

MyLab[®] & Mastering[®]

Science and Engineering

Efficacy Report 2015



MyLab & Mastering: Science and Engineering

Edited by Michelle D. Speckler

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Welcome Letter

We are pleased to share with you this fifth edition of *MyLab & Mastering: Science and Engineering, Efficacy Report*. At Pearson, we define *efficacy* as a measurable impact on improving someone's life through learning. We are embarking on a global education initiative and dedicating ourselves to the pursuit of efficacy and improved learner outcomes.

In the pages that follow, we tackle some of the most pressing issues facing educators today, including student engagement, identification of at-risk students, adaptive learning, and active learning and flipped classrooms. These issues also provide context for the 12 data-supported case studies in this white paper that illustrate successful Pearson technology implementations at both two- and four-year schools and across a variety of disciplines.

For more case studies, visit the **Pearson Results Library**, an online repository of more than 600 data-driven case studies quantifying the positive impact of MyLab & Mastering programs on metrics such as learning outcomes, retention, and subsequent success. This comprehensive database is cross-referenced by institution type, course format, state/province, and more.

We extend our gratitude to each contributing instructor. Every case study was submitted voluntarily and without compensation, and every instructor submitted his or her study and remained available for follow-up interviews. Their efforts are invaluable in helping Pearson achieve its efficacy mission. We invite you to contact us with any questions about this report, as well as to share your ideas, your best practices, and your own results. We are happy to provide both consultation and data collection tools to help you measure the impact of redesigning your course to include the MyLab & Mastering technology in your course.

We look forward to hearing from you.

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Pearson's Efficacy Program and Standards for Efficacy Research

At Pearson, we believe that learning is a life-changing opportunity, and that education should have a measurable, proven impact on learners' lives. It's what Pearson's efficacy program and tools are all about. They're how we measure and improve our likelihood of impact on learners and ensure we are doing all we can do to equip learners to succeed.

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 to verify the 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 PhD-level statisticians who provide practical advice about tracking and analyzing student data after the redesign of 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 (1) conduct efficacy studies, (2) provide our editorial staff with detailed reports on the quality of our online content, and (3) 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 studies 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. To maintain objectivity, Pearson does not offer compensation for participation in efficacy studies.

Research Standards

Pearson adheres to Software & Information Industry Association guidelines for evaluation of 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 betsy.nixon@pearson.com for more information.

Student Engagement

The National Center for Education Statistics of the US Department of Education reports that in fall 2006, approximately 59 percent of all first-time, full-time students who began earning bachelor's degrees at four-year institutions in the United States completed their degrees within six years.¹ Similar graduation and retention rates are found in science, technology, engineering, and mathematics (STEM) programs: 48 percent of bachelor's degree students and 69 percent of associate degree students who entered STEM majors from 2003 to 2009 left their majors by spring 2009. Roughly half of the students who left switched to non-STEM majors; the remainder left college entirely before earning degrees or certificates.² Lack of completion on such a scale has had adverse effects on both those individuals and society at large.

“Fewer American students are earning degrees in the STEM fields, medicine, and other disciplines critical to global competitiveness, national security, and economic prosperity.”

—Spellings Commission Report, a 2006 report commissioned by then-secretary of education Margaret Spellings on the state and future of American higher education³

Colleges and universities are paying attention: administrators and educators at institutions across the nation are drawing from both one another and the latest pedagogical research to find better ways of supporting their STEM students. Much of the conversation surrounds ways of increasing student engagement. But what exactly does *student engagement* mean? The National Survey of Student Engagement of Indiana University Bloomington defines it as representing two key components of the college experience: (1) the amount of time and effort students

put into their studies and other educationally purposeful activities and (2) how an institution deploys its resources and organizes its curricula and other learning opportunities to promote participation in activities proven to be linked to student learning.⁴

Because student engagement takes place both inside and outside the classroom and because technology is such an integral part of students' everyday lives, many instructors use interactive technology to engage their students. The degree of technology implementation ranges from optional to required and graded, to being a major teaching and learning component of courses.

The Higher Education Research Institute at the University of California, Los Angeles, conducts an annual survey taken by hundreds of two- and four-year-college students across the United States. The survey collects extensive information that can be used to develop a profile of incoming students. One section of the survey focuses on technology use connected with education. With open-source educational Web sites being used more and more frequently at the K–12 level, the survey finds that “Students were . . . much more likely to utilize these resources independently—almost seven out of ten (69.2%) incoming first-year students have used such sites ‘frequently’ or ‘occasionally’ to learn something on their own.”⁵ Today's students are already familiar with and motivated to use technology. The key is how to best implement technology in order to enhance student engagement so that retention and graduation rates improve.

Asst. Prof. Issa Salame of City College of the City University of New York conducted a study of an integrated model in his General Chemistry course using Peer Led Team Learning and MasteringChemistry. Results of the study were published in the *Journal of Academic Perspectives*.⁶ As part of the study, several

⁴<http://nsse.iub.edu/html/about.cfm>.

⁵<http://www.heri.ucla.edu/monographs/TheAmericanFreshman2013-Expanded.pdf>.

⁶Issa I. Salame and Nathan J. Hershberger, “Studying the Impact of Combining Online-Homework and Peer-Led Team Learning on Students' Attitudes and Performance in General Chemistry,” *Journal of Academic Perspectives* 2013;2:7. <http://www.journalof-academicperspectives.com/back-issues/volume-2013/volume-2013-no-2/>.

¹http://nces.ed.gov/programs/coe/indicator_cva.asp.

²<http://nces.ed.gov/pubs2014/2014001rev.pdf>.

³<http://www2.ed.gov/about/bdscomm/list/hiedfuture/reports/final-report.pdf>.

student questionnaires were administered that included the following questions:

- What did you appreciate most about the combined online homework [MasteringChemistry] and peer-led-team learning approach?
- List three things you found useful about the combined online homework [MasteringChemistry] and peer-led-team learning approach?

In both cases, MasteringChemistry's Hints, Guided Solutions, and Answers features had the highest number of favorable responses, followed by Practice Problems and then the human component. Students who struggle while studying or doing homework on their own need guidance in the moment of learning or there is a risk they will abandon the task. Salame's results indicate that engaging students via instant feedback can retain their attention and propel the learning process forward.

Salame's results indicate that engaging students via instant feedback can retain their attention and propel the learning process forward.

In their article "The Power of Feedback,"⁷ educational researchers John Hattie and Helen Timperley of the University of Auckland systematically investigate the impact of feedback, provide conceptual analyses of it, and review the evidence related to its impact on learning and achievement. Their evidence shows that although feedback is among major influences on learning and achievement, the type of feedback and the way it is provided can be differentially effective. They conclude that the data "demonstrated the most effective forms of feedback provide cues or reinforcement to learners; are in the form of video-, audio-, or computer-assisted instructional feedback." These are the types of feedback used in engaging and informing students in Mastering.

In their comprehensive book *Student Engagement in Higher Education: Theoretical Perspectives and Practical Approaches for Diverse Populations*, editors Stephen Quaye and Shaun Harper assess the different ways diverse populations of students experience college and the group-specific barriers to success those students encounter. Based on the 41 contributors' 540 cumulative years of full-time professional experience in various capacities at two-year and four-year institutions of higher education, the editors unequivocally state about students: "Those who are actively engaged in educationally purposeful activities, both inside and outside the classroom, are more likely than are their disengaged peers to persist through graduation. This assertion has been empirically proven and consistently documented by numerous higher education researchers."⁸

Each of the case studies that follow involves the implementation of a Pearson Mastering product as part of a greater course redesign. Each case study describes how the product was used and reports the resulting outcomes. Even though other variables not as easy to measure—such as motivation and effective study habits—can affect student learning, it is evident that students who engage and put forth effort in their courses both need and value the proper tools and resources to help them achieve success.

⁷John Hattie and Helen Timperley, "The Power of Feedback," *Review of Educational Research* 2007;77:81. <http://education.qld.gov.au/staff/development/performance/resources/readings/power-feedback.pdf>.

⁸Stephen John Quaye and Shaun R. Harper (eds.), *Student Engagement in Higher Education: Theoretical Perspectives and Practical Approaches for Diverse Populations*, 2nd ed., New York: Routledge, 2014, p. 49.

MasteringA&P

School Name [University of Houston, Houston, TX](#)
Course Name [Human Physiology](#)
Course Format [Lecture](#)

Key Results Students who used MasteringA&P to complete extra-credit homework earned significantly higher exam scores than students who did not use MasteringA&P.

Submitted by

Chad Wayne, Instructional Associate Professor

Course materials

Human Physiology: An Integrated Approach, Silverthorn

About the Course

The University of Houston is a public, four-year university serving approximately 40,000 students. The majority of students attend the university full-time, and approximately 40 percent receive Pell Grants.¹

Human Physiology is an upper-level biology elective course. It is a lecture course, with lab taken separately. Approximately 65 percent of the students who take the course are biology majors, 80 percent are juniors or seniors, and the majority plan to go into health or biological science fields. The course covers the integrated treatment of bodily functions from molecular to organismic levels. Course content is divided into four units:

- Plasma membrane and membrane transport, cell signaling, electrical signaling, the neuron, and the synapse
- The nervous system and muscles
- The cardiovascular and respiratory systems
- The renal, digestive, endocrine, and reproductive systems

Challenges and Goals

Associate Professor Chad Wayne wanted to address several challenges in his course, including student performance and withdrawal rates. He also sought to encourage more academic independence and content retention, as some students did not know how to study and were solely depending on lecture to prepare for tests.

Wayne believes that required homework is a poor way to assess understanding of course content, that students tend to see homework as busy work to finish as quickly as possible, and that they aren't motivated to use it as a tool to learn. On the other hand, he notes that students always ask for extra credit. Unlike required homework, students tend to see extra credit as a bonus opportunity—when given the opportunity to use extra credit for practice, he feels they tend to learn from it.

Implementation

Prior to fall 2011, Wayne did not include a MasteringA&P extra-credit option in his course. No homework was assigned, and final grades were determined by four exams. It was only after his students requested more practice problems to prepare for exams, in addition to end-of-chapter review questions, that he adopted MasteringA&P, which he chose in part because it requires neither extra lecture time nor hands-on grading.

He set up the program so students could work at their own pace. The program's automatic grading and immediate feedback enable his students to identify information they know from what they don't, develop critical-thinking skills, and make conceptual connections—all of which help improve their performance in the course.

Starting in fall 2011, Wayne offered a MasteringA&P extra-credit homework option for each unit of 200–300 questions that includes videos, tutorials, multiple-choice, true/false, and fill-in-the-blanks. Questions are randomized, and students have up to three attempts per question, with a minor penalty per attempt. The assignment is open until the morning of the applicable exam, and there is no time limit. His goal was for students to think through questions, not guess.

Students can add one extra point to each unit exam by earning at least 50 percent on an extra-credit MasteringA&P assignment, plus an additional point for every 10 percent earned above that

¹2013 Texas Public Higher Education Almanac, *Texas Higher Education Coordinating Board*, p. 43.

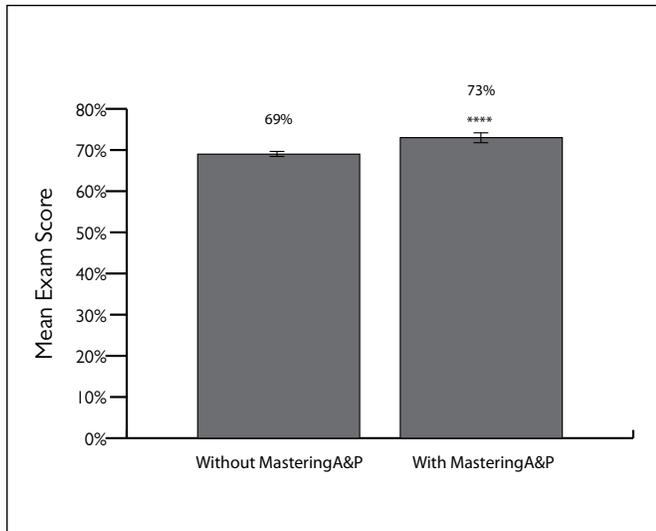


Figure 1. Mean Exam Scores for Students Not Offered MasteringA&P ($n = 812$) and Students Who Did MasteringA&P Extra Credit ($n = 605$) Error Bars = Standard Error, Significance **** $p < 0.0001$

to a maximum of five points for each exam. Students who earn less than 50 percent do not earn any extra credit.

Assessments

100 percent Exams (four)

Results and Data

Data was collected over the course of four years. Students who did not complete the course were not included in the results.

- A total of 1,647 students were in the study: 905 students were not offered MasteringA&P, 742 students were offered MasteringA&P extra credit.
- Of the students who were not offered MasteringA&P, 90 percent completed the course.
- Of the students who were offered MasteringA&P extra credit, 92 percent completed the course.
- Of the students who had extra-credit opportunities, 89 percent had recorded activity in MasteringA&P.

Analysis of exam scores for students who did MasteringA&P extra-credit assignments indicates that they had a significantly higher exam average than did students who were not offered MasteringA&P (Figure 1). Students who were offered MasteringA&P but did not earn extra credit were not included in the analysis.

In addition, data for students taking the course for the first time and students repeating the course for the second or more times was evaluated. For both first-time and repeating students,

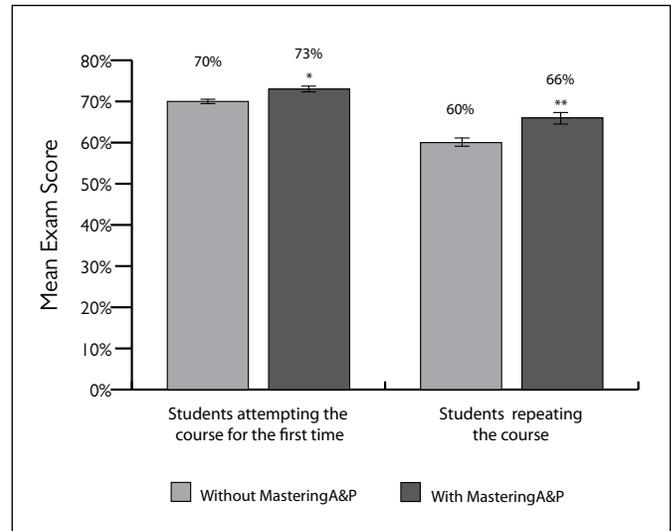


Figure 2. Mean Exam Scores Based on MasteringA&P Extra-Credit Participation and Course Repeat (without MasteringA&P: First Time, $n = 721$; Repeat, $n = 91$ / with MasteringA&P: First Time, $n = 571$; Repeat, $n = 34$) Error Bars = Standard Error, Significance * $p < .05$, ** $p < .01$

those using MasteringA&P had significantly higher exam scores. However, the gap in mean exam scores for students who were repeating the course using MasteringA&P compared with repeating students who were not offered MasteringA&P ($p = 0.002$) was larger than for students taking it for the first time with MasteringA&P compared with first-time students not offered MasteringA&P ($p = 0.02$) (Figure 2). Although repeating students still had lower exam averages than students taking the course for the first time, results indicate that MasteringA&P could help these students do better in the course.

The Student Experience

MasteringA&P extra credit continues to be offered to students. In fact, the participation rate has increased over subsequent semesters—students talk with each other on campus and tell others that the way to succeed in the course is to do MasteringA&P extra credit. Students like that they can work at their own pace and obtain feedback that helps them focus their efforts.

Conclusion

The question that Wayne was studying was whether or not students who regularly completed homework performed better on exams than students who did not. Evaluation of participation and performance rates shows that the majority of the students participated in extra-credit work and that exam scores have increased. Wayne plans to continue to study and evaluate the data and will report more findings in the future.

MasteringBiology

School Name University of Hawaii at Manoa, Honolulu, HI
Course Name Introduction to Biology II
Course Format Lecture

Key Results Students who consistently attempt MasteringBiology homework tend to have significantly higher exam scores than students who skip the homework.

Submitted by
Justin Walguarnery, Lecturer

Course materials
Campbell Biology, Reece, Urry, Cain, Wasserman, Minorsky, and Jackson

About the Course

The University of Hawaii System includes 10 campuses and dozens of educational, training, and research centers across the Hawaiian Islands. As the public system of higher education in Hawaii, the system enrolls more than 52,000 undergraduate students.

