess the weekly assignments.

With careful planning, MasteringEngineering can augment lecture material and improve learning week by week. The first year of implementation presented a learning curve, but I now feel extremely confident with the program and look forward to tweaking the assignments this year.

Submitted by Catherine Dobson
University of Hull
The goal of Earth Systems Science is to offer each student a better appreciation and understanding of planet Earth through an earth-systems approach to studying the planet. This includes all of the Earth’s spheres—the atmosphere (weather and climate), hydrosphere (water in all its forms), lithosphere (earth’s surface), and biosphere (living plants and animals). Students of any major take this course. It includes both a lecture and lab.

I am a proponent of active and self-guided learning, and believe that students need continuous interaction with the materials to succeed in the course. In spring 2012 I adopted MasteringGeography because it includes resources to help achieve those goals. I assign MasteringGeography prelecture homework and postlecture quizzes for each chapter that we cover. The assignments include reading questions, end-of-chapter questions, and tutorials.

Assessments
- 66 percent: Exams (three at 22 percent each)
- 20 percent: Lab
- 9 percent: MasteringGeography homework
- 5 percent: Lab exam

Results and Data
To understand the impact that MasteringGeography had on my course, I analyzed my students’ results and found a positive correlation between MasteringGeography scores and the final course grade. Student scores on MasteringGeography predicted half of the variation in final course grade, despite MasteringGeography assignments accounting for only nine percent of students’ final scores (see figure 1).

The results also showed that more than 99 percent of students who completed their MasteringGeography assignments with an average of 80 percent or higher successfully completed the course with a final grade of A, B, or C.

In addition, I conducted a student survey which indicated that students overwhelmingly believe that MasteringGeography benefitted them in the course, and that they would recommend the use of Mastering courseware in all available courses (see table 1).

![Figure 1. Correlation between MasteringGeography Scores and Final Course Grades, Spring 2012 (n=168, r²=.50)](image-url)
The Student Experience

My students report the benefits of MasteringGeography as: 1) providing the flexibility to work when they want, 2) being able to interact with the material as often as needed and in different formats, and 3) identifying what is important based on what is assigned.

In a 2012 survey, students were asked what they liked best about MasteringGeography. Their comments included:

- “[MasteringGeography] explained the material in a different way than in class—it helped me understand the concepts that were difficult to comprehend.”
- “I loved the study sections. They really helped prepare me for the test. The practice greatly helped me to understand the materials.”
- “I liked that the quizzes and assignments gave me hints and explained where to look in the book when I didn’t understand something. I also liked the interactive animations.”

Conclusion

Based on the positive course results and student feedback for MasteringGeography, I will use it again in spring 2013. In addition, I adopted MasteringEnvironmentalScience for my fall 2012 Introduction to Environmental Geosciences course.

To further increase my students’ incentive for active learning and to help achieve my goal of flipping the classroom, in spring 2013 I will increase the number of credits earned by completing MasteringGeography homework and quizzes. I also plan to decrease the amount of in-class time spent lecturing and increase the amount of time devoted to interactive learning activities, including discussions, debates, and small group projects on data analysis and interpretation.
Implementation

World Regional Geography is a survey of the world’s regions emphasizing the spatial arrangements of resources, population, institutions, economic activities, and cultural landscapes, and their significance for distinctive regional problems. Students of any major may take this course. Both traditional face-to-face and online sections are offered. My goal in this course is to motivate students to explore course materials through self-guided learning, prompting more critical thinking and a deeper understanding of complex concepts.

I tested MasteringGeography during the summer of 2011 and adopted it for the fall 2011 semester. I like to use a wide range of activities to expose students to multiple approaches for learning course concepts—MasteringGeography provides the resources to accomplish that goal.

I make all MasteringGeography assignments available to my students at the beginning of the semester, and they are made unavailable two days before the corresponding exam. I give one homework assignment per chapter and include end-of-chapter, coaching, map, and video exercises. I use the item difficulty diagnostics to help select assignment problems.

Assessments

80 percent Exams (four)
20 percent MasteringGeography homework

Results and Data

Since we rotate teaching the course, I compared course results from fall 2011, my first full semester using MasteringGeography, to my last semester teaching the course without it in 2009. The results show that after using MasteringGeography, As and Bs increased and Cs, Ds, and Fs decreased. See figure 1.

“...It appears that effort and performance on MasteringGeography homework is a strong predictor of success in the course.”

In addition, there is a strong correlation between students’ MasteringGeography homework scores and their final course grades (see figure 2). It appears that effort and performance on MasteringGeography homework is a strong predictor of success in the course.

• More than 97 percent of students who scored at least 70 percent on the homework completed the course with an A, B, or C.
• Students who received a D or F in the course averaged a score of 50 percent on their MasteringGeography homework.