Introduction to Biology II is the second course in a two-semester sequence for life science majors. It is a three-credit lecture course, with a separate, concurrent lab. Both the lecture and lab courses use MasteringBiology. Topics covered include the anatomy, physiology, and systematics of plants and animals; behavior; and ecosystems, populations, and communities. This study encompasses only the lecture portion of the course.

Challenges and Goals

Large course enrollments make it difficult for Lecturer Justin Walguarnery to identify before the first exam students who are struggling or at risk. He believes that students need timely feedback to help identify the concepts they need to work on and resources to help guide them through the learning process. He implemented MasteringBiology to provide his students with immediate feedback and automatic grading *while* they do their homework, so they know where to focus remediation efforts.

Implementation

In fall 2013, Walguarnery used MasteringBiology for homework, with the goal of helping students review course concepts and prepare for exams. He gave three exams and assigned eight MasteringBiology homework assignments during the semester.

Walguarnery assigned a postlecture MasteringBiology assignment for each chapter covered. Assignments were posted at the end of each week on the topics covered during that week and consisted primarily of activity questions. Assignments were untimed, and students had until the end of the following week to complete them.

Assessments

40 percent	Final exam
40 percent	Exams (two)
15 percent	MasteringBiology
5 percent	Attendance

Results and Data

Data for the fall 2013 semester were analyzed, looking primarily at the course performance of students who attempted MasteringBiology homework assignments versus students who skipped one or more assignments (which was considered to be an assignment with a score of zero).

Figure 1 shows that students who skipped two or more out of eight MasteringBiology homework assignments earned statistically significantly lower exam averages than did students who attempted all the homework assignments.

The results of the analysis show the following:

- The average number of MasteringBiology homework assignments skipped was 1.8.
- Thirty-five percent of students attempted all of the MasteringBiology homework assignments and earned an average homework score of 92 percent.
- Forty-four percent of students skipped three or more MasteringBiology homework assignments and earned an average homework score of 47 percent.

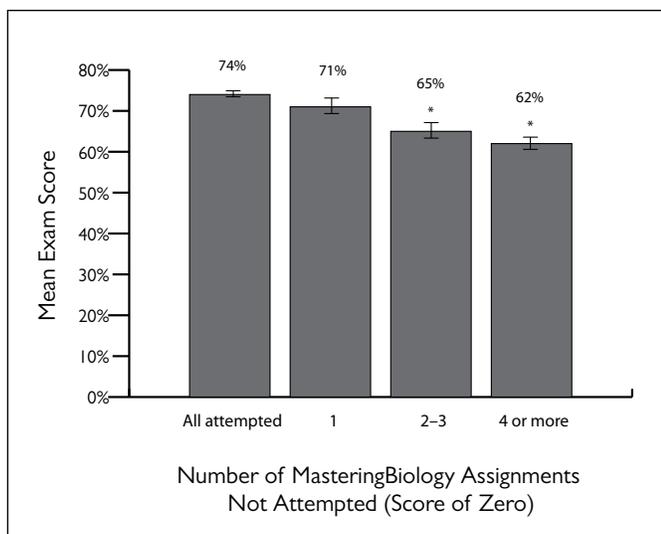


Figure 1. Introduction to Biology II Mean Exam Scores Based on Number of MasteringBiology Homework Assignments Not Attempted. Fall 2013 (All attempted, $n = 79$; 1, $n = 47$; 2-3, $n = 55$; 4 or more, $n = 43$. Error Bars = Standard Error. Bars with * indicate statistically significant difference from All attempted bar.)

To further understand the impact of skipped homework, individual unit exam performance was evaluated using the Exam I score as a baseline. Students were divided into two groups: the Low Exam I Group scored at or below the median (68 percent) for that exam, the High Performing Group scored above the median.

An evaluation of exam trajectories during the rest of the semester was done based on the number of MasteringBiology homeworks (HW) attempted after Exam I (a total of six for Exams 2 and 3), thereby dividing each group (Low and High Exam I) into a Low HW group (less than four attempted) or High HW group (four to six attempted). The following three key findings were observed (Figure 2):

- The Low Exam I groups (Low and High HW) are statistically equivalent on Exam I (as well as on HW prior to Exam I, not shown here). However, by Exam 3, the Low Exam/High HW group is statistically significantly higher than the Low Exam/Low HW group.
- The High Exam I/High HW group is statistically significantly higher than the High Exam I/Low HW group at baseline and at Exams 2 and 3, and this gap increases.
- By Exam 2, the High Exam I/Low HW group and Low Exam I/High HW groups are statistically equivalent.

The findings indicate a trend toward higher exam averages for students who put the effort into MasteringBiology homework despite initial performance on Exam I.

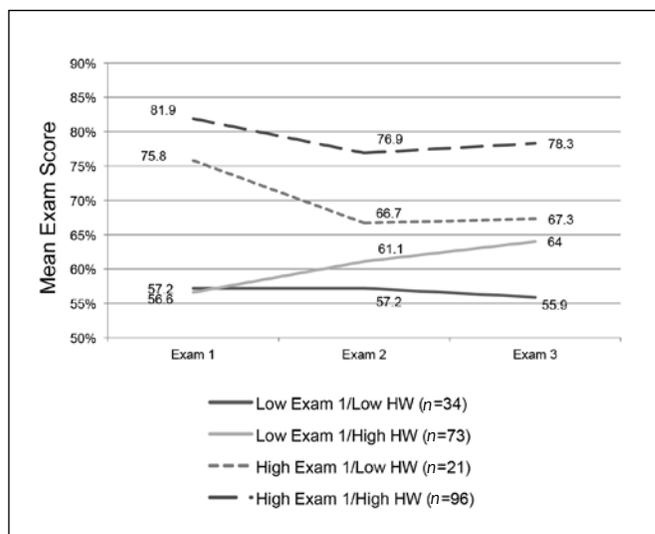


Figure 2. Exam Performance Based on Exam I Scores as the Baseline and Number of MasteringBiology Homework Assignments Attempted

The Student Experience

Student feedback on MasteringBiology has been positive. Comments include:

- “I liked the MasteringBiology homework assignments. They helped me prepare for the exams.”
- “I liked how [WValguarnery] made use of MasteringBiology for homework. It was a good and different way to do homework, compared to other courses.”
- “I liked MasteringBiology best.”
- “The online homework was easy, and helped with the understanding of the lesson.”

Conclusion

Large class sizes can make it difficult to identify students who are struggling, to understand what concepts they are struggling with, and to provide remediation in a timely manner. While motivation can impact student performance, having resources available for students to learn at their own pace and on their own time can be critical to the learning process.

Exam data show that students who put the effort into doing MasteringBiology homework tend to have significantly higher exam scores than do students who skip MasteringBiology assignments, and that the number of homework attempts may be a better indicator of success than Exam I performance.

MasteringChemistry

School Name **Butler University, Indianapolis, IN**

Course Name **General Chemistry II**

Course Format **Lecture and lab**

Key Results Average American Chemical Society exam percentiles increased when MasteringChemistry was used to help students develop study skills and gain content mastery.

Submitted by

Robert Pribush, Professor

Course materials

Chemistry, McMurry and Fay (as of fall 2013)

About the Course

Butler University is a four-year college serving approximately 4,000 undergraduate students. The majority of students attend full-time, with a graduation rate of 74 percent within six years (for the 2007 cohort). Ninety-one percent of full-time degree-seeking freshmen starting in 2012 were still enrolled in 2013.¹

General Chemistry is a two-semester course taught on campus with a lecture and lab component. Students who enroll in these courses are primarily prepharmacy, health sciences, and biology majors; other majors include premed, education, engineering, physics, and psychology. General Chemistry II covers chemical kinetics, solution chemistry, acid-base chemistry, chemical equilibrium, thermodynamics, and electrochemistry. Successful completion of General Chemistry I with a grade of C or better is a prerequisite to General Chemistry II.

Challenges and Goals

Professor Robert Pribush has taught this course for many years. His main goal for students taking the course is to help them master chemistry concepts. Because he understands the importance of study skills for continued success, he also focuses on helping his students develop skills that will help them become better lifelong learners; become more precise, careful, and conceptual problem solvers; and learn to honestly assess their performances in timely but nonintimidating manners.

In 2006, Pribush was concerned with his students' performance on the American Chemical Society (ACS) national standardized general chemistry exam, which is used as the final exam for

General Chemistry II. Student performance seemed to have peaked, and he sought a way to enhance content mastery. He also observed that many students appeared not to have been challenged in high school, resulting in a naive work ethic and poor understanding of how to succeed in college. To address the issue, he began emphasizing the importance of being active and responsible learners and promoting effective study skills.

Pribush implemented MasteringChemistry in fall 2007 with the intention of evaluating the effectiveness of the online, graded homework system on both content and study-skills mastery. He posited that if MasteringChemistry was effective, average ACS exam scores would increase and students would identify the program as a positive influence on their course success. Enrollment averaged 72 students per academic year (AY).

Implementation

MasteringChemistry is a huge part of Pribush's course: it is used for graded homework and to glean diagnostic data on student performance and student misconceptions that Pribush uses to evaluate overall learning both during and at the end of the semester.

Each semester, students are assigned approximately 87 graded MasteringChemistry homework assignments of 10 problems each (800–900 problems), with an assignment due for most chapter sections. Assignments take approximately one hour each and are due two days after the material is covered in class. Homework is a formative assessment tool, so course credit is assigned accordingly.

Assessments

64 percent	Exams (four)
16 percent	Final exam
16 percent	MasteringChemistry homework
4 percent	Laboratory/participation

¹http://www.butler.edu/media/3430095/cds_b.pdf.

Results and Data

During the period of this study, the same ACS exam was given and its results compared (Figure 1). Pribush made changes to how he implemented MasteringChemistry during this period of time, along with departmental and administrative changes, as follows:

- In AY 2007/08, the first year MasteringChemistry was used, ACS percentiles increased: students who used the program for one semester averaged a two-percentile increase; two-semester MasteringChemistry users averaged a seven-percentile increase.
- In AY 2008/09, Pribush promoted use of MasteringChemistry's hints during problem solving by changing the default settings to decrease penalties for opening them. He used the same textbook and MasteringChemistry assignments as the prior year, and results show a seven-percentile increase on the ACS exam.
- In AY 2009/10, Pribush focused on the metacognition/self-efficacy exercises in MasteringChemistry. One week before each exam, students were sent the learning outcomes associated with each exam question. They were instructed to match the learning outcomes with a homework assignment. Then, for each learning outcome, the students predicted how they would perform on the exam, and their predictions were compared with actual exam results. The average ACS exam scores were two percentile points higher than the previous year.
- In AY 2010/11, to equalize course enrollments among sections, registration was changed so that instructor names were not listed with specific sections. Pribush believes that he is perceived as a more-challenging instructor and that therefore he may have gotten better-academically-prepared students who were looking for a more rigorous class. After the change, he had a more diverse group of students in his sections. Results of the ACS exam decreased from the prior year but remained two percentile points above the final year that MasteringChemistry was not in use.
- In AY 2012/13, a textbook change was made. In addition, Pribush observed that more students were less academically prepared than in the past. There was a decrease in student performance on the ACS exam during this year, which prompted a review of the course and a decision to make changes in textbook and homework assignments for the next year.

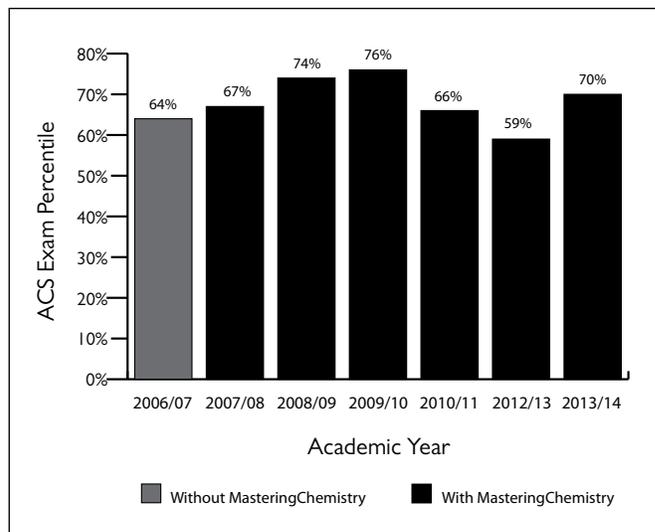


Figure 1. General Chemistry II American Chemical Society Exam Percentiles, Fall 2006–Spring 2011, Fall 2012–Spring 2014 ($n = \sim 504/\sim 72$ per academic year). No data was collected during academic year 2011/12 due to sabbatical.

- In AY 2013/14, the department switched to a textbook that more closely matched course goals and made a decision to make the higher-level chemistry courses more rigorous. As a result, students in the General Chemistry sequence needed to be better prepared in order to succeed in the more-advanced courses. Pribush began assigning higher-level MasteringChemistry problems in General Chemistry to develop students' critical-thinking skills in preparation for more-challenging courses. Results of the ACS exam show an increase of 11 percentile points over the prior year (six percentile points above the final year when MasteringChemistry was not in use).

Pribush believes that by addressing content needs for success in the program and by helping students develop the skills needed for learning, there has been a trend toward higher ACS exam scores since MasteringChemistry was implemented.

Student Resource	Rating
MasteringChemistry	1.3
Instructor	1.4
Lecture	1.5
Exams	1.7
Exam outlines	1.8
Learning objectives	1.9
In-class problem sessions	2.1
Lab lecture	2.5
Textbook	2.5
Solution manual	2.6
Working with classmates outside class	2.8
Lab experiments	2.8
Self-rating exercises	3.0
Group lab work	3.0
Online interaction with instructor	3.2
Lab assistant	3.3
Lab notebook reports	3.4
Instructor office hour	3.5
Former General Chemistry students	3.5
Other	4.2

Table 1. Student Ranking of Course Resources, AY 2009/10 ($n = 75$)
1 = Very Strong Impact, 5 = No Impact

The Student Experience

Students in General Chemistry II were asked to rate several course resources in terms of the impact they had on student understanding of course material, with 1 = a very strong impact and 5 = no impact. Students ranked MasteringChemistry as the highest resource out of 20 (Table 1).

Student comments about MasteringChemistry include:

- “MasteringChemistry can be a hassle sometimes, making sure that I do it every night, but overall it helps me out greatly by making sure I stay up-to-date with the class and that I am not falling behind.”
- “MasteringChemistry, as much as I hate it, has probably helped me the most. I hate it because you have to fully understand the concept to get a good grade. In high school I was one to do the absolute minimum to get the A, which unfortunately led to my not understanding the concepts. I appreciate that Dr. Pribush makes us do our assignments on MasteringChemistry, and I believe that this has helped me succeed the most.”
- “I know my grades are better! I also know that I don’t sit in class and wonder what’s up. Last year I took the course and thought I knew what was going on; this year I know when I don’t understand a concept because I can’t complete the homework assignment online. I use the hints on [the problems] I was having trouble with and I understand. It’s like having a personal tutor.”

Conclusion

By monitoring MasteringChemistry data both during and after each semester, Pribush can immediately address student misconceptions and areas of weakness in class, adjust his implementation of MasteringChemistry to enhance student learning, and more easily understand the impact of pedagogical changes on learning. The data enable him to compare his students’ performances on the ACS exam with the national average and to investigate what may have impacted those results. In addition, anecdotal responses from students reveal the key role of MasteringChemistry in modifying student work ethic and performance.

Pribush has begun a new study evaluating student performance based on time on task. Using data from MasteringChemistry, initial findings indicate that better students spend less time on MasteringChemistry homework because they are more efficient at preparing for homework by reading and using the resources as questions arise. Pribush believes that poorer-performing students wait until the last minute and spend more time trying to guess the answer to complete the assignment by the due date. As he continues to collect data in MasteringChemistry, he will test this theory and report the results.

MasteringEngineering

School Name University of Colorado Boulder, Boulder, CO

Course Name Dynamics

Course Format Lecture and lab

Key Results Students who used MasteringEngineering for homework attempted more homework assignments and were more likely to earn an A in the course than students who did paper-and-pencil homework assignments.

Submitted by

Jeffrey Knutsen, Instructor

Course materials

Engineering Mechanics: Dynamics, Hibbeler

About the Course

The University of Colorado Boulder is a public university serving nearly 32,000 students a year. In fall 2013, its mechanical engineering program was the largest in the College of Engineering and Applied Science. Approximately 24 percent of the college's undergraduate students are female, and 12 percent are underrepresented minorities.¹

Dynamics is the second course for mechanical engineering majors. It covers dynamic behavior of particle systems and rigid bodies; 2D and 3D kinematics and kinetics; impulse, momentum, potential, and kinetic energy; and work, collision, and vibration. Both lecture and homework assignments involve computers, hands-on laboratory work, and written reports.

Challenges and Goals

Instructor Jeffrey Knutsen alternates teaching Dynamics in the fall and spring semesters. Course skills build upon prior physics courses and use key calculus skills. Success in the course is critical, as its content is essential for some mechanical engineering careers, and potential employers expect proficiency with the material.

Developing good problem-solving techniques is essential for success both in the course and in future careers. An online system that can provide automatic grading is one way to provide students in large-enrollment courses with additional problem-solving practice.

Previously, Knutsen had encountered issues with another online program, so he decided to test MasteringEngineering. He hypothesized that because the program is able to randomly generate problems, student copying—from one another and from the solutions manual—would decrease.

Implementation

In spring 2012, Knutsen asked students to select a homework format: online in MasteringEngineering or paper and pencil. So that all students would be assigned the same level of homework, he assigned the end-of-section problems, which can be assigned as paper-and-pencil homework from the textbook or electronically in MasteringEngineering. Homework was due at the end of each week.

Knutsen's goal was to compare the performance of students who used MasteringEngineering with that of students who completed paper-and-pencil homework. Although they selected only one option, early in the semester some students did both formats. Of the students who selected paper-and-pencil homework in spring 2012, none did work in MasteringEngineering. Of the students who selected MasteringEngineering, however, some did both formats or paper-and-pencil work in lieu of MasteringEngineering for some of the assignments.

Assessments

45 percent	Midterms (three)
20 percent	Final exam
15 percent	Homework
10 percent	Reading, quizzes, and clicker questions
10 percent	Workshops and labs

¹<http://www.colorado.edu/engineering/about/facts>.

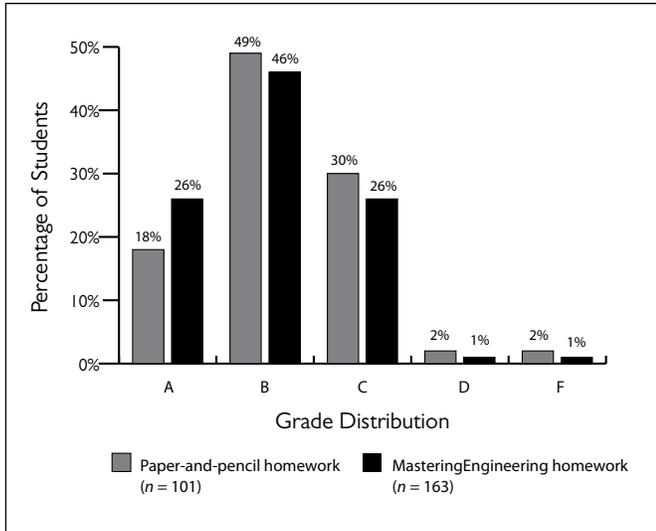


Figure 1. Grade Distribution for Students Completing MasteringEngineering and Paper-and-Pencil Homework, Spring 2012–Fall 2013

Results and Data

Combined data for two semesters that Knutsen taught the course indicate that students who used MasteringEngineering as their homework format earned more As in the course than students who did paper-and-pencil homework (Figure 1). More students who completed paper-and-pencil homework earned a B or C in the course. There was a slight difference in the number of Ds and Fs.

The results for students who selected MasteringEngineering for homework but who did some assignments as paper and pencil or did some assignments in both formats were evaluated in more detail for spring 2012 because the enrollment of 206 facilitated a better analysis than fall 2013's enrollment of 58.

Of the students who selected MasteringEngineering, 38 percent did the first assignment on paper, and 22 percent of those students used both formats. Knutsen then asked students to select a format and continue with it. On the second assignment, 8 percent of students who selected MasteringEngineering did paper-and-pencil homework, and 42 percent of those students did both. For the fourth and remaining assignments, less than 3 percent of the MasteringEngineering students did the assignment on paper.

Of the group who selected MasteringEngineering homework, students who did only MasteringEngineering received more As and fewer Ds and Fs than students who went back and forth between paper and MasteringEngineering or who elected to do only paper-and-pencil homework (Figure 2).

In addition, the results show the following:

- In spring 2012, 75 percent of students who selected MasteringEngineering attempted all homework;

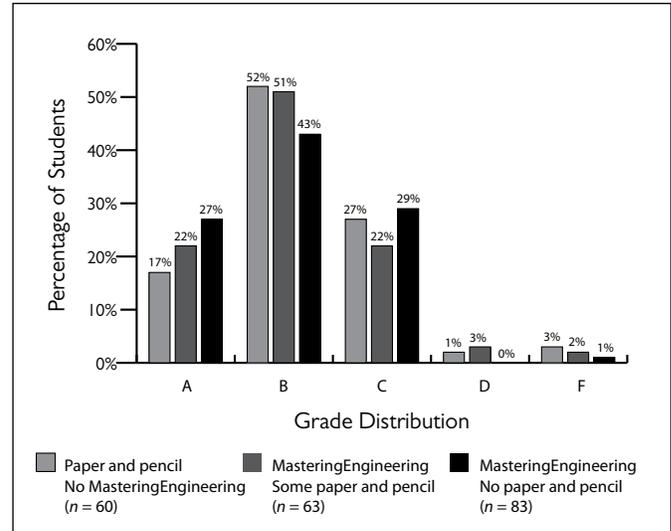


Figure 2. Grade Distribution by Homework Format, Spring 2012

58 percent of students selecting paper and pencil attempted all assignments.

- In fall 2013, 59 percent of students who selected MasteringEngineering attempted all homework; 37 percent of students who selected paper and pencil attempted all assignments.

Although other variables, such as student self-selection, may have impacted results, preliminary results show that students who used MasteringEngineering completed more homework—a critical factor to mastering necessary problem-solving skills.

The Student Experience

Students appreciated MasteringEngineering's immediate feedback—they knew right away if their calculations were correct. They also liked that MasteringEngineering recognized common mistakes, such as sign errors and significant figures, which helped them correct their mistakes and move forward. As can happen with automated grading, students also got frustrated if their solutions were incorrect and their full problems were marked incorrect. Also, although they were allowed multiple attempts to solve problems, it was sometimes difficult for students to identify what part of their problems was incorrect.

Conclusion

Preliminary results show that students who selected MasteringEngineering for homework attempted more homework and were more likely to earn an A in the course than students who selected paper-and-pencil homework. Because other variables could have impacted the outcome of the study, Knutsen believes additional research is needed to gather more data and collect more qualitative feedback from students.

Early Intervention

Many researchers say lack of college readiness is a major contributor to poor retention and graduation rates. According to a report¹ by the National Center for Public Policy and Higher Education and the Southern Regional Education Board, “Every year in the United States, nearly 60 percent of first-year college students discover that, despite being fully eligible to attend college, they are not academically ready for postsecondary studies.” Many educators say, “Few high schools have successfully and intentionally implemented all the elements necessary to align their programs for college success.”²

This is particularly evident in STEM programs, with a recent report stating that only “36 percent of 2013 U.S. high school students are ready for college-level science. U.S. students recently finished 27th in math and 20th in science in the ranking of 34 countries by the Organization for Economic Cooperation and Development [sic].”³ Students who are not ready for college-level courses are at risk of not achieving their educational goals and missing the opportunity to pursue STEM programs and careers, some of the fastest-growing job opportunities today.⁴

Many researchers believe that lack of college readiness is a major contributor to poor retention and graduation rates.

A recent study by the US Department of Education’s Civil Rights Data Collection looked at the number of high schools across the nation that are offering biology, chemistry, and physics. Of the 25,030 high schools in the study, 87 percent

offered biology; 75 percent offered chemistry; and only 63 percent offered physics. Among the most-highly-populous states, chemistry is offered in only 54 percent of high schools in Florida and 53 percent of high schools in California. The opportunity for high school students to take physics is available in only 68 percent of Illinois schools, 66 percent of New York schools, 47 percent of California schools, and 39 percent of Florida schools.⁵ Access to biology in high schools is much better, but it is still not universal. Most important, the statistics do not take into consideration the level of high school courses offered so as to be able to identify whether the courses are providing curricula needed for college success.

“The earlier an academically at-risk student is identified, the better the prognosis for their success in college.”⁶

Many colleges and universities make valiant efforts to promote college readiness and student success at the institutional level, but many STEM instructors say the individual gaps in student knowledge mean that those issues would be more effectively addressed at the course level. STEM instructors are facing more and more underprepared students as well as larger enrollments and an increase in administrative duties, which causes time constraints that affect their ability to help each student individually and which makes it all the more critical to be able to identify struggling students as early as possible.

If instructors offer only a few exams during the semester, then by the time they learn a student is struggling, it may be too late. *Leading indicators*—the metrics used for predicting future

¹*Beyond the Rhetoric: Improving College Readiness through Coherent State Policy—a Special Report by the National Center for Public Policy and Higher Education and the Southern Regional Education Board, June 2010, p. 1. http://www.highereducation.org/reports/college_readiness/CollegeReadiness.pdf*

²David T. Conley, “The Challenge of College Readiness,” *The Prepared Graduate* (April 2007), 65:7:23-29.

³<https://www.nmsi.org/AboutNMSI/TheStemCrisis/STEMEducationStatistics.aspx>.

⁴National Center for Education Statistics, *The Nation’s Report Card: Mathematics 2011*. Washington: US Department of Education Institute of Education Sciences.

⁵US Department of Education Office for Civil Rights, *Civil Rights Data Collection (CRDC), Data Snapshot: College and Career Readiness Issue Brief #3 (2014)*, pp. 20-22. Note: High schools is defined as public schools offering grades 10 or 11. Data represents 99% of high schools in the CRDC universe (25,030 high schools).

⁶Higher Ed Impact, “Identifying At-Risk Students: What Data Are You Looking At?” <http://www.academicimpressions.com/news/identifying-risk-students-what-data-are-you-looking>.

performance—can help identify at-risk students long before so-called *lagging indicators*—like exams—can.

At the very start of a course, diagnostic exams and introductory assignments can indicate which students may be at risk. Such information can help an instructor monitor those students more closely, reinforce available remediation and resources, and make informed teaching decisions during the semester based on student needs, which should help more students succeed in the course. To that end, MyReadinessTest offers a diagnostic exam that, when administered at the beginning of a semester, can help identify students who may not have the skills necessary to succeed in a course. Similarly, instructors who require their students to complete Introduction to Mastering assignments will be able to identify which students may be more motivated based on completion of the assignments and thereby tend to do better in the course. Introduction to Mastering also lets students review the basic content needed for success in a course, such as required math skills.

“Early alert systems... can be instrumental in beginning an intervention that can help facilitate student success and increase retention.”⁷

The MyReadinessTest and Mastering diagnostics provide information that can help instructors meet the challenge of large, diverse, and underprepared populations. The case studies that follow offer insight into how the use of MyReadinessTest and Mastering can quickly and efficiently (1) identify students most at risk and (2) provide remediation for those who need it.

⁷*ibid.*

MasteringPhysics

School Name Georgia Southern University, Statesboro, GA

Course Name Introduction to Physics

Course Format Lecture and lab

Key Results Over a four-year period of study, students who attempted all of the MasteringPhysics homework assignments earned significantly higher final exam averages than students who skipped assignments.

Submitted by

Delena Bell Gatch, Associate Professor

Course materials

College Physics, Young

About the Course

Georgia Southern University is the fifth-largest university in the University System of Georgia, with an enrollment exceeding 20,000 students a year. The school's first-year retention rate of first-time, full-time, degree-seeking freshmen who entered in fall 2012 (and returned in fall 2013) was 80 percent.¹

Introduction to Physics is taken primarily by construction management and exercise science majors. Certain course material, including vectors, kinematics, Newton's laws of motion, and conservation laws, requires mathematical skills at a trigonometry level. Upon completion of the course, successful students can demonstrate a conceptual understanding of physics, advanced problem-solving skills, and basic laboratory skills.

Challenges and Goals

According to Associate Professor Delena Bell Gatch, the students who take her course tend to work well in groups, have competent technology and lab skills, and exercise strong writing skills. "However, they often are not mathematically prepared for the course," she says. "Some struggle with conceptual understandings, are unable to see the connections between the concepts and problems, and spend too much time equation hunting and trying to memorize procedures to solve specific problems."

Gatch implemented MasteringPhysics to help promote regular student engagement with course content and to provide her

students with immediate feedback and grading so they know where they need remediation. In addition, she consults the program's diagnostics before each class to better understand student misconceptions and needs.

Implementation

From fall 2010 to fall 2013, Gatch's students met both in a large lecture and in smaller-group labs twice a week. In each of the reported semesters, she assigned a weekly MasteringPhysics homework assignment comprising a mix of question types, including tutorial, activity, and end-of-chapter questions.

For fall 2010, spring 2011, and fall 2011, she also assigned the Introduction to Mastering assignment as the first required assignment. For subsequent semesters, she added content to the introductory assignments. The Introduction to Mastering assignment was implemented as follows:

- Prior to spring 2012—Seven Introduction to Mastering questions
- Spring 2012 through spring 2013—The same seven Introduction to Mastering questions + 10 items from the math review questions of Mastering Chapter 0
- Fall 2013—Eight Introduction to Mastering questions + 16 math review items, several of which address vectors

Assessments

55 percent	Exams (three exams and a comprehensive final)
15 percent	MasteringPhysics homework
15 percent	Lab exercises
10 percent	In-class activities
5 percent	Service learning project

¹2013/14 Fact Book, p. 8, <http://em.georgiasouthern.edu/osra/wp-content/uploads/sites/5/fb1314.pdf>.

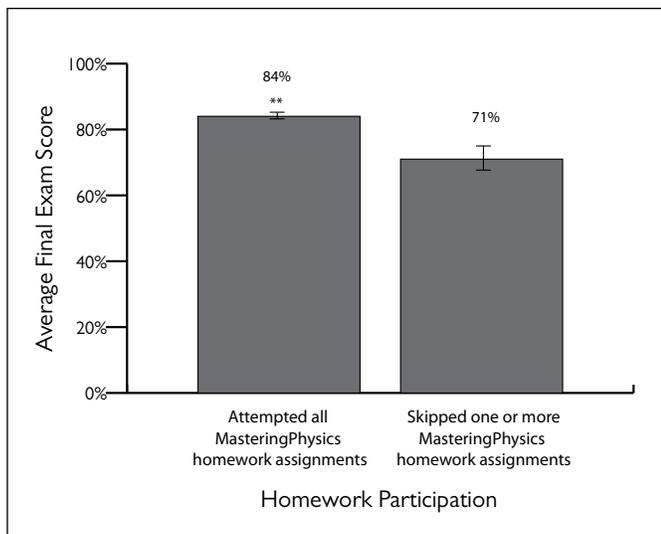


Figure 1. Average Final Exam Scores per MasteringPhysics Homework Participation, Spring 2013 (Attempted all, $n = 116$; Skipped one or more, $n = 31$) Error Bars = Standard Error, Significance $**p < 0.01$

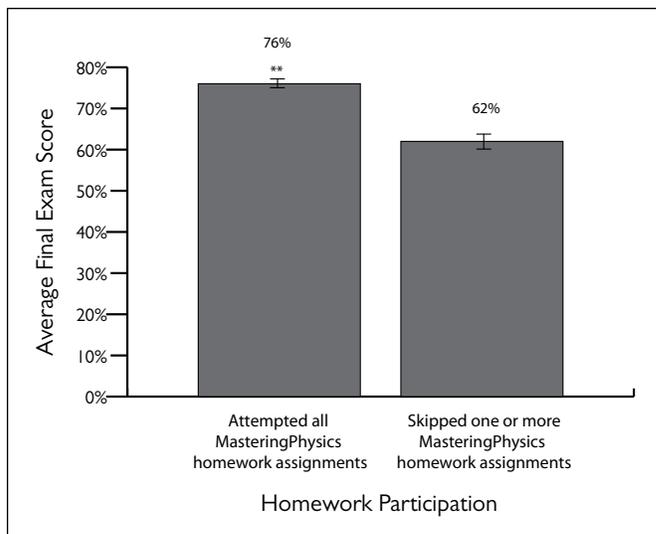


Figure 2. Average Final Exam Scores per MasteringPhysics Homework Participation, Fall 2013 (Attempted all, $n = 98$; Skipped one or more, $n = 28$) Error Bars = Standard Error, Significance $**p < 0.01$

Results and Data

Gatch evaluated student performance based on participation in MasteringPhysics homework during the spring and fall 2013 semesters. She found that students who attempted all of the MasteringPhysics homework assignments scored significantly higher on the comprehensive final exam, with $p = 0.007$ for spring 2013 and $p = 0.001$ for fall 2013 (Figures 1 and 2). For purposes of this study, a skipped homework was considered one with a score of 0; and the analysis does not include any students who did not take the final exam. Results also showed the following:

- Spring 2013, 21 percent of students skipped one or more MasteringPhysics homework assignments. The average number of assignments skipped was 2.5 of 13 assignments.
- Fall 2013, 22 percent of students skipped one or more MasteringPhysics homework assignments. The average number of skipped assignments was 3.7 of 15 assignments.
- In each semester, 26 percent of students who skipped MasteringPhysics homework assignments skipped four or more assignments.