Key Results

Students are more engaged with the interactive resources in MasteringGeography and explore the concepts more fully outside of class, resulting in higher levels of learning, retention, and student success.
The Student Experience

I find that my students overwhelmingly enjoy learning with MasteringGeography. They like to be exposed to the content in different formats, and find the interactive videos and map exercises more engaging than looking at the content in a print book. After adopting MasteringGeography, I saw both student interest and retention improve, along with course grades.

Conclusion

MasteringGeography facilitates self-guided learning as it’s online and asynchronous, and students are able to work at their own pace. When students are able to spend time interacting with the course materials in different formats, they come to class better prepared. This, in turn, frees up class time because I needn’t cover all of the concepts in lecture, and enables me to focus on more difficult concepts and to integrate more active learning.

Submitted by Christopher Sutton
Western Illinois University
Implementation
The General Microbiology course was developed in 2010 and is designed for biology, preprofessional, and prenursing majors. It is a traditional course, and includes one lecture and two labs per week.

I adopted MasteringMicrobiology when the course was developed because I believe regular engagement with course material is important for students, and MasteringMicrobiology helps students know how they are doing.

Spring 2012 was the third semester that I taught the course. By then I was more familiar with the MasteringMicrobiology content and regularly assigned homework. My course consisted of a lecture, covering possibly multiple chapters, followed by a MasteringMicrobiology homework assignment comprising interactive tutorials and end-of-chapter questions, and lab time. I also added my course learning outcomes to the MasteringMicrobiology course.

Assessments
47.5 percent Lab
30 percent Exams
12.5 percent Final exam
6 percent MasteringMicrobiology homework
4 percent Participation (clickers)

Results and Data
An analysis of student final course grades from the spring 2012 semester showed that those students who did better on their MasteringMicrobiology homework also performed better in the course.

- 75 percent of those students who earned an A in the course averaged a score of at least 80 percent on their homework.
- 70 percent of those students who earned a B in the course averaged a score of at least 80 percent on their homework.
- Those students who passed the class with an A, B, or C in the course averaged a score of 80 percent on their homework.
- Those students who did not pass the class averaged a score of 31 percent on their homework.

The study also showed that student final exam scores had a significant, positive correlation with the MasteringMicrobiology homework scores. See figure 1.

An assessment based on the incorporated learning outcomes was given at the end of the semester in MasteringMicrobiology. This assessment also showed a positive correlation with final exam scores. See figure 2.
The Student Experience
Students have access to computers in the lab and use their extra time there to log into MasteringMicrobiology. They enjoy having a tool to help them be productive and use it to do homework and watch animations. Once one student logs in and starts working in MasteringMicrobiology, more follow. It’s like positive peer pressure. They all want to succeed, and they know that MasteringMicrobiology can help them do so.

Conclusion
MasteringMicrobiology can predict a student’s success based on the effort that student puts into the MasteringMicrobiology homework. If a student completes the homework consistently, his or her homework scores and final grade will reflect the effort.

Submitted by Denise Foley
Santiago Canyon College
Key Results

Students who use the MasteringPhysics tutorials demonstrated repeatable learning and near-term problem solving transfer as measured by the time to completion of problems, the number of errors made, and the number of hints requested on follow-up problems.

Study Design

After the first six weeks of the semester, the ~430 students in Introductory Newtonian Mechanics were divided, based on homework scores, into two equally skilled groups. The groups were given related tutorial problem pairs, which both entailed the same concepts and methods, that they solved in opposite order relative to each other without any intervening problems (e.g., if problem A was presented to one group followed by problem B, then problem B was presented to the other group followed by problem A. Thus, one group was unprepared for problem A while the other group was prepared for it by having solved problem B, and vice versa. The two groups were named prepared and unprepared relative to a tutorial problem pair under consideration. Six problem pairs were assigned for credit in the concept domains of linear momentum, angular motion, energy conservation, gravitation, rotational dynamics, and torque. See figure 1. (For details, see R. Warnakulasooriya, D. J. Palazzo, and D. E. Pritchard, Evidence of problem-solving transfer in Web-based Socratic tutor, Proceedings of the 2005 Physics Education Research Conference, pp. 41–43; R. Warnakulasooriya, D. J. Palazzo, and D. E. Pritchard, Time to completion of Web-based physics problems with tutoring, Journal of the Experimental Analysis of Behavior, 2007, 88, pp. 103–113.)

Results and Data

Three results were noted.

1. The prepared group solved a given problem on average $15 \pm 3\%$ more quickly than the unprepared group. This effect was observed across the six concept areas and hence on all of the 12 problems, providing robust evidence of learning from a prior problem leading to problem-solving transfer. See figure 2.

2. The prepared group requested $15 \pm 6\%$ fewer hints on a given problem compared with the unprepared group.

3. The prepared group made $11 \pm 3\%$ fewer errors on a given problem compared with the unprepared group. See figure 3.

Figure 1. The rate-of-completion graphs for a tutorial problem for the prepared and the unprepared groups plotted against the logarithmic time, where the time to completion is measured in seconds. For the prepared group, the peak rate of completion is shifted toward shorter times compared with the unprepared group.
With acknowledgment to Prof. David E. Pritchard, Massachusetts Institute of Technology.