In addition to analyzing performance on the MasteringPhysics homework assignments, Gatch evaluated spring 2012–fall 2013 student performance on the Introduction to Mastering assignment. She posited that the assignment’s tutorial math problems would help students review the math skills they needed for the course. Data indicated that students who scored 80 percent

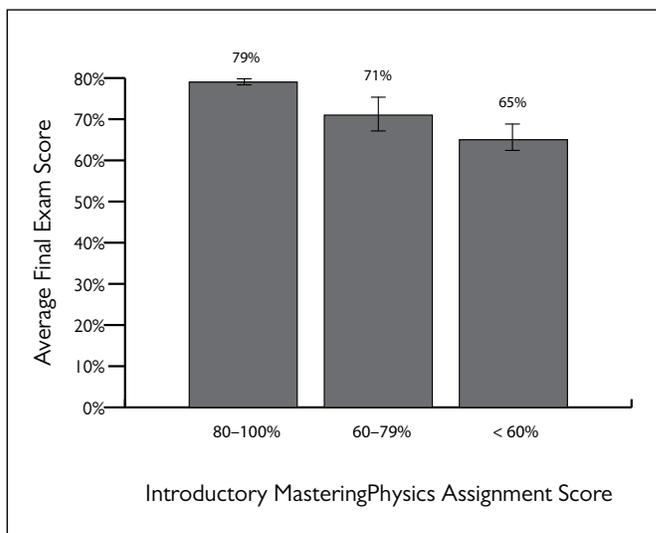


Figure 3. Average Final Exam Scores by Performance on Introductory MasteringPhysics Homework, Spring 2012–Spring 2013 (80% or higher, $n = 500$; 60–79%, $n = 29$; less than 60%, $n = 42$) Error Bars = Standard Error

or higher on the Introduction to Mastering assignment earned significantly higher final exam scores than students who scored lower on this assignment (Figure 3).

The scores from the Introduction to Mastering assignment with the math review questions could serve as a leading indicator identifying students who may be at risk in the course.

“With MasteringPhysics, I can monitor student performance and get a sense of student motivation based on participation in homework assignments. This kind of consistent monitoring and assessment of student results also enables me to target at-risk students earlier in the course and to focus my teaching specifically on those concepts students need help on.”

Finally, Gatch examined participation data alone (without taking performance into consideration) for the Introduction to Mastering assignment during this same period and for three prior semesters when the assignment included only the Introduction to Mastering questions. Similarly, the data showed that students who attempted the introductory assignment did significantly better on the final exam than did students who skipped it. She notes, “While this assignment does not contain specific physics concepts being taught in the course, the decision to skip the assignment could be an indicator of student motivation, which impacts student performance in the course.”

The Student Experience

In spring 2013, Gatch asked her students what strategies for success they would share with incoming fall 2013 students. Student feedback included:

- “I would stress doing the homework early and not looking up the solutions online, to do all the work.”
- “Try very hard to understand the material, not just memorize it.”
- “Take practice quizzes online to reduce the risk of making simple mistakes and ensure that you know the material.”

Gatch has a strong interest in physics education research and is currently investigating students’ motivation in various programs across the university, as well as the experiences of new faculty in developing student-centered instruction. Results from this study will be published in the future.

Conclusion

Because MasteringPhysics homework offers Gatch’s students the opportunity to practice outside of class, they are more prepared for both class and lab and perform better on assessments. Data indicate that students who attempted all of the MasteringPhysics homework tended to earn higher final exam scores and that student motivation can be a key variable that can impact performance.

MasteringPhysics also helps Gatch target her teaching. “With MasteringPhysics, I can monitor student performance and get a sense of student motivation based on participation in homework assignments,” she says. “This kind of consistent monitoring and assessment of student results also enables me to target at-risk students earlier in the course and to focus my teaching specifically on those concepts students need help on.”

MyReadinessTest

School Name Robeson Community College, Lumberton, NC

Course Name General Chemistry I

Course Format Lecture and lab

Key Results Student scores on the MyReadinessTest diagnostic exam were predictive of student success in the course.

Submitted by

Louis McIntyre, Department Chair

Course materials

Principles of Chemistry: A Molecular Approach, Tro

About the Course

Robeson Community College, one of 58 community colleges in North Carolina, is located in rural Robeson County. In 2012, the county had the highest county-level poverty rate in the state and it consistently ranks as one of the poorest counties in the nation.¹ More than 38 percent of the county population identifies as Native American.² The college is an open-door, two-year community college with a full-time enrollment of approximately 2,500 students. The school's six-year graduation rate for the 2007 cohort was 38.6 percent.³

General Chemistry I is the first course in a two-semester sequence covering the fundamental principles and laws of chemistry. Upon completion, students are able to demonstrate an understanding of fundamental chemical laws and concepts as needed to pursue further study in chemistry and related professional fields. This is a college-transfer course that includes both lecture and lab components. The majority of students who take this course are nursing majors or plan to transfer to a four-year institution.

Challenges and Goals

Robeson serves many nontraditional, first-generation college students. As such, a high number are not college ready and require remediation to succeed. In 2012, the science department conducted a Mastering-enabled redesign across all science courses to address the issue of underprepared students and to provide a resource for remediation outside the classroom. Other goals for the redesign included reducing the time and labor needed to grade homework and developing an effective way to track learning outcomes. An evaluation of the results of four redesigned science courses—Anatomy and Physiology, Biology, Chemistry, and Microbiology—was published in *MyLab & Mastering: Science and Engineering*, V.4.⁴

The enrollment of students in General Chemistry I who are without the background and skills needed continues to be an issue impeding success, and identifying these students as early as possible is an important goal. Because MyReadinessTest provides a diagnostic exam that assesses students' skills on targeted topics applicable to chemistry, the decision was made to administer this to students starting in fall 2013. The hypothesis was that performance on the MyReadinessTest diagnostic exam taken at the start of the semester would serve as a predictor of student success, identifying students who may be at risk, from both academic and technological standpoints.

Implementation

Beginning in fall 2013, the MyReadinessTest diagnostic exam was administered to students as a required assignment during the first week of the semester. MyReadinessTest then generates a personalized study plan based on those results. Students had the opportunity to use the study plan for remediation throughout the semester on their own time as an optional learning

¹North Carolina's counties remain in poverty's tight grip, Tazra Mitchell, North Carolina Budget and Tax Center, Poverty and Policy Matters (<http://pulse.ncpolicywatch.org/2014/01/11/north-carolinas-counties-remain-in-povertys-tight-grip/#sthash.Nt6bLeXs.dpuf>).

²<http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF>.

³NC Community Colleges Creating Success, North Carolina 2014 Performance Measures for Student Success (http://www.nccommunitycolleges.edu/sites/default/files/basic-page/2014_performance_report_5-12-14.pdf).

⁴MyLab & Mastering: Science and Engineering, V. 4, 2014, pp. 12, 28, 58, 86.

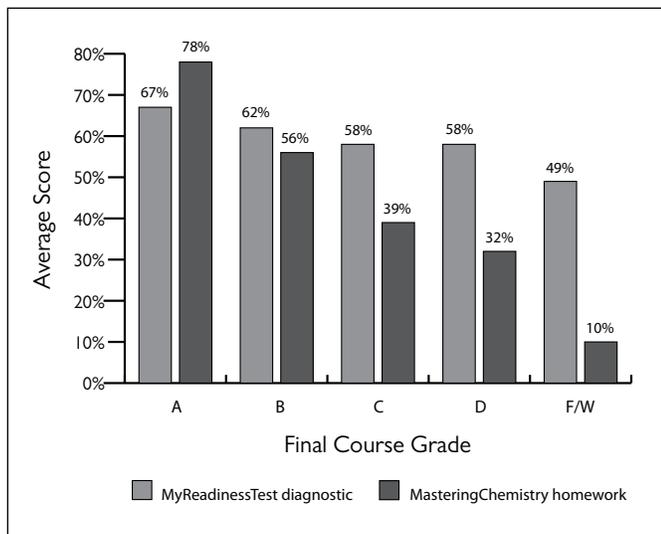


Figure 1. MyReadinessTest and MasteringChemistry Scores per Final Course Grade, Fall 2013 ($n = 119$)

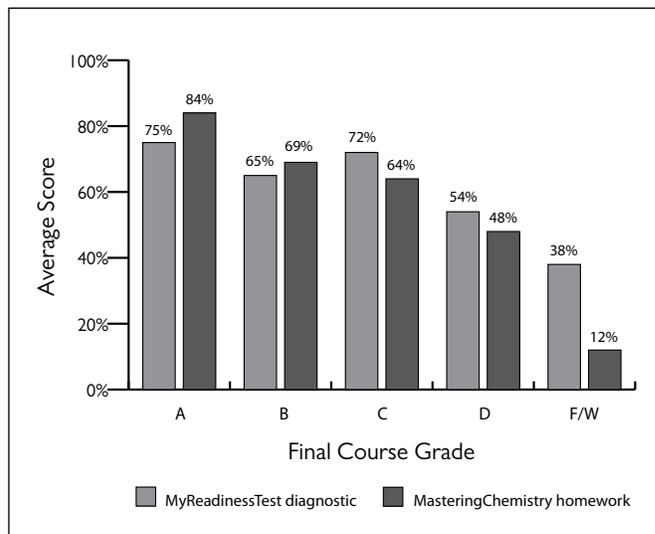


Figure 2. MyReadinessTest and MasteringChemistry Scores per Final Course Grade, Spring 2014 ($n = 49$)

resource. There were no other changes made to the course, and the MasteringChemistry prelecture homework assignments continued to be assessed at the same weight and due weekly.

Assessments

50 percent	Lecture exams
15 percent	Final exam
15 percent	MasteringChemistry homework
15 percent	Lab (participation, reports, practicals, and exams)
5 percent	Other

Results and Data

The MyReadinessTest diagnostic exam provides performance information on seven topics and, in turn, helps students identify problem-solving issues. Fall 2013 MyReadinessTest diagnostic exam scores indicated that the majority of students were not prepared for the level of math needed for General Chemistry I. The MyReadinessTest diagnostic exam score average was highest for students who completed the course with an A and lowest for students failing or withdrawing from the course (Figure 1). In addition, students who earned an A in the course tended to put more effort into MasteringChemistry homework and earned higher homework scores, while most D/F/W students put little effort into MasteringChemistry homework (Figure 1). The amount of time students spend working in MasteringChemistry and in MyReadinessTest can indicate motivation—a variable that can impact course results.

Based on findings from fall 2013, a decision was made to institute a benchmark score on the MyReadinessTest diagnostic test for spring 2014. Students were required to complete the MyReadinessTest diagnostic exam by a certain date prior to the semester start.

Students who scored 70 percent or higher on the MyReadinessTest diagnostic exam were placed in General Chemistry I unconditionally. Students who scored below 70 percent were placed in General Chemistry I conditionally and advised that they might need to take additional courses in order to succeed. Students who heard the advice and proceeded to take General Chemistry I were asked to sign a waiver stating that the instructor reviewed the syllabus and course requirements with them and that they understood they did not meet the preenrollment requirements. Students also acknowledged that they were proceeding in the course at their own risk.

There were 66 students at the start of spring 2014. Due to late registrations, only 49 completed the MyReadinessTest diagnostic exam. The following data includes only students who took the MyReadinessTest diagnostic exam. Figure 2 shows spring 2014 results, which were similar to those from fall 2013, in which A students earned higher diagnostic exam scores than students earning an F or withdrawing from the course. Data also showed that:

- Students who successfully completed the course with an A, B, or C averaged 76 percent on the MyReadinessTest diagnostic test.

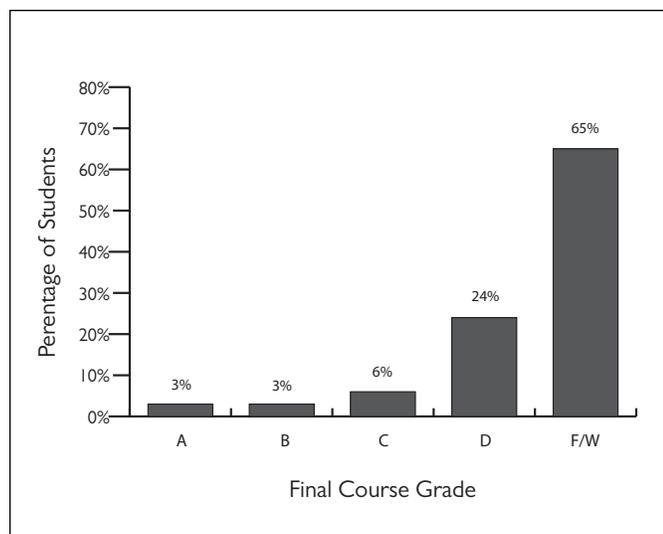


Figure 3. Grade Distribution for Students Scoring Less Than 70 Percent on the MyReadinessTest Diagnostic Exam, Spring 2014 ($n = 34$)

- Twenty-five out of 49 students who took the MyReadinessTest diagnostic exam withdrew from the course. Those students averaged 51 percent on the MyReadinessTest diagnostic exam.
- Twenty-two percent of students earned an F and scored an average of 62 percent on the MyReadinessTest diagnostic exam.
- Eighty-nine percent of students who earned below 70 percent on the MyReadinessTest diagnostic exam failed or withdrew from the course (Figure 3).

These results show that the MyReadinessTest diagnostic exam scores can be leading indicators of at-risk students. Based on these findings and due to the high number of students who struggle in the course but need to complete it for their programs of study, the college agreed to implement a new developmental chemistry course that was offered starting in fall 2014.

Following are policies for the fall 2014 General Chemistry I course:

- Students pursuing a program of study that requires General Chemistry I must take the MyReadinessTest diagnostic exam for chemistry. Students who score less than 70 percent are advised to consider taking the Preparatory Chemistry course.
- Students pursuing an associates degree in nursing and scoring less than 70 percent on the MyReadinessTest diagnostic exam for Chemistry are required to take the Preparatory Chemistry course.

- Students who have not had high school chemistry or have not had it in the last five years are advised to take the Preparatory Chemistry course.

These changes, along with the addition of the MyReadinessTest diagnostic exam as a placement test, are designed to help students succeed in the course so they can pursue their academic goals.

The Student Experience

Because General Chemistry I is a requirement for so many programs, students tend to enroll in the course despite the potential consequences that come with not being prepared for it. In spring 2014, the majority of students who signed the waiver and proceeded to the course—despite being advised about the risk—either failed or withdrew.

Robeson faculty and administration understand that students want to move forward in their academic programs, but until now they had limited options. Today, students who aren't prepared for a college-level General Chemistry course have the option of a developmental chemistry course. This enables underprepared students to remediate needed skills before attempting General Chemistry.

In a survey, students were asked if the MyReadinessTest diagnostic exam was a good indicator of student preparation for the math requirements of general chemistry. Following is one student's reply:

“I felt like I was prepared for Chemistry. However, because it may have been a while since I'd done that type of math, I didn't do as well [on the MyReadinessTest diagnostic exam] as I could have.”

Conclusion

Robeson Community College's student population is diverse, and many students are not prepared for college-level courses. To meet the challenge and improve outcomes, the school's science department implemented a departmentwide redesign. Adding MyReadinessTest to General Chemistry I provided instructors with an additional resource to help them identify, as early in the semester as possible, which students were most at risk of failing. Today, the school continues to analyze and track results to understand the impact of its redesign. Future plans include adding MyReadinessTest to the Anatomy & Physiology course and continuing to track outcomes for all courses.

MyReadinessTest

School Name Tarrant County College, Fort Worth, TX
Course Name Anatomy and Physiology I
Course Format Lecture and lab

Key Results Students who scored less than 75 percent on MyReadinessTest diagnostic exams had higher rates of not completing the course. Similarly, students who mastered more than 50 percent of the items in the Study Plan earned significantly higher exam scores.

Submitted by
Paul Luyster, Associate Professor

Course materials
Human Anatomy and Physiology, Marieb and Hoehn

About the Course

Tarrant County College is a two-year public institution with multiple regional campuses serving approximately 11,000 students. More than 44 percent of its students are minorities, 32 percent receive Pell Grants, and approximately 73 percent attend school on a part-time basis.¹

Anatomy and Physiology (A&P) I teaches the structure and function of human anatomy, including neuroendocrine, integumentary, musculoskeletal, digestive, urinary, reproductive, respiratory, and circulatory systems. It includes both a lecture and lab component. Generally, A&P I students plan to enter an allied health or nursing program. This is often the first science course these students take—if they do not earn an A or B, they may not be accepted into their desired program.

Challenges and Goals

Students who are not college ready face barriers to academic success. In Texas, only 38 percent of students who rank below the state readiness standard when they enter college are still enrolled in higher education after three years (compared to 57 percent of college-ready students).²

According to Associate Professor Paul Luyster, many of his students are not prepared for this course and do not know the basic concepts needed to succeed. As a result, he spends extra time trying to get those students caught up, which can impact his ability to cover higher-level concepts and applications. He adopted MyReadinessTest in spring 2013 to help identify at-risk students, to provide remediation in a timely manner without taking more class time, and to help more students succeed in the course.

Implementation

MyReadinessTest for A&P assesses students' proficiency in the foundational concepts needed for success in A&P courses and remediates gaps in targeted topics, including basic skills and basic math.

In spring 2013, Luyster assigned the MyReadinessTest diagnostic test in the first week of class as an optional, extra-credit assignment. MyReadinessTest generated personalized study plans based on individual student performance on the diagnostic tests, which students could access and work on at their own pace. Luyster also used MasteringA&P for homework and exam review.

Assessments

50.0 percent Lecture exams (four)
25.0 percent Lab practicals (two)
12.5 percent Final exam
12.5 percent MasteringA&P homework

¹2013 Texas Public Higher Education Almanac, *Texas Higher Education Coordinating Board*, pp. 24–25.

²2013 Texas Public Higher Education Almanac, *Texas Higher Education Coordinating Board*, p. 13.

Initial findings show that MyReadinessTest diagnostic test scores may be an early indicator of students at risk of withdrawing or not completing the course.

Results and Data

For the spring 2013 semester, 41 percent of students took the MyReadinessTest diagnostic test. Table I shows course completion rates based on the percentage of students who did and did not take the MyReadinessTest diagnostic test. Incompletes indicate a student did not officially withdraw, but received a zero on the final exam.

	Completed	Withdrew	Incomplete
Took the MyReadinessTest Diagnostic Test	84%	11%	5%
Did not take the MyReadinessTest Diagnostic Test	55%	31%	14%

Table I. Comparison of Completion Outcomes for Students Who Did and Did Not Take the MyReadinessTest Diagnostic Test, Spring 2013 (Did, $n = 81$; Did Not, $n = 117$)

Data also indicated the following:

- Of students completing the course, 52 percent took the diagnostic test with an average score of 61 percent.
- Of students officially withdrawing from the course, 20 percent took the diagnostic test with an average score of 54 percent.
- Of students not taking the final exam, 20 percent took the diagnostic test scoring an average of 54 percent.
- The lowest MyReadinessTest diagnostic test score was 36 percent and the highest score was 91—an indication of the wide range of student abilities in the class.

Initial findings show that MyReadinessTest diagnostic test scores may be an early indicator of students at risk of withdrawing or not completing the course. An assessment of the diagnostic scores shows that performance on the test can be a leading indicator for students who will successfully complete the course. Students who scored 50–74 percent on the diagnostic test had a higher rate of not completing the course than students scoring 75 percent or higher, and students who scored below 50 percent had an even higher rate of not completing the course (Figure I).

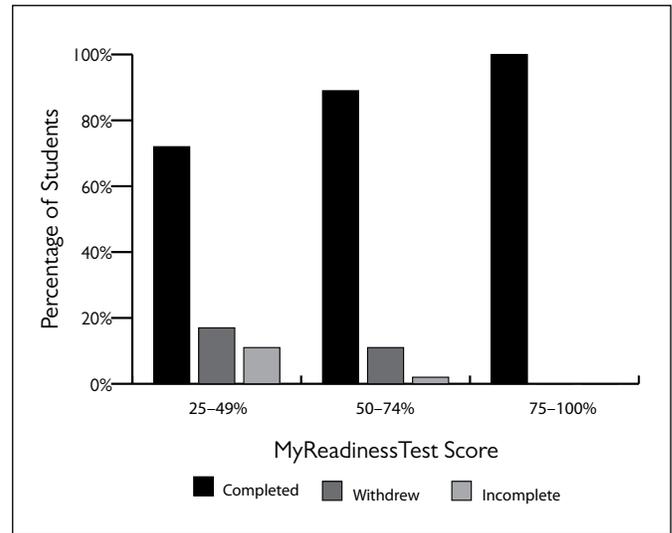


Figure I. Distribution of MyReadinessTest Diagnostic Test Scores and Course Completion, Spring 2013 (Completed: 25–49%, $n = 13$; 50–74%, $n = 24$; 75–100%, $n = 8$ / Withdrew 25–49%, $n = 3$; 50–74%, $n = 6$ / Incomplete: 25–49%, $n = 2$; 50–74%, $n = 2$)

For students who completed both the MyReadinessTest diagnostic test and the course, there was a weak correlation between MyReadinessTest diagnostic test scores and final exam scores ($r^2 = 0.1469$). Motivation is a likely factor since students who know what they need to study and put forth the effort can improve their knowledge and thus their performance in the course.

For example, one student scored 46 percent on the diagnostic test, spent more than 3.5 hours working in his study plan, and then scored 90 percent on his MasteringA&P homework. He earned 84 percent on the first exam, 98 percent on the second exam, and 94 percent on the final exam. On the other hand, a second student scored 37 percent on the MyReadinessTest diagnostic test and 62 percent on the final exam. He finished the course, but spent no time working in the MyReadinessTest study plan and scored only 34 percent on his MasteringA&P homework. He ended the course at 55 percent—a failing grade.

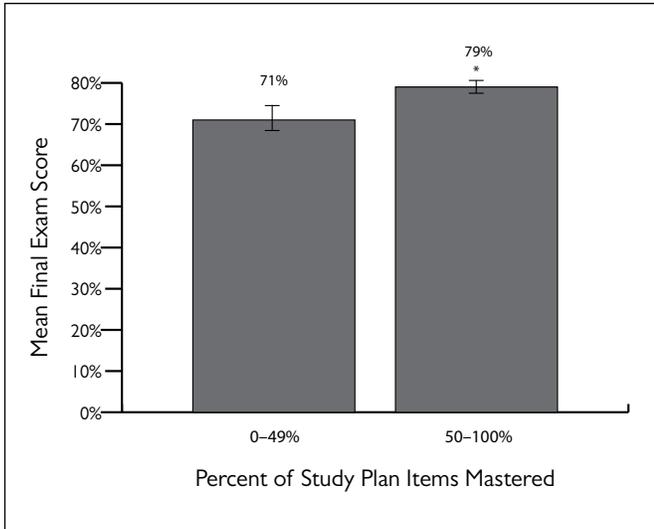


Figure 2. Distribution of Mean Final Exam Scores and Study Plan Mastery, Spring 2013 (0-49%, $n = 12$; 50-100%, $n = 61$ / Error Bars = Standard Error, Significance $*p < 0.05$)

Luyster also looked at students who spent time remediating in the study plan, which is generated based on the items a student has not mastered after taking the MyReadinessTest diagnostic test. An examination of data from students who mastered more than 50 percent of the items in their MyReadinessTest study plan showed that those students earned a higher mean final exam score than students who mastered less than 50 percent of the items (Figure 2). *Note: Included in this data are students who took the diagnostic test and students who did not take the diagnostic test but who worked in the general study plan; it includes only students who completed the course.*

The Student Experience

Students reported that the MyReadinessTest diagnostic test was useful and that they appreciated a study tool that identified specific areas needing attention. A total of 56 students out of 81 took the diagnostic test and continued to work in their resulting study plans during the semester—those students mastered an average of 62 out of 70 items.

Students who scored lower on the MyReadinessTest diagnostic test had a higher risk of not completing the course.

Conclusion

Students who scored lower on the MyReadinessTest diagnostic test had a higher risk of not completing the course. In addition, students who mastered more than half of the items in the MyReadinessTest study plan tended to have higher final exam averages.

Based on the results of this study, Luyster plans to require that all students complete the MyReadinessTest diagnostic test so that he can identify at-risk students as early as possible. He also plans to continue gathering and analyzing additional MyReadinessTest results.

Adaptive Learning

Once diagnostic tests help instructors identify exactly what their students already know and which students are at risk of not succeeding (see Early Intervention, page 15), a challenge remains: to provide timely and effective remediation. One of the most powerful aspects of learning is the notion of accountability in that students who take ownership of their learning tend to be more proactive and achieve higher outcomes. It follows then that the most-effective remediation helps students find out what they don't know and provides students with the tools they need to learn it.

Personalized learning resources such as Knewton adaptive learning address the fact that students have widely diverse learning styles. No two students are identical: students learn and forget at different rates, come from different educational backgrounds, and have different intellectual capabilities, attention spans, and modes of learning.¹ With all of the other duties educators face, providing face-to-face personalized remediation for each student in need would be a daunting task. Fortunately, advances in personalized and adaptive-learning technology more effectively address that need than ever before.

“Adaptive learning technologies are potentially transformative.”²

Pearson recognizes that need and has partnered with technology developers such as Knewton to include adaptive-learning features in the Mastering platform. Adaptive technology works by continuously assessing student performance and activity in real time. Then, using data and analytics, it personalizes content to reinforce concepts that target each student's individual strengths and weaknesses.

For students, adaptive learning is a critical advance over traditional learning methods. With adaptive learning, students receive personalized guidance where and when they need it most. In turn, students tend to exhibit greater engagement, improved knowledge retention, and greater subject-matter mastery—important criteria to facilitate student success.

For educators, adaptive learning is a way to address diverse student populations and individual remediation needs. Because adaptive learning helps student stay on track and achieve higher levels of subject matter mastery, more class time can be devoted to teaching higher-order ideas, explaining and expanding complex concepts, and helping students reinforce what they've learned.

The case studies that follow are examples of how adding Knewton Adaptive Follow-Up activities to Mastering implementations can increase positive learning outcomes. The studies show a trend towards increased exam performance, and student feedback indicates that Knewton Adaptive Follow-Up exercises were beneficial in students' mastery of concepts and in some cases, motivated students to work harder.

¹<http://www.knewton.com/>.

²<http://mfeldstein.com/faculty-know-adaptive-learning/>.

MasteringBiology with Knewton Adaptive Follow-Up

School Name Collin College, Plano, TX

Course Name General Biology I

Course Format Lecture and lab

Key Results When Knewton Adaptive Follow-Up was added, there was a statistically significant increase in end-of-semester student exam scores.

Submitted by

Rebecca Orr, Professor; Shellene Foster, Statistical Analyst

Course materials

Campbell Biology, Reece, Urry, Cain, Wasserman, Minorsky, and Jackson

About the Course

Collin College is a multicampus, two-year college in North Texas that enrolls approximately 27,000 students, 67 percent of whom attend part-time. General Biology I is taken primarily by students who intend to pursue a degree in the health sciences (e.g., nursing, dental hygiene, respiratory care, and surgical technology) or plan to transfer to a four-year institution. The course covers the fundamental principles of living organisms, including physical and chemical properties of life, organization, function, evolutionary adaptation, and classification. Concepts of cytology, reproduction, genetics, and scientific reasoning are also included. The course has lecture and lab components.

Challenges and Goals

Students who take General Biology I at Collin College come from a variety of backgrounds and have different skill levels and styles of learning; some are not college or course ready. Addressing the needs of this diverse group can be a challenge.¹

Professor Rebecca Orr has been using MasteringBiology for several years, but recently added Knewton's Adaptive Follow-Up (AFU) to her implementation as a way to help students

identify individual gaps in knowledge and remediate at their own pace and on their own time.

Implementation

Orr's use of MasteringBiology has progressed from an optional resource to a required component. In 2013, she published a study on the effect of online testing as a learning event in the introductory (majors) biology classroom using MasteringBiology to deliver required quizzes. Through detailed statistical analysis, the benefit of quizzing was demonstrated to be significant for students of diverse academic abilities.²

In response to the results of that study, Orr continues to require preexam MasteringBiology quizzes. The course consists of three different types of MasteringBiology assignments:

- **Prelecture reading assignments (untimed homework).** Ten-question, multiple-choice assignments designed to offer quick feedback regarding students' initial comprehension of course material. Students may request hints but are limited to two attempts. Diagnostics from these assignments help guide lecture discussion.
- **Practice assignments (untimed homework).** Chapter-specific tutorials, activities, BioFlix™, and misconception questions. Homework assignments require 30 to 60 minutes to complete. Students may request hints and they have multiple attempts.
- **Required quizzes (timed).** Designed to provide a snapshot of where students are in preparation for upcoming exams. Quizzes comprise original content that has been uploaded into MasteringBiology. Topics and wording prepare students for the types of questions that will be on the

¹Studies show that students who are not college ready face serious barriers to academic success. In Texas, 38 percent of students who are below the state readiness standard when they enter college graduate or are still enrolled in higher education after three years. This is compared to 57 percent of students who are college ready upon entry. 2013 Texas Public Higher Education Almanac, Texas Higher Education Coordinating Board, p. 13 (www.theccb.state.tx.us).

²"Increasing Student Success Using Online Quizzing in Introductory (Majors) Biology," Rebecca Orr and Shellene Foster, *CBE—Life Sciences Education*, Vol. 12, 509–514, Fall 2013 (<http://www.lifescied.org/content/12/3/509.full?sid=01bb2df8-239e-4c41-8406-bd40fc6e1d22>).

exams. To discourage group work, students randomly receive one of three versions of each quiz, and questions are randomized within each quiz.

The first MasteringBiology homework assignment is due by the end of the first week of class to encourage students to get registered in MasteringBiology, and, if necessary, make adjustments to optimize use of the platform. There are four exams each semester.

During summer 2013, Orr tested MasteringBiology's new Knewton Adaptive Follow-Up feature. AFU questions focus students on gaps in their understanding based on individual performance on a MasteringBiology parent assignment and, as such, vary from student to student. Preliminary results from the semester were published in *MyLab & Mastering: Science and Engineering*, V. 4.³

Summer 2013	Spring 2014
No Adaptive Follow-Up for exams 1 and 2	No Adaptive Follow-Up for exams 1 and 2
Optional Adaptive Follow-Up for the second two exam periods	Required Adaptive Follow-Up for the second two exam periods
Two sets of Adaptive Follow-Up	Three sets of Adaptive Follow-Up
Adaptive Follow-Up due two days after parent assignment	Adaptive Follow-Up due two days after parent assignment
Test-out set at 95 percent mastery	Test-out set at 95 percent mastery
Value set as extra credit added to homework portion of lecture grade	Value set as credit added to homework portion of lecture grade

Table 1. Study Implementation of Knewton Adaptive Follow-Up, Summer 2013 and Spring 2014

Results from that study indicated that student success may increase when AFU is used with MasteringBiology homework. To test this finding, Orr repeated the study in spring 2014 making the implementation changes shown in Table 1. Rather than optional AFU (as in summer 2013), AFU sets were required and the number of potential AFU sets increased from two to three.