"Quickness" was determined by finding the time at which the highest rate of completion for the respective groups was observed and calculating the difference. Time to completion is defined as the time between the first opening of a problem and the submission of the completed problem in that all the main parts of a given problem were answered correctly without any log ins/log offs.

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Study Design
Sixty-four MasteringPhysics tutorial items given throughout the semester were randomly divided into two sets of 32 items each with one problem on a given conceptual domain in each. The average difficulty of a given set for a student was computed as a linear combination of the average values of time to first correct response, number of incorrect responses given when feedback is absent (except “try again”), and number of hint requests. The results were based on 325 students.

Results and Data
The correlation between the average difficulty of the first item set and that of the second item set is about 0.92 yielding a high reliability of about 96%. The high correlation implies that about 85% of the variance is explained by the regression line (see figure 1). In contrast, a similar study for problems in a paper-based final exam accounted for about 40% of the variance. (See D. E. Pritchard and E. S. Morote, Reliable assessment with CyberTutor, a Web-based homework tutor, World Conference on E-Learning in Corporate, Government, Health, and Higher Education, 2002, pp. 785–791.) Thus, MasteringPhysics data such as time to first correct response, number of incorrect responses without feedback, and number of hint requests, can be used to reduce the measurement error by a factor of two. (The statistical uncertainty in the correlation is between 0.89 and 0.93 with high confidence. We can be fairly confident that we would obtain higher reliability values under repeated measurement under similar conditions.)

Conclusion
Mastering content offers highly reliable assessment (over 90%) as evidenced by the aforementioned study. Such high reliability aids instructors by providing a high level of confidence in Mastering content and assessments in that information provided by Mastering, whether on an individual student or the class as a whole, is validated for further intervention and instruction.

Key Results
The highly reliable assessment (over 90%) of Mastering’s content means that instructors can be confident about the information they obtain from the program, and that they can use that data to effectively plan individual intervention or class instruction.
Study Design

The study is fundamentally observational in nature and falls into the category of retrospective data analysis. It consisted of analyzing student interaction data in MasteringPhysics where students were given online homework problems that typically consisted of two to four parts. A problem was considered copied if it was determined that a student answered all parts of that problem correctly without requesting any learning resources, such as hints from MasteringPhysics.

Results and Data

The researchers found that copying increased over the course of the semester, which they attribute to increased academic demands. They also suggest the need for social networks to mature over the course of the term to support copying.

Researchers found that students who tend to exhibit non-copying behavior—a majority—complete their homework in a timely manner by working “steadily over the three days prior to the deadline.” Students who exhibit repetitive copying behavior complete only 10% of the homework two days prior to the due date and complete the majority of the work (about 60%) during the final six hours. These students also submit 15% of their homework after the due date. The researchers conclude that overall, “students are more likely to copy a problem if it is more difficult, if it is later in the assignment, if they do it closer to the deadline, or if the assignment is later in the term.”

The most significant finding is the relationship between degrees of copying behavior and declining scores. As shown in figure 1, the average scores of all student groups identified in terms of the exhibited copying rate did not differ statistically at the onset of the semester as determined by the MBT pretest. However, by the “final exam, heavy copiers (>50% of problems copied) scored 1.3 standard deviations below the low-copying group of students.” The researchers concluded that a student who copied all of their homework would perform about two standard deviations below a student who did not copy at all, and, that “doing all assigned work is a surer route to exam success.”

Conclusion

Online homework copying can be identified via a combination of statistical and data mining methods, and students who exhibit copying behavior show distinct temporal patterns. Students who copy most perform about two standard deviations less than students who do not exhibit such behavior. A restructuring of the MIT course has resulted in a significant four-fold reduction in online homework copying. For information on how MIT restructured its course, see Patterns, correlates, and reduction of homework copying, Physical Review Special Topics: Physics Educational Research, 2010, Vol. 6, Issue 1, pp. 010104–11. http://prst-per.aps.org/abstract/PRSTPER/v6/i1/e010104.

With acknowledgment to Prof. David E. Pritchard, Massachusetts Institute of Technology.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Product Name: MasteringPhysics
Course Name: Introductory Newtonian Mechanics, Fall 2003

Key Results
Research has shown that the Mastering system data can predict students’ final exam scores with a correlation of over 0.6. This predictive ability provides instructors with the opportunity to provide personalized instruction for students at risk of failing the course.

Study Design
The students were assigned weekly MasteringPhysics homework and were given a paper-based final examination at the end of the semester. MasteringPhysics data for 236 students was applied to develop an algorithm that would take into account such variables as time to completion of an item, number of hint requests, and fraction of items solved in less than 2.5 minutes.