For all semesters in the study, AFU was not used for exams 1 and 2. For purposes of comparison, those scores were averaged and used to compare general student ability in a given semester.

In spring 2014, MasteringBiology homework was a streamlined version of the one assigned in spring 2013. This increased the item availability of questions for the AFU exercises. The same quizzes and exams were used in all semesters. For the third and fourth units in spring 2014, AFU assignments were added to each MasteringBiology practice assignment.

Based on her experience with Knewton Adaptive Follow-Up, Orr recommends the following best practices:

- Enable the test-out feature to motivate students to complete the MasteringBiology parent assignment.
- Carefully select what is added to the MasteringBiology parent assignment. Keep in mind that AFU sets for the current chapter are drawn from the same item library.
- Schedule due dates of future assignments so the Knewton adaptive engine can integrate consideration of future content prerequisites into current recommendations.
- Streamline homework assignments to account for total time to do the MasteringBiology parent assignment and the AFU sets (~15 minutes per set).
- Select items for the MasteringBiology parent assignment that specifically address ultimate learning goals.
- Sequester items you don't want in AFU assignments in an unscheduled assignment.
- When enabling AFU for an assignment that includes content from multiple chapters, be aware that the sets will be drawn from *all* material covered in the assignment. Inclusion of even one item from a given chapter results in the potential for all information prerequisites to that chapter being included in the set. If you skip a chapter or include only one section from a given chapter, temporarily sequester items from chapters (or portions of chapters) that you don't want included in AFUs.

Assessments

Course Grade

75 percent Lecture

25 percent Lab

Lecture Grade

80 percent Exam average

10 percent MasteringBiology quizzes (100 total points)

10 percent MasteringBiology homework (1,500 total points)

³http://www.pearsonmylabandmastering.com/northamerical/results/files/Mastering_Final_v4.pdf.

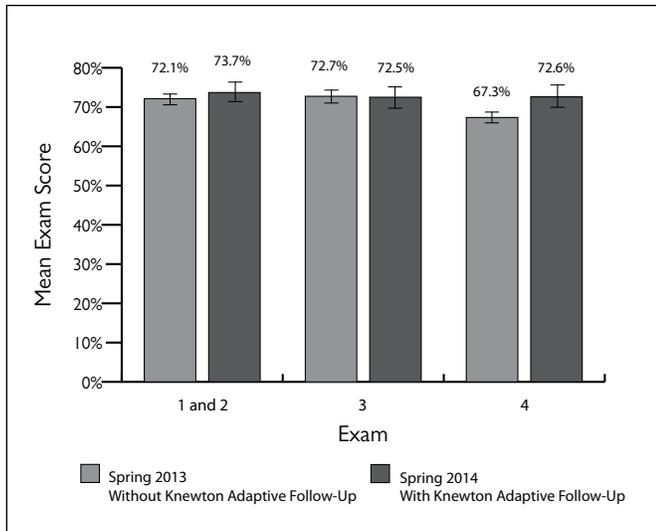


Figure 1. Mean Exam Scores before and after Implementation of Knewton Adaptive Follow-Up, Spring 2013 and Spring 2014 (spring 2013, $n = 121$; spring 2014, $n = 36$; Error Bars = Standard Error, exam 4, $p = 0.032$)

Results and Data

The summer 2013 study indicated that by exam 4 the gap in exam averages of those students who were offered Knewton Adaptive Follow-Up became pronounced. After making the changes in Table 1 in spring 2014, Orr reevaluated the results.

Figure 1 shows that offering Knewton Adaptive Follow-Up has a significant effect: student performance on exam 4 increased with the effect of exams 1 and 2 factored out ($p = 0.032$). Table 2 shows participation in Knewton Adaptive Follow-Up for summer 2013 and spring 2014.

The Student Experience

Student feedback has been positive.

- “I really like how [Knewton Adaptive Follow-Up] takes me back to the basics so I know where I need to study to build my strengths.”
- “Have [Knewton Adaptive Follow-Up] for all of the practices from the beginning of class.”
- “I originally thought that the [Knewton Adaptive Follow-Up] assignments were going to be a waste of time, but they are actually more of a benefit.”

Students report putting more effort into MasteringBiology parent homework because of the test-out option. According to one student, “Adaptive Follow-Up questions motivated me to learn the material better. I really think it’s just the idea of testing out of something that makes me feel smarter and

	Summer 2013 (AFU Optional)	Spring 2014 (AFU Required)
Earned Adaptive Follow-Up credit	74.8%	78.7%
Tested out of Adaptive Follow-Up by earning 95 percent or more on the MasteringBiology parent assignment	16.7%	36.6%
Chose to actively work on Adaptive Follow-Up sets after completing the parent assignment	58.1%	42.1%
Did not participate in Adaptive Follow-Up	25.2%	22.3%

Table 2. Participation in Knewton Adaptive Follow-Up, Summer 2013 and Spring 2014 (summer 2013, $n = 37$; spring 2014, $n = 36$)

encourages me to get a better grade on the [MasteringBiology parent] homework.”

Conclusion

Knewton Adaptive Follow-Up provides individualized recommendations to increase student proficiency in course content and delivers content based on demonstrated understanding of topics as well as the content graphed as a prerequisite for the success of future assignments.

Evaluation of AFU during summer 2013 and spring 2014 shows that AFU had a significant, positive effect on student exam performance. Students often complain about their perceived disconnect between the time and effort spent studying and their subsequent performance on exams. A resource that can identify individual gaps in knowledge facilitates the kind of focused effort and targeted remediation students need to succeed.

In fall 2014, Orr enabled the Knewton Adaptive Follow-Up sets beginning with Chapter 2. This was both in response to student requests that AFU be available earlier and a reflection of the results obtained to date. Orr will continue to evaluate the impact on student learning in future semesters.

In 2000, the Texas Higher Education Coordinating Board adopted *Closing the Gaps by 2015: The Texas Higher Education Plan*.⁴ The report focuses on key goals and outcome measures which include student participation (as measured by enrollment) and success (as measured by certificate and degree completion). Completion of a program starts with a student achieving success in core courses, such as General Biology I. By redesigning the course to enhance individual student learning, Orr is providing a learning opportunity to help more students accomplish their educational and career goals.

⁴2013 Texas Public Higher Education Almanac, *Texas Higher Education Coordinating Board*, p. 1.

MasteringChemistry with Knewton Adaptive Follow-Up

School Name Hudson Valley Community College, Troy, NY

Course Name General Chemistry I

Course Format Lecture and lab

Key Results The introduction of new concepts prior to lecture increased student engagement and participation, and the addition of prelecture and Knewton Adaptive Follow-Up assignments resulted in higher exam averages.

Submitted by

Donna Barron, Assistant Professor

Course materials

Introductory Chemistry (custom), Tro

About the Course

Hudson Valley Community College serves approximately 13,000 students each semester. Eight out of 10 students come from the immediate, capital region, and approximately 50 percent are enrolled part-time.

General Chemistry I is taken primarily by science, health, and engineering majors planning to transfer to a four-year institution. The course covers atomic structure, chemical bonds, reactions and equations, properties of gases and liquids, and changes in state, solutions, and stoichiometry.

Challenges and Goals

According to Assistant Professor Donna Barron, students often do not understand the learning process and tend to employ the same type of passive learning they did in high school versus taking responsibility for learning and practicing problem solving outside of class. When students don't take responsibility for learning concepts on their own, it impacts the type of activities that can be done during class time.

Barron also observes that students tend to stop listening when they hear new words or terms they don't recognize. For students who haven't prepared, that can be much of the content covered in class. "If a student's attention is lost, they'll miss out on information they need to succeed in the course," she says. She assigns MasteringChemistry homework to introduce

content to students prior to class and to help them become familiar with concepts on their own time. Barron hypothesizes that this helps students come to class with a better understanding of what they don't know, and that as a result of redesigning the course to include Knewton Adaptive Follow-Up (AFU) assignments and prelecture work, student learning will increase.

Implementation

Barron implemented MasteringChemistry in 2009 so she could offer her students online homework with immediate feedback and grading. MasteringChemistry homework was due after the chapter lecture and tended to include activity and tutorial questions. As Barron became more knowledgeable about how to use MasteringChemistry to enhance learning, she made changes to her implementation to flip the classroom.

In spring 2013, Barron added MasteringChemistry prelecture homework assignments: short, untimed assignments due before lecture designed to help increase student awareness about new topics and to identify student misconceptions and areas of misunderstanding. Barron tells students it is okay to be confused after doing the homework because the concepts will become clear during class.

In spring 2014, Barron assigned both MasteringChemistry prelecture and postlecture homework, and offered optional Knewton Adaptive Follow-Up exercises for extra credit. AFU exercises are designed to help students fill in any gaps in their understanding, so each assignment is generated from a student's performance on their MasteringChemistry parent homework.

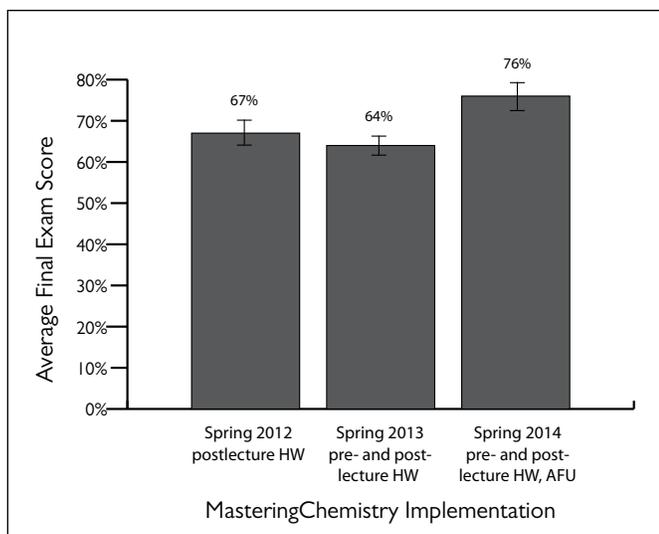


Figure 1. Average Final Exam Scores by Implementation, Spring 2012–14 (2012, $n = 30$; 2013, $n = 27$; 2014, $n = 24$; Error Bars = Standard Error)

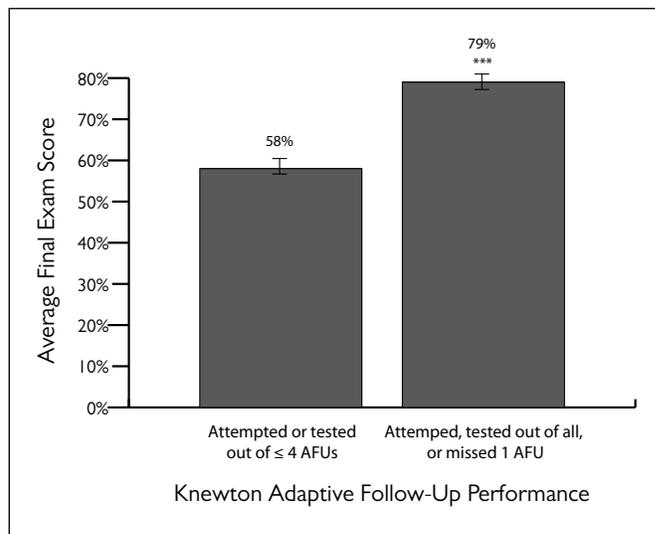


Figure 2. Average Final Exam Scores by Knewton Adaptive Follow-Up Performance, Spring 2014 (Completed ≤ 4 , $n = 17$; Attempted all/Missed one, $n = 7$; Error Bars = Standard Error, Significance $p < 0.001$)

Students automatically received extra credit for AFU assignments if they earned at least 80 percent on MasteringChemistry postlecture parent homework. Students who earned less than 80 percent were required to complete the AFU assignment to earn extra credit. AFU assignments were available starting with Chapter 6; there were seven AFU assignments available in spring 2014.

Using MasteringChemistry in these ways has freed up class time and enabled Barron to integrate more active learning exercises, to address specific misconceptions, and to explore real-life applications. Time lecturing on theory has been reduced, and Barron no longer uses PowerPoints—class time is used for discussions, problem solving, and learning games.

Assessments

37.5 percent	Exams (three)
25.0 percent	Lab
25.0 percent	Final exam
12.5 percent	MasteringChemistry

Results and Data

To understand the impact of the changes made to the course, final exam averages from the spring semesters in 2012, 2013, and 2014 were evaluated. Figure 1 shows a significant increase in the final exam average in spring 2014. To assess whether optional Knewton Adaptive Follow-Up assignments had an impact on learning, spring 2014 student data were split into two groups: those who tested out of, attempted all, or skipped only

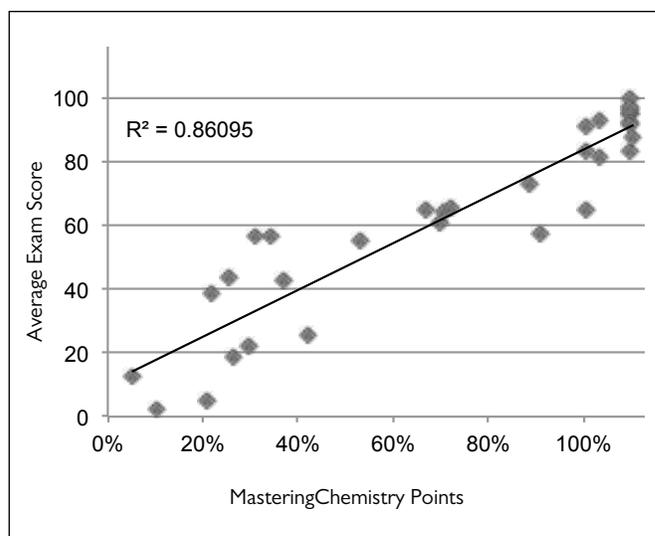


Figure 3. Correlation of MasteringChemistry Homework Points to Average Exam Score, Spring 2014 ($n = 24$)

“Just as the name suggests, [MasteringChemistry] helped me master chemistry. I wish I had this kind of program for every class.”

—Student

one AFU assignment (out of seven); and those who attempted or tested out of four or fewer AFU assignments. All students fell into one of those categories. Figure 2 shows that students who attempted all AFU assignments or skipped only one AFU assignment had significantly higher final exam averages ($p = 0.0004$). This analysis includes only students who completed the course by taking the final exam.

Additional analysis of the spring 2014 exam results explored the correlation between MasteringChemistry homework scores and average (of three) unit exam scores. Figure 3 shows a strong correlation between MasteringChemistry points and the average unit exam score ($r^2 = 0.8609$). Although not shown here, there was also a correlation between MasteringChemistry homework scores and final exam averages, with $r^2 = 0.6811$. This correlation includes only students who took the final exam.

The Student Experience

Barron reports a change in student attitude toward online homework, and student feedback indicates that many students understand the benefit of doing it. She says that students enjoy class more since the implementation of prelecture MasteringChemistry homework, and that class participation increased. Students recognize the topics being discussed, and the work in class clarifies any concepts they didn't understand on the homework.

In a spring 2014 survey, students were asked about the MasteringChemistry assignments. Comments include:

- “Just as the name suggests, [MasteringChemistry] helped me master chemistry. I wish I had this kind of program for every class.”
- “I could rework the problems for test review.”
- “[MasteringChemistry] was a great overall tool. It allowed me to focus on what was important in each chapter. The rework for practice was an excellent way to check my understanding of topics when studying for exams.”

Conclusion

MasteringChemistry was initially adopted to address student engagement and preparedness, but has since evolved from postlecture homework only to the use of both pre- and post-lecture homework, plus Knewton Adaptive Follow-Up extra-credit assignments to address individual student remediation needs.

Since the latest redesign, Barron reports a trend toward higher exam scores for students who do the MasteringChemistry homework and Knewton Adaptive Follow-Up sets. To further promote this trend, Barron plans to continue offering AFU extra-credit assignments, but will raise the test-out score from 80 to 95 percent to encourage topic mastery.

Active Learning/Flipping the Classroom

In 2006, the Spellings Commission report recommended that “America’s colleges and universities embrace a culture of continuous innovation and quality improvement by developing new pedagogies, curricula, and technologies to improve learning, particularly in the area of science and mathematical literacy.”¹ Since then, as technology has developed and enhanced learning possibilities outside class, time during class has been freed up for experiential activities and conceptual learning. And universities and colleges have seized the opportunity to redesign their lecture-based courses, thereby enhancing student learning, serving more students, and, frequently, saving money.

STEM courses are especially poised to benefit from the influence of learning technologies and active learning. According to Jo Handelsman, associate director for science at the White House Office of Science and Technology Policy and on leave as a professor in the Department of Molecular, Cellular and Developmental Biology at Yale University: “A traditional lecture format in a large introductory classroom often emphasizes content rather than process and in doing so often fails to convey to students the nature of hypothesis-based inquiry that is at the heart of scientific research. There is reason to believe that this deficit diminishes learning outcomes and may contribute to the loss of some of our most talented students at the introductory level.”² She reiterates her point by adding “Many talented college students flee STEM majors because they find introductory courses uninspiring. This can be corrected by incorporating classroom teaching practices that engage students in the learning process, known as active learning, which has been shown to reduce STEM attrition. *Active learning* includes any activity in which every student must think, create, or solve a problem.”³

As universities and colleges look to increase retention and levels of student success in the STEM disciplines, more and more instructors are incorporating active learning into their courses. Eric Mazur, physicist and professor at Harvard University,

developed Peer Instruction, a method for interactively teaching large lecture classes. “When you think about learning, the information transfer is the easy part and can be done online or by video,” he says. “The hard part is making meaning out of that information for students.”⁴ Findings from Mazur’s study show that most of the assessed Peer Instruction courses produced learning gains commensurate with interactive engagement pedagogies, and more than 300 participating instructors (more than 80 percent) considered their implementation of Peer Instruction to be successful. Perhaps most striking is that more than 90 percent of those using the method have plans to continue or expand their use of Peer Instruction.”⁵

As universities and colleges look to increase retention and student success in the STEM disciplines, more instructors are incorporating active learning into their courses.

One look at the data, and the movement toward active learning makes sense. Early 2014 saw the publication of a meta-analysis of 225 studies that report data on examination scores or failure rates when comparing student performance in undergraduate STEM courses under traditional lecturing versus active learning. The authors concluded that: “The President’s Council of Advisors on Science and Technology has called for a 33 percent increase in the number of science, technology, engineering, and mathematics (STEM) bachelor’s degrees completed per year and recommended adoption of empirically validated teaching practices as critical to achieving that goal. The studies . . . document that *active learning leads to increases in examination performance that would raise average grades by a half a letter, and that failure rates under traditional lecturing increase by 55 percent over the rates observed under active learning* [editor’s emphasis]. The analysis supports the theory claiming that calls to increase

¹Spellings Commission report. <http://www2.ed.gov/about/bdscomm/list/hiedfuture/reports/final-report.pdf>.

²Handelsman J, Miller SI, Pfund C. New York: W.H. Freeman; 2007. *Scientific Teaching*.

³Mark J. Graham, Jennifer Frederick, Angela Byars-Winston, Anne-Barrie Hunter, and Jo Handelsman, “Increasing Persistence of College Students in STEM,” *Science* (September 27, 2013);341:1456.

⁴<http://www.olin.edu/collaboratory/mazur-testimonial/>.

⁵Catherine H. Crouch and Eric Mazur, “Peer Instruction: Ten Years of Experience and Results,” *The Physics Teacher* (April 2002);40.

the number of students receiving STEM degrees could be answered, at least in part, by abandoning traditional lecturing in favor of active learning.”⁶

Frequently, the flipped-classroom model is adopted when an instructor makes the decision to incorporate active-learning strategies into the classroom. The Center for the Integration of Research, Teaching, and Learning describes the flipped approach by comparing it with the traditional classroom. “In the traditional approach to college math and science teaching, students come to class to get a first exposure to the material through lecture, then try to make sense of that material through problem sets and other activities after class. The ‘flip’ involves shifting the first exposure to outside of class [prelecture] and the deeper learning to class time.”⁷

Frequently, the flipped-classroom model is adopted when an instructor makes the decision to incorporate active learning strategies into the classroom.

Matthew Stoltzfus is a lecturer at Ohio State University who teaches large introductory chemistry lecture courses via the flipped classroom model. He describes the impact this approach has on students. “The flipped-classroom model allows for a deeper, more-hands-on, and more-engaging experience for students in the classroom, enabling students to start with lower-level concepts at home and discuss higher-level concepts or areas of struggle in the classroom. The model provides more-meaningful interactions for students and teachers by giving teachers higher-quality face time with students.”⁸

For instructors focused on developing students’ critical-thinking skills, the flipped model with active learning in the classroom offers a solution. “The ability to engage in careful, reflective thought is viewed in education as paramount. Teaching students to become skilled thinkers is a goal of education. Students must

be able to acquire and process information since the world is changing so quickly. Some studies purport that students exhibit an insufficient level of skill in critical or creative thinking. . . . Multiple forms of student engagement exist when high-level thinking is fostered. Examples of engagement include collaborative group activities, problem-solving experiences, open-ended questions that encourage divergent thinking, activities that promote the multiple intelligences and recognize learning styles, and activities in which both genders participate freely.”⁹

As stated in the fact sheet for the 21st Century Readiness Act—a piece of legislation introduced into Congress in 2011 and which defines college and career readiness—“Skills known as the four Cs; Critical thinking and problem solving, Communication, Collaboration, and Creativity and innovation, and the ability to learn, apply, and adapt them to all subjects are becoming increasingly more important for college and career readiness. Colleges and employers agree that students who learn to fuse subject knowledge and these skills in school are better prepared to enter the workforce. As our economy continues to rebuild and many citizens continue their search for employment, it is in our national interest that federal education policy support education readiness initiatives that fuse subject knowledge and skills to prepare and graduate students who are ready for the jobs in the 21st century, to ensure U.S. competitiveness, and to help weather further economic downturns.”¹⁰

With a flipped-classroom model, students take responsibility for their learning outside the classroom so that critical thinking and conceptual learning can take place in the classroom. However, students need the tools to do it on their own. The case studies that follow are examples from instructors who have flipped their classrooms and used Mastering as part of their flipped-classroom redesign. Each of the instructors discovered that after flipping the classroom, the results showed a trend toward better student performance and increased levels of student and instructor satisfaction, all of which promote increased retention and student success—and better prepare students with the twenty-first-century skills they’ll need for long-term career success.

⁶Scott Freeman, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth, “Active Learning Increases Student Performance in Science, Engineering, and Mathematics,” *Proc Natl Acad Sci U S A* (June 10, 2014);111(23):8410–8415. www.pnas.org/cgi/doi/10.1073/pnas.1319030111.

⁷<http://www.cirtl.net/node/7788>.

⁸Brian Lukoff and Matthew Stoltzfus, “Professors: Here’s How to Flip Your Classroom,” *eCampus News*, March 24, 2014. <http://www.ecampusnews.com/top-news/professors-flipped-classroom-425/>.

⁹<https://www.mentoringminds.com/research/critical-thinking-strategies-guide>.

¹⁰Fact Sheet: S. 1175 & H.R. 2536, *The 21st Century Readiness Act*.

MasteringBiology

School Name [Rochester Institute of Technology, Rochester, NY](#)

Course Name [General Biology II](#)

Course Format [Lecture and lab, online, flipped, and hybrid](#)

Key Results Course redesign, with increased implementation of MasteringBiology and more active learning, resulted in a trend toward both higher exam scores and a tightening of exam scores.

Submitted by

Sandra J. Connelly, Assistant Professor

Course materials

Campbell Biology: Concepts and Connections, Dickey, Reece, Simon, and Taylor

About the Course

Rochester Institute of Technology (RIT) is a private four-year institution in suburban Rochester, New York, with an enrollment of approximately 18,000 students. RIT is an internationally recognized leader in preparing deaf and hard-of-hearing students for successful careers in professional and technical fields, and provides access and support services for the more than 1,200 deaf and hard-of-hearing students who live, study, and work with hearing students on the RIT campus.

General Biology II is the second course in a three-quarter (10-week) sequence. It is a fundamental biology course designed

for nonbiology majors who have a lab science requirement. The course takes a broad approach to the field of biology, with this session focusing on an introduction to anatomy and physiology of plants and animals. Students taking the course can be from any major, range from freshmen through graduate students, and include deaf and hard-of-hearing students.

Challenges and Goals

One of the challenges Assistant Professor Sandi Connelly faces is the students' levels of preparedness. They may struggle for many reasons, including poor reading and writing comprehension, English as a Second Language, learning disabilities, lack of fundamental knowledge in science, poor study skills, and lack of dedication to the course. Connelly redesigned the course and implemented MasteringBiology as a way to address these issues by providing remediation and study resources, increased engagement both inside and outside the classroom, and the ability to better assess student learning and success.

Years	MasteringBiology Assignment	Credit	Attempts	Time Allowed	Completion Rate
Fall 2008–Spring 2010	Homework	Optional	3	Unlimited	Not measured
Fall 2010–Spring 2011	Homework	5%	3	Unlimited	~80%
Fall 2011–Spring 2012	Homework	15%	2	Unlimited	~100%
Fall 2012–Spring 2013	Homework	20%	2	Unlimited	>97%
	Quiz	5%	1	60 minutes	>97%
Fall 2013–Spring 2014	Homework	15%	2	Unlimited	>96%
	Quiz	10%	1	60 minutes	>96%
Fall 2014–Spring 2015	Homework	10%	2	Unlimited	TBD
	Knewton Adaptive Follow-Up*	Extra credit			TBD
	Quiz	10%	1	60 minutes	TBD

Table 1. Use of MasteringBiology, Fall 2008–Spring 2015

*Knewton Adaptive Follow-Up items are generated based on an individual student's performance on the MasteringBiology parent homework and will vary from student to student.

Implementation

Connelly's use of MasteringBiology started as optional in 2009 and since then has progressed. She continues to evaluate and redesign her course, increase the active-learning component and put a heavier emphasis on building critical-thinking skills and assessing qualitative items (Table 1).

Beginning with the fall 2014 semester, Connelly added Knewton Adaptive Follow-Up exercises to MasteringBiology homework and quizzes. Homework assignments are now worth 10 percent and contain active tutorial questions that involve watching or reading to complete the exercises.

Adaptive Follow-Up exercises comprise five questions for extra credit. Students who earn less than 90 percent on their MasteringBiology homework are required to do these exercises to receive credit. Students who earn 90 percent or higher on their homework automatically receive the extra credit. Exercise questions are generated based on a student's homework performance and target gaps in a student's content knowledge. MasteringBiology quizzes, which contain reading or test bank questions, continue to be given and are worth 10 percent course credit.

Connelly teaches the course in multiple formats including traditional lecture and lab, online, flipped, and hybrid. Her strategy for offering alternative formats, such as the flipped and hybrid models, is to put the responsibility for learning on students outside the classroom via videos, worksheets, and MasteringBiology homework; and to assess student learning during class via active-learning exercises, critical-thinking problems, and quizzes.

For example, Connelly assigns students short videos to watch before class time. To keep students engaged, individual videos are no longer than 8-10 minutes, and total no longer than 60 minutes per topic. Then, students complete a worksheet prior to class and one or more activities in class, such as writing a guided response, completing a case study, performing an applied experiment, or participating in a group activity.

Following class, students complete an online MasteringBiology homework assignment designed to help them understand whether they have mastered the concept. They may watch the videos again, if needed, and may be asked to write about important points. Finally, students take a low-stakes quiz either online in MasteringBiology or in class, depending upon timing and the amount of content covered by the date of the quiz.

In-class group activities are designed to help students develop critical-thinking and application skills. It also helps them learn to work in groups, to make contact with fellow students, and to see how science is relevant to their lives. By observing their participation in these activities, misconceptions or issues can be addressed as they arise during class.

Assessments

65 percent	Exams
25 percent	MasteringBiology
10 percent	Other (video worksheets, in-class activities)

Results and Data

Results for this course were first published in Pearson's *MyLab & Mastering: Science and Engineering, V. 4*.¹ Connelly believes it is important to continually evaluate results after a redesign in order to understand its impact on student learning. Since 2009, results have shown a consistent increase in exam averages, with the largest increase in 2011–12 when MasteringBiology was integrated more significantly into the course.

Figure 1 (next page) shows an increase in exam averages for both the plant and animal exams, often the most predictive of students' performances in the second course in general biology and which include concepts that are built upon in the third course.

Because of the diversity of students, it is difficult to obtain a huge jump in scores, but the trend shows higher scores in addition to a tightening of exam scores. The standard deviation and ranges are decreasing, and the average time students spend on assignments is increasing—both of which indicate that students are putting effort into their MasteringBiology homework assignments.

¹MyLab & Mastering: Science and Engineering, V. 4, 2014, www.pearsonmylabandmastering.com/northamerical/results/files/Mastering_Final_v4.pdf.

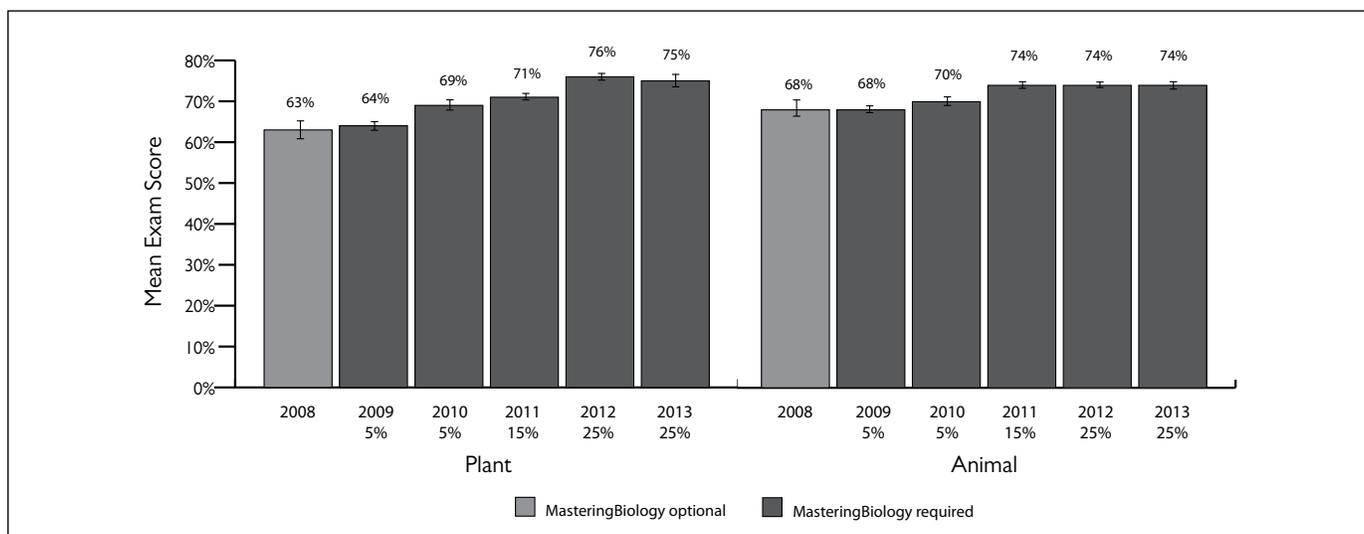


Figure 1. Average Plant and Animal Exam Scores by MasteringBiology Credit Value, 2008–13 (2008, $n = 271$; 2009, $n = 278$; 2010, $n = 281$; 2011, $n = 250$; 2012, $n = 264$; 2013, $n = 172$)

The Student Experience

It is critical that students are engaged in course content and motivated to learn. Although Connelly has added additional course work, and hears students complain about it, she reports that they are happier in the end because they are learning more and recognize the importance of that to their future successes. Student feedback about both the class and MasteringBiology includes:

- “Best class ever! I would recommend it to anyone.”
- “Thank you for giving us this amazing opportunity.”
- “In the short term, MasteringBiology will help me get better grades. This, in turn, will help me get a better job.”
- “I am not a strong or confident test taker, but as long as my classes use MasteringBiology, I know I will be prepared and capable of doing well on every exam. This will benefit me throughout college as I strive for the best grades possible, which is important because I plan to apply to graduate school, where outstanding grades are required.”