Results and Data
The algorithm that was developed by using data obtained via MasteringPhysics predicts the paper-based final exam score with a correlation of about 0.64. The correlation implies that about 40% of the variance in the final exam scores is explained by the regression line. The statistical uncertainty in the correlation is between 0.52 and 0.69 with high confidence. See D. E. Pritchard and R. Warnakulasooriya, Data from a Web-based homework tutor can predict student’s final exam score, ED MEDIA 2005: World Conference on Educational Multimedia, Hypermedia & Telecommunications, pp. 2523–2529.

Conclusion
The predictive ability of the Mastering platforms aids instructors in confidently assessing students at risk of failing the course and provides the necessary remediation. “[Given the fact that a student is being assessed] over the course of the semester over several hundreds of problems with many variables that directly correlate with [the student’s] skill, it gives [a] better way to deal fairly with a student’s actual skill. This eliminates the high-stakes nature of a final exam. Given such assessment capabilities, teachers could confidently determine a student’s skill without worrying about the one who miraculously passed, deserved to pass, or failed, just because of some ‘bad luck.’”

Figure 1. Correlation between the predicted versus the actual final exam score for 236 students at Massachusetts Institute of Technology in fall 2003 using MasteringPhysics.

1 This is comparable to the ability of the SAT math scores to predict freshman grade point averages, for which the correlation is about 0.5. Correlation values above 0.6 are generally considered as high while those below 0.3 are considered low.

2 D. E. Pritchard and R. Warnakulasooriya, Data from a Web-based homework tutor can predict student’s final exam score, ED MEDIA 2005: World Conference on Educational Multimedia, Hypermedia & Telecommunications, pp. 2523–2529.

With acknowledgment to Prof. David E. Pritchard, Massachusetts Institute of Technology.
Implementation
All first-year physics students take Dynamics as a core course during their first semester. The students’ previous knowledge and experience varies—some have not taken any mechanics classes; others may have taken as many as four or more.

Prior to 2006, Dynamics was taught in the traditional manner—two one-hour lectures per week, a weekly workshop, and small group tutorials. It suffered from relatively poor examination results and mediocre student feedback. In 2006/07, we changed the delivery of the course via student-centered teaching techniques, including modified Just-In-Time Teaching, e-learning, and e-assessment. For the latter, we used MasteringPhysics.

Qualifiable goals included increased student engagement and personal responsibility for learning; a change in student attitudes toward learning from wanting to be “spoon fed” to constructing their own understanding; and deep conceptual understanding rather than learning to pass exams. Quantifiable goals included increased student examination scores.

Assessments
We replaced the two traditional lectures with one overview lecture at the beginning of each week that introduces students to the material they need to study that week. After the lecture, the students construct their own understanding by studying the course material online in our virtual learning environment. A rich suite of e-learning material is provided, including more than 50 “talklets” (mini PowerPoint presentations with voiceovers) and numerous “physlets” (Java applets). Once students feel that they understand the material, they complete a four- to six-problem MasteringPhysics assignment.

Students submit weekly assignments by 9 a.m. each Friday. We use MasteringPhysics to analyze student performance and identify concepts and problems with which they are struggling. From this, we select the content of the Just-in-Time Response and Problem sessions. For these sessions, the cohort is divided into four groups, and the students work problems in the areas of difficulty revealed by the MasteringPhysics assignment. Students are encouraged to discuss problems, and each group is supported by an academic staff member and a postgraduate assistant.

Results and Data
Students were not enamored with MasteringPhysics during the first year and student feedback was poor. By removing the American notation and adding hints to the end-of-chapter problems, we greatly enhanced student satisfaction.

• In a 2009/10 poll, 49 percent of students rated MasteringPhysics as the most valuable aspect of the course in terms of aiding their learning.

• Generally, more than 90 percent of students submit the weekly MasteringPhysics assignments—a significantly better submission rate than that obtained for the weekly tutorial work.

Examination performance has improved since the introduction of this integrated teaching approach.

• The average grade is approximately 10 percent higher.

• The failure rate has decreased significantly—from 32 percent to 5–14 percent in recent years.

Conclusion
MasteringPhysics has enhanced the delivery of our Dynamics course. The weekly MasteringPhysics assignments help ensure that students keep up with course material as it is delivered, rather than leaving their learning until just before the final examination. The assignments offer students an opportunity to practice problem solving, in addition to their tutorial work.

Submitted by Marion Birch and Niels Walet
The University of Manchester
Key Results

Students who used MasteringPhysics tutorials with hints and answer-specific feedback submitted significantly fewer incorrect responses and requested fewer answers on conceptually identical end-of-chapter questions than students who used the tutorials without the hints and feedback.

Text

*Physics for Scientists and Engineers: A Strategic Approach with Modern Physics, 2e, Randall D. Knight*

Implementation

Physics with Calculus is a traditional course taught on campus. Two sections are offered, each with an enrollment of approximately 200 students. In a study designed to quantify MasteringPhysics’ impact on learning transfer from tutorial questions to end-of-chapter (EOC) questions, students were divided into two groups of approximately 130 students each. Both groups received the same first three chapter assignments in MasteringPhysics, identifying no statistically significant difference in the two groups’ ability. In four subsequent assignments (Chapters 4, 6, 8, and 9), the first group (Tutorial Group) was given a series of preparatory items (MasteringPhysics tutorial items with hints and feedback), followed by two conceptually identical EOC questions. The second group (Nontutorial Group) received the same preparatory items (MasteringPhysics tutorials, but with the hints and feedback removed), followed by the same two EOC questions given to the tutorial group. The preparatory group that would receive tutorial instruction in one assignment would become the nonpreparatory or the nontutorial group on the next and vice versa. Thus, at the end of the study both student groups have received an equal number of tutorial and nontutorial assignments. All items were assigned for credit.

Assessments

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td>In-class computerized tests/exams</td>
</tr>
<tr>
<td>20%</td>
<td>MasteringPhysics homework</td>
</tr>
<tr>
<td>10%</td>
<td>Classroom response system</td>
</tr>
</tbody>
</table>

Results and Data

Students in the tutorial group submitted fewer wrong answers and requested fewer solution requests. During the preparatory phase, the tutorial group submitted fewer incorrect responses on 81 percent of the items. The average percentage reduction in incorrect responses per student due to tutorials is 10±4% (effect size = 0.2). See figure 1.

![Figure 1](image-url)
Similarly, the tutorial group submitted fewer incorrect responses on 63% of the EOC items (test phase). The average percentage reduction in incorrect responses per student due to tutorials in the test phase is 8±4% (effect size=0.1). See figure 2.

Since the items are identical in both the tutorial and nontutorial groups during the preparatory phase except for the scaffolding provided for the tutorial group, the reduction in solution requests for students in the tutorial group is indicative of learning from prior hints and answer-specific feedback within a given tutorial item. This effect is transferable from the preparatory phase to the test phase, although the effect diminishes by a factor of 0.6. The average percentage reduction in solution requests per student in the test phase due to having a tutorial as opposed to an identical nontutorial is 7±4% (effect size=0.3). See figure 4.

Conclusion

From a replication perspective, the results are encouraging in that the percentage reduction in errors-per-student due to tutorial preparation is similar to the previous observations (11±3%) made under a microlearning protocol (Evidence of problem-solving transfer in web-based Socratic tutor, Warnakulasooriya et al., Proceedings of the 2005 Physics Education Research Conference, Heron, McCullough, Marx (Eds.), pp. 41–43, American Institute of Physics). Hence the above is supportive evidence for the correctness of the previous conclusions of the reductions in incorrect responses due to tutorials. Furthermore, the reductions in errors observed under the test phase due to tutorials is encouraging since replication was not under identical settings but occurs after the relaxation of the previous protocol, in which the test phase included a tutorial item immediately following a preparatory tutorial.
Implementation

This is the first course of a 3- or 4-semester sequence of physics courses with calculus, designed for students in engineering, physics, geology, astronomy, chemistry, and some biological sciences. Students who take this course are generally planning to transfer to a four-year school.

In addition to requiring MasteringPhysics since 2005, I use the revised Force Concept Inventory assessment (I. Halloun, R.R. Hake, E.P. Mosca, and D. Hestenes), and consistently adhere to the following test protocol:

- The FCI is given on the first day of class to all students.
- The test is not graded until the end of the semester. I intentionally try not to “teach to the test.”
- Those students who remain in the class are given the same exam again during the last week of the semester.
- Both answer sheets are processed and compared, generating pre, post, difference, and normalized gain scores.

In 2008 I started using video clips for homework assistance, customizing MasteringPhysics homework problems, and offering extra credit for posting YouTube videos that helped explain key concepts.

Since 2009 I’ve used MasteringPhysics to create exam-review problem sets and to hold in-class competitions in which students race to complete sample, conceptual exam problems as a team.

Since fall 2011 I’ve had students complete two MasteringPhysics assignments per week: an introductory, prelecture assignment; and a more-traditional, comprehensive homework assignment comprising a mix of MasteringPhysics tutorials and end-of-chapter discussion questions, exercises, and problems.

Most recently, in spring 2012, I added homework quizzes—brief, one-problem, in-class quizzes focusing on a single problem from the weekly assignment.

Assessments

<table>
<thead>
<tr>
<th>Percentage</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 percent</td>
<td>Exams</td>
</tr>
<tr>
<td>20 percent</td>
<td>MasteringPhysics homework and quizzes</td>
</tr>
<tr>
<td>20 percent</td>
<td>Labs</td>
</tr>
<tr>
<td>12 percent</td>
<td>Discussion, group work, and class participation</td>
</tr>
<tr>
<td>8 percent</td>
<td>Research paper and presentation</td>
</tr>
</tbody>
</table>

Key Results

Force Concept Inventory (FCI) posttest scores have consistently risen with the use of MasteringPhysics, despite a decrease in FCI pretest scores during the same period of time.