In addition, class attendance has increased. Prior to redesign, approximately 75 percent of students regularly attended class. Today approximately 95 percent attend on a regular basis. And when they are in class, students are participating and engaged.

Conclusion

Teaching to a diverse group of students presents challenges, including how to ensure each student gets what they need to learn and succeed. One result of redesigning her course so that students come to class more prepared is that Connelly can now do more in-class activities that help assess student understanding and develop conceptual understanding and critical-thinking skills.

In fall 2014, Connelly implemented a hybrid-flipped class, a very new approach to courses at RIT—especially a College of Science general education course. Students are responsible for upwards of five hours of videos to prepare for exams, and they may meet with Connelly only three times (one time per week) between exams.

The change was motivated by space constraints—there were literally no available seats in the room. The new design will be assessed side by side with Connelly’s online class, flipped class (which meets two times per week), and traditional lecture class in the fall and spring semesters of 2014. Because all students are assessed in the same way and have the same learning outcomes regardless of the delivery, Connelly can conduct a valid analysis of the new design. These findings will help guide future directions for the course.

MasteringBiology

School Name Vincennes University, Vincennes, IN

Course Name Principles of Biology I and II

Course Format Lecture and lab, flipped classroom

Key Results After implementing MasteringBiology as part of a four-year course redesign to a flipped classroom, students earned more As and Bs and earned higher average final exam scores.

Submitted by

Curtis Coffman, Associate Professor and Biology Department Chair

Course materials

Campbell Biology in Focus, Urry, Cain, Wasserman, Minorsky, Jackson, and Reece

About the Course

Vincennes University offers both two- and four-year degree programs, and enrolls more than 15,000 students across multiple campuses. The main campus is located in a rural area.

Principles of Biology I and II is a two-course sequence offering an integrated approach to the study of living organisms. Topics include genetics; cytology; respiration; photosynthesis; ecology; evolution; living-organism domains and kingdoms; plant morphology, physiology, and development; and animal morphology and physiology.

The students who take these courses are primarily pre-professional majors (i.e., premed, dentistry, pharmacy, physical therapy, and veterinary majors), in addition to agriculture, earth science, zoology, forensics, biotech, biology, and marine biology majors. The majority are full-time, traditional, college-age students.

Challenges and Goals

Associate Professor and Biology Department Chair Curtis Coffman found that students did not come to class prepared, which impacted how class time was spent. To promote that students take more responsibility for their learning and come to class with a better understanding of basic content, he redesigned the course to a flipped classroom. By assigning basic content to students prior to class, he can now focus on active learning and help students develop a deeper understanding of conceptual problems, which will help them succeed in future courses.

Implementation

The redesign was rolled out over a four-year period. The starting point was when Coffman attended a 2010 workshop for the National Association of Biology Teachers on lecture-free teaching by Bonnie Wood, professor at the University of Maine at Presque Isle, who wrote a book by the same title.

Coffman developed preclass worksheets to encourage students to prepare prior to lecture. Over a three-year period, he then collected active-learning exercises and case studies to incorporate into the class. In fall 2013, he added MasteringBiology and preclass videos to ensure students were prepared for in-class activities. Preclass work now includes the following:

1. 10–13 minutes of video that covers content to be discussed in class. The main sources of videos are YouTube, Crash Course Biology, and Bozeman Science.
2. A preclass MasteringBiology homework assignment, which may include BioFlix™, exercises, and quiz questions.
3. A paper-and-pencil assignment based on the textbook reading. Coffman creates the questions, which are focused on important background information.

The new, flipped format provides students with the same information three different ways to address different learning needs and help students make connections. Students who complete the work come to class with an understanding of basic concepts and a recognition of what they don't yet understand. Coffman uses the diagnostic reports in MasteringBiology to check for knowledge gaps and address misconceptions in class.

The following activities are utilized in class:

- Case studies
- Process modeling
- Group discussion questions
- Textbook data analysis and graphing for skills exercises

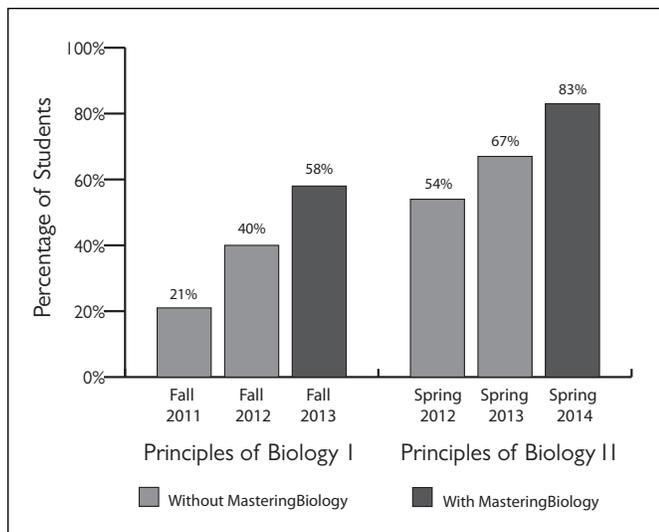


Figure 1. Percentage of Students Earning an A or B with and without MasteringBiology, Fall 2011–13 and Spring 2012–14 (Fall 2011, $n = 50$; Fall 2012, $n = 43$; Fall 2013, $n = 52$; Spring 2012, $n = 35$; Spring 2013, $n = 33$; Spring 2014, $n = 41$)

In-class activities come from sources including the National Center for Case Study Teaching in Science, *The American Biology Teacher*, and Coffman himself. These activities encourage the development of critical-thinking skills and focus on conceptual learning of biology topics.

Assessments

60 percent	Exams (five exams and a final)
25 percent	MasteringBiology
10 percent	Preclass chapter outlines
5 percent	In-class activities

Results and Data

Data for Principles of Biology I and II for the first semester MasteringBiology was in use indicated an improvement in student performance: the number of students earning an A or B in the course increased in both Principles of Biology I and II (Figure 1); in the spring 2014 Principles of Biology II course, in which the students had used MasteringBiology in the fall Principles of Biology I class, the A/B rate was 16 percentage points higher than the prior semester without MasteringBiology.

In addition, students earned significantly higher exam scores for both Principles of Biology I and II after using MasteringBiology (Figure 2). The final exam average for Principles of Biology I was notably higher than prior averages ($p = 0.000007$), with the Principles of Biology II exam significantly higher than prior semesters ($p = 0.019$).

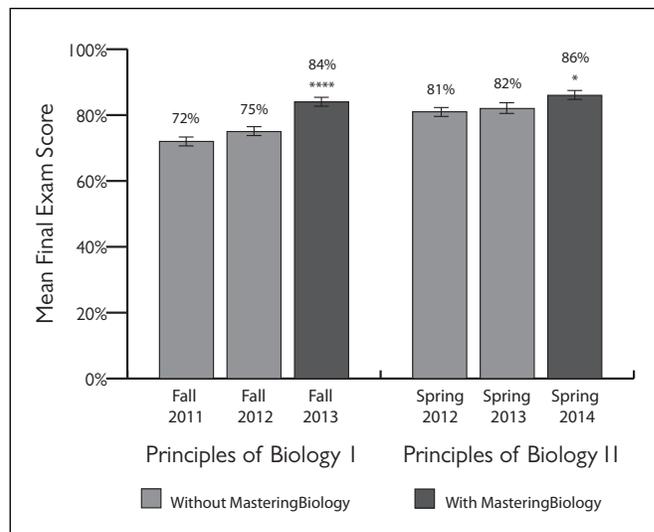


Figure 2. Mean Final Exam Scores with and without MasteringBiology, Fall 2011–13 and Spring 2012–14 (Fall 2011, $n = 50$; Fall 2012, $n = 43$; Fall 2013, $n = 52$; Spring 2012, $n = 35$; Spring 2013, $n = 33$; Spring 2014, $n = 41$) Error Bars = Standard Error, Significance * $p < 0.05$, **** $p < .0001$

The Student Experience

Students say that they enjoy using MasteringBiology and use it as a study tool to help prepare for exams. Prior to exams, students can often be found in the computer lab working on MasteringBiology, reviewing homework, and using the study area resources. In addition, student evaluations on the overall class have become much more positive since the redesign.

Conclusion

Coffman reports that since flipping his classroom and adding MasteringBiology, students come to class better prepared and understand what they know and don't know. In addition, topics are covered in more depth, which better prepares students for higher-level courses in the future.

According to Arthur Chickering and Stephen Ehrmann, "Learning is not a spectator sport. Students do not learn much just sitting in classes listening to teachers, memorizing prepackaged assignments, and spitting out answers. They must talk about what they are learning, write reflectively about it, relate it to past experiences, and apply it to their daily lives. They must make what they learn part of themselves."¹ The flipped format does just that.

¹Chickering, Arthur W. and Ehrmann, Stephen C., "Implementing the Seven Principles: Technology as Lever," American Association for Higher Education and Accreditation Bulletin, 1996.

MasteringMicrobiology

School Name Shoreline Community College, Shoreline, WA

Course Name Microbiology

Course Format Winter–fall 2012: traditional lecture, winter 2013–winter 2014: flipped classroom

Key Results Assessment scores increased and more students earned As and Bs after a redesign of the course to a flipped format with MasteringMicrobiology to enhance student learning outside the classroom.

Submitted by

Judy Meier Penn, Professor

Course materials

Microbiology with Diseases by Body System, Bauman

About the Course

Shoreline Community College is a suburban school on a quarter system. The students who take Microbiology are primarily nursing and allied health majors, and are a mix of returning adult students and recent high school graduates representing a wide range of ages, cultures, skills, and life experiences. This five-credit lecture and lab course is a survey of microorganisms with a focus on health-care applications: disease process, microbial control, and immunology. Laboratory techniques covered in the course include isolation and identification of bacteria.

Challenges and Goals

Professor Judy Meier Penn reports that in her traditional lecture, she could interact with only a few students. She sought a way to increase student participation in class and ensure that students came to class prepared, to integrate more interactive learning, and to reduce the amount of time she lectured on basic concepts.

Thanks to improved lecture-capture technology, Penn also wondered if she could eliminate the face-to-face lecture and free up class time. She had used group activities in the past, and noticed that students (1) seemed to understand the associated material much better after those activities and (2) seemed able to move to higher levels of learning beyond memorization.

Implementation

Penn started using MasteringMicrobiology in fall 2009, class testing the beta version because she believed it provided resources that would facilitate accomplishing her course goals. It helped students prepare for class by having them do an activity outside of class in MasteringMicrobiology, and it helped her to better understand student comprehension of the materials prior to class meetings.

Previous to implementing MasteringMicrobiology in her course, Penn gave a paper-and-pencil pop quiz or other short in-class assessment to obtain real-time feedback. MasteringMicrobiology enables her to identify student issues and misconceptions *prior* to class meetings. She can now use valuable class time to review problem areas and focus on more-active learning.

MasteringMicrobiology enables [Penn] to identify student issues and misconceptions prior to class meetings.

In the winter 2013 quarter, Penn redesigned her course by flipping the classroom and changing her implementation of MasteringMicrobiology. Assessments include eight quizzes and one comprehensive final exam per quarter. She drops each student's lowest quiz score. The remainder of the course assessments are as follows:

- **Lecture:** MasteringMicrobiology homework assignments plus activities completed in class. MasteringMicrobiology assignments are a combination of end-of-chapter, tutorial, and Penn's own custom-written questions. These questions are designed to help students learn—she allows multiple attempts and there is no time limit.

- **Lab:** Prelab assignments are completed before each lab session and include (1) reading the exercise, (2) preparing a flow diagram of the procedure and preparing locations for recording results in lab notebooks, and (3) taking a prelab quiz in MasteringMicrobiology to ensure content mastery.

In addition, Penn offers two optional, not-for-credit MasteringMicrobiology assignments: a practice quiz (objective questions to practice for the graded quiz) and lab study questions (study questions to test understanding of course content and the application of it from lab).

Students receive the information they need before each class by reading, viewing a video lecture, and completing a MasteringMicrobiology assignment. During class time, they participate in group activities, such as working on application questions including case studies; pairing up with other students to practice explaining processes; and making models and diagrams that illustrate concepts.

When she moved to a flipped classroom, Penn identified the following best practices:

- *Introduce the format and activities with a positive attitude and show statistics that illustrate improvements in quiz or course grades.* If students understand the change can help them, they are more likely to move out of their comfort zone and fully participate in it.
- *To help students come to class prepared, give them low-stakes MasteringMicrobiology assignments after they have watched the lecture videos and done the readings.* Encourage students to complete assignments without looking up answers, so they can truly assess what they understood.
- *To make the most of group activities, do the following:*
 - Spend part of the first class asking students to brainstorm the qualities that make a good group member and discuss ways to involve all members in discussions.
 - During the 10 instructional weeks of the quarter, change groups only one or two times during the term and have students complete peer reviews.
 - Have students suggest two people they'd like to work with and put them with at least one of those people in subsequent group assignments.

- When forming groups, include a mix of success levels, genders, and ethnicities, as well as at least one person who has the potential to be an effective leader. Provide an online group page in the school learning management system where they can share and discuss course content.
- Make sure that group activity assignments are aligned with what students are tested on and how they are tested, e.g., the same level of Bloom's taxonomy and course objectives.

Assessments

55 percent	Quizzes (eight, the lowest is dropped)
25 percent	Lab
10 percent	Lecture assignments
10 percent	Comprehensive final exam

Results and Data

Penn compared student success rates from the traditional and flipped quarters and discovered that the biggest change was a five-percentage-point increase in As and Bs (Figure 1).

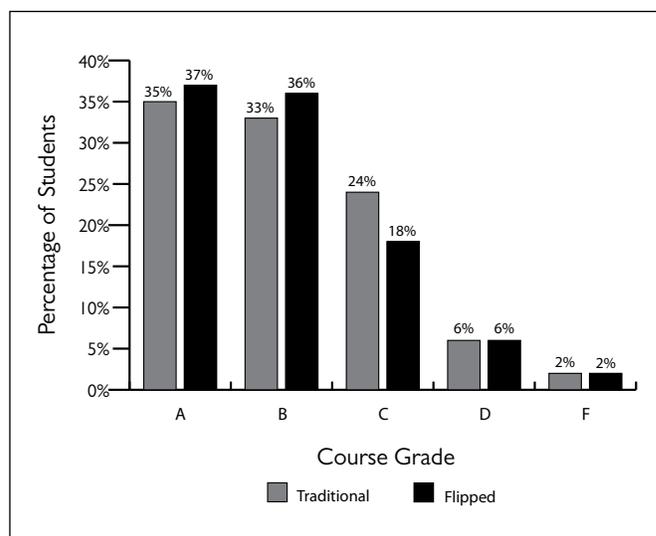


Figure 1. Comparison of Grade Distribution in Traditional and Flipped Classroom Settings, Fall 2012–Winter 2014 (Traditional, Fall 2012–Winter 2012, $n = 54$; Flipped, Spring, Winter, Fall 2013, Winter 2014, $n = 132$)

In the flipped format, students share strategies for reading, test taking, and problem solving; and they are more likely to form study groups and hold online study sessions.

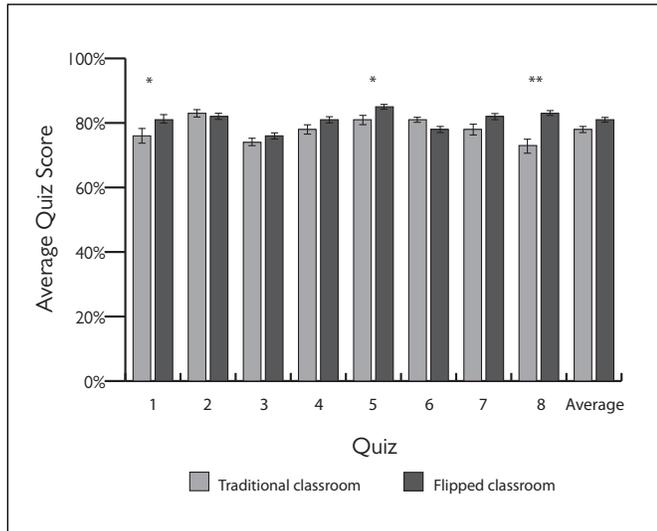


Figure 2. Comparison of Average Quiz Scores in Traditional and Flipped