"MasteringPhysics is the single best thing I’ve done to improve how I teach physics.”

Using only posttest results to assess student success is misleading, as students may enter the course already knowing the material. By normalizing the results, we’re able to compare overall student success in learning what they apparently did not know before.

1. Normalized gain is defined as the ratio of “corrected” answers compared to the total number of wrong answers on the initial pretest:

\[ ng = \frac{(posttest\ score) - (pretest\ score)}{30 - (pretest\ score)} \]
Results and Data

During the last four terms, FCI pretest scores have been comparable, and may even be starting to trend lower. During the same period, posttest scores have consistently risen. As measured by the FCI, student understanding of basic mechanics has improved. See figure 1.

Students using MasteringPhysics achieved larger normalized gains than did those in earlier years (see figure 2), and they also achieved larger normalized gains than those students in physics classes in which MasteringPhysics was not used as extensively (although there were many differences in approaches, as well). In addition, my second- and third-term students show much more aptitude tackling complex problems, and course completion rates are up approximately 10 percent compared to courses offered 10 years ago, in which MasteringPhysics was not used.

Due to the small number of courses taught during the examined timeframe, and to course enrollments of only 25–50 students, significant conclusions about specific causes and effects are impossible to quantify. Additionally, the many variables involved—including types of students, textbooks, changes in labs, and changes in approaches—make it inappropriate to suggest that MasteringPhysics alone has produced the trends observed. That said, as I use the program more and more—for lecture problems, remediation, exam preparation, and collaborative group work—I repeatedly witness its very positive impact on my students.

The Student Experience

Students report that the immediate feedback on homework assignments helps them feel more successful. In end-of-term anonymous surveys, more than 90 percent of students surveyed indicate that the use of MasteringPhysics is “important,” “very important,” or “most important” to their success.

Student comments include the following:

- “I used hints for some problems, and that helped me solve [for] the correct answer. I really like those hints that remind us to think about the sign or asks if a certain force or variable matters in the problem.”
- “The MasteringPhysics homework helped me to understand the material better and to manage my time better. I liked having more than one chance to answer a question and getting hints when I was unsure.”

Conclusion

I’ve used MasteringPhysics for more than six years and I’m convinced that it has significantly improved both my teaching and my students’ learning. I now know what my students know, what they don’t know, and why. Time that was once spent grading homework now is used for improving my lectures and labs. Plus, I’ve seen better questions asked in lecture, more-active participation in labs, and slightly better exam scores. Perhaps most important, many more students seem to feel that they have the opportunity to succeed. I believe that is a direct reflection of the outstanding pedagogy inherent in the MasteringPhysics program.

Submitted by Scott Hildreth
Chabot College
GEORGIA INSTITUTE OF TECHNOLOGY

Product Name: MasteringPhysics
Course Name: Physics II: Electricity and Magnetism
Credit Hours: Four

Key Results: Students are more motivated to spend their time and effort on for-credit MasteringPhysics problems than they are on practice problems. The increased amount of engagement results in better performance in the course.

Text

Physics for Scientists and Engineers: A Strategic Approach, 2e, Randall D. Knight

Implementation

This second-semester, calculus-based course for Introduction to Physics covers electromagnetism, applications of electromagnetism, and light. Course goals include teaching students basic electromagnetism at the conceptual level and helping them develop problem-solving skills to apply to future studies. The course is primarily composed of engineering students, plus some science and a few physics majors; and comprises a lecture and lab.

We began using MasteringPhysics in fall 2004. We adopted MasteringPhysics because we believed the tutorials would help students learn needed problem-solving skills.

MasteringPhysics homework consists of a for-credit assignment corresponding to each class meeting. These assignments include tutorial questions and a few end-of-chapter questions. In addition, students are assigned a weekly, not-for-credit, practice assignment, which contains primarily end-of-chapter questions.

Because the practice homework is not for credit, some students assume that it is optional. We examined how much time students spend on for-credit MasteringPhysics homework compared to the amount they spent on not-for-credit practice problems. Our analysis showed that students overwhelmingly spend more time on for-credit work than on not-for-credit work—and that those students who spend more time on MasteringPhysics homework perform better in the course. See figure 1.

We also looked at data from more than 3,000 students from 2004–2008 to see how well students did in the course based on the percent of practice homework assignments attempted.

Assessments

50 percent Quizzes (weighted average of five)
25 percent Final exam
10 percent Laboratory
5 percent MasteringPhysics homework

5 percent Recitation
5 percent Class participation

Results and Data

We looked at the amount of time students spent on for-credit MasteringPhysics homework compared to the amount they spent on not-for-credit practice problems. Our analysis showed that students overwhelmingly spend more time on for-credit work than on not-for-credit work—and that those students who spend more time on MasteringPhysics homework perform better in the course. See figure 1.

We also looked at data from more than 3,000 students from 2004–2008 to see how well students did in the course based on the percent of practice homework assignments attempted.
We did not look at the grade of the practice homework, but rather that it was opened and attempted. Our results show a positive correlation between the percent of practice homework attempted and the average course grade point average. See figure 2.

In this same analysis, we found the following:

- 51 percent of students attempted less than 25 percent of the practice problems. Of those 51 percent, 48 percent earned a final course grade less than 60, and only 17 percent earned a final course grade higher than 75.

- 18 percent of students attempted more than 75 percent of the practice problems. Of those 18 percent, 24 percent earned a course grade less than 60, and 40 percent earned a final course grade higher than 75.

The Student Experience

Each year we ask those students who have achieved an A in Physics II to advise incoming students on how to succeed in the course. Below are some of their comments.

- “Make sure that you do the homework in its entirety because it is the best way to reinforce and even learn the lecture material. We all know the answers to the homework questions are available online if you know where to look. Take some advice from someone who didn’t use those answers and earned an A in the class: the homework assignments are the most valuable learning tool provided to you; don’t squander this tool by cheating just to finish a little early or to get a 100.”

- “I probably spent longer than most working on the homework, but that was how I learned everything.”

- “The homework definitely helped me a lot. It was great practice between tests, and that made studying for the actual tests a lot easier. As long as you seriously work through every problem by yourself (hints are helpful), you can learn and retain a lot of material.”

Conclusion

Students who put more time and effort into doing MasteringPhysics problems perform better in the course. We have found that, on average, students who ignore the not-for-credit, practice assignments can expect to score lower on both the quizzes and the final exam—and will likely earn a lower final course grade.

Submitted by Eric Murray and Martin Jarrio
Georgia Institute of Technology
Best Practices: 8 steps to success with your Mastering implementation

The institutions included in this report did more than simply add Mastering to their curricula. How they used the program significantly contributed to their positive results. Below you’ll find eight recommended best practices that will help both you and your students get the most out of your Mastering implementation.

1. Schedule a First Day of Class presentation.
First Day of Class presentations facilitate a seamless registration and enrollment process. Contact your local Pearson representative or visit www.firstdayofclass.com for more information.

2. Set student expectations.
Students’ attitudes toward Mastering homework typically progress from skeptical to accepting to enthusiastic. On end-of-term surveys, 90 percent of students report that Mastering is their preferred method of doing homework. Point students to the “Five ways to improve your grade” link on their course home page and emphasize that students who embrace Mastering score higher on exams.

3. Require students to complete the Introduction to Mastering assignment.
The Introduction to Mastering assignment teaches students how the hints work, how to enter answers, and how they can expect to be graded. This introductory assignment appears automatically upon course creation.

4. Require Mastering for a minimum of 10 percent of the final course grade.
Pearson usage statistics and survey responses indicate that more than 90 percent of students complete assignments that contribute significantly to their grade. By contrast, typically fewer than 10 percent of students do optional assignments.

5. Assign as many course-appropriate coaching/tutorial activities as practical.
Mastering’s tutorials and coaching-type activities provide immediate, answer-specific feedback and optional hints, which coach students through the toughest topics and help them learn from their mistakes. These items, plus end-of-chapter and test bank problems, offer students opportunities for both learning and assessment.

6. Use the recommended grading settings.
Although fully customizable, Mastering’s default grading and presentation settings promote active learning and motivate students to think, work, and learn.

7. Use Mastering’s one-click diagnostics.
Mastering’s diagnostics can help you identify each assignment’s most difficult topics and your students’ most common misconceptions. Use this information to inform your lectures and to compare your students’ performance to the system average.

8. Rely on the Pearson community.
Turning to a Pearson representative, learning technology specialist, or technical support when you need help will ensure a positive experience for both you and your students. For peer-to-peer support, consult with an expert Mastering user via the “Ask an Expert Mastering User” link on your course home page.
Glossary of Terms Used in this Report

To ensure clear and consistent understanding of the terms used in this report, we have taken the liberty of defining several of them here. Please note that these definitions are simply for the purposes of this report and do not necessarily reflect either official or dictionary-true versions.

Case study is a data-supported report of success—such as increased exam scores, improved retention, or higher post-test gains—with supporting qualitative evidence of improved learning, engagement, or readiness.

Completion rate is the percentage of students who registered for a course and completed the course through the final exam, excluding those students who officially dropped (withdrew from) the course. This is also called the retention rate.

Course redesign is the process of restructuring how the content of a course is delivered. It involves redesigning a whole course (rather than individual classes or sections) usually to achieve better learning outcomes, often at a lower cost. This usually is done by taking advantage of the capabilities of technology. Course redesign is most effective in large-enrollment courses.

Distance-learning course is a course where students do not have regular face-to-face class meetings and do not have to maintain a regular presence on the particular campus that is granting the credit. Most if not all learning activities are conducted online. This type of course is also called an online course.

Drop/fail/withdraw (D/F/W) rate is the percentage of students who register for a course and at the end earn a grade of D, F, or W (drop, fail, or withdraw) in the course.

Experimental study is an observational or controlled study that was designed and conducted to quantify Mastering’s impact on student learning. Attention has been paid to possible confounding factors in drawing conclusions.

Hybrid course is a course that has some face-to-face classroom activities and some online activities.

Integrated use refers to the fact that an instructor makes a Mastering product a part of the syllabus and assigns work to be completed by the student.

Online course is a course where students do not have regular face-to-face class meetings and do not have to maintain a regular presence on the particular campus that is granting the credit. Most if not all learning activities are conducted online. This type of course is also called a distance-learning course.

Pass rate is the percentage of students whose final grade is A, B, C, or D. This is not the same as the success rate, which does not include the grade of D.

Required use means an instructor mandates the use of a Mastering product by students for an individual grade that is part of the final course grade. It is the opposite of optional use.

Retained students are those students who registered for and completed the course through the final exam. This excludes those students who officially dropped (withdrew from) the course.

Retention rate is the percentage of students who registered for a course and completed the course through the final exam, excluding those students who officially dropped (withdrew from) the course. This is also called the completion rate.

Subsequent success refers to the success that students experience in higher-level courses due in part to their having first successfully completed other, lower-level Mastering-supported courses.

Success rate is the percentage of students who registered for a course and earned a final course grade of A, B, or C. Note that a final grade of D is not included in the success rate.

Various formats refers to institutions’ using varied implementation models to teach with a Mastering product.
List of Contributors

Manohar Arora, Colorado School of Mines
Andrea Aspbury, Texas State University
Jo Barton, University of Essex
Louise Beard, University of Essex
Marion Birch, The University of Manchester
Robert Boyce, University of North Carolina, Wilmington
Leslie G. Butler, Louisiana State University
Dan Cernusca, Missouri University of Science and Technology
Jung Choi, Georgia Institute of Technology
Sandra J. Connelly, Rochester Institute of Technology
David V. Dearden, Brigham Young University
Catherine Dobson, University of Hull
Bruce Fisher, Roane State Community College
Kathy-Sarah Focsaneanu, University of Ottawa
Denise Foley, Santiago Canyon College
Valerie Freichs, University at Buffalo, State University of New York
David Garton, Georgia Institute of Technology
Abigail Goosie, Walters State Community College
Eileen Gregory, Rollins College
Randall W. Hall, Louisiana State University
William D. Heyman, Texas A&M University
Scott Hildreth, Chabot College
Martin Jarrio, Georgia Institute of Technology
Eric Murray, Georgia Institute of Technology
Amy Pope, Clemson University
Robert Pribush, Butler University
David E. Pritchard, Massachusetts Institute of Technology
Gerry Rayner, Monash University
Malia Rose, Ventura College
Emmalou T. Satterfield, Missouri University of Science and Technology
Tonya Shearer, Georgia Institute of Technology
Steven Socol, McHenry County College
Christopher Sutton, Western Illinois University
Stephen Testa, University of Kentucky
Niels Walet, The University of Manchester
Klaus Woelk, Missouri University of Science and Technology
Kayleen Young, University of North Carolina, Wilmington

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What Students Are Saying

Increased Understanding
“Helps me focus on what to study.”
—Student, University of North Carolina, Wilmington (p. 8)

“MasteringBiology provided the tools I needed to get a better grasp on more-difficult concepts. I could actually see the processes happening in videos and activities.”
—Student, Georgia Institute of Technology (p. 16)

“[MasteringGeography]” explained the material in a different way than in class—it helped me understand the concepts that were difficult to comprehend.”
—Student, Texas A&M University (p. 52)

“I probably spent longer than most working on the homework, but that was how I learned everything.”
—Student, Georgia Institute of Technology (p. 68)

Interactivity
“I wish our exams were as interactive as MasteringBiology. I love learning that way.”
—Student, Rochester Institute of Technology (p. 14)

“I used hints for some problems, and that helped me solve [for] the correct answer. I really like those hints that remind us to think about the sign or asks if a certain force or variable matters in the problem.”
—Student, Chabot College (p. 66)

Ease of Use
“The online assessments are a fun and interactive way to learn biology.”
—Student, University of Essex (p. 22)

More-effective Studying
“It seemed like there was a natural progression to the ideas presented that made going from one problem into the next less daunting. It made partial problems out of the steps in calculation so I always felt I was on the right track.”
—Student, McHenry County College (p. 30)

“The timed MasteringChemistry quiz was a major wake-up call! I had no idea how long I was taking to solve problems. It really opened my eyes and helped me prepare for exams!”
—Student, University of Ottawa (p. 34)

“MasteringChemistry was extremely helpful for learning concepts for exams.”
—Student, Missouri University of Science and Technology (p. 40)

“The MasteringPhysics homework helped me to understand the material better and to manage my time better. I liked having more than one chance to answer a question and getting hints when I was unsure.”
—Student, Chabot College (p. 66)

“More Mastering—’nuf said!”
—Student, Rochester Institute of Technology (p. 14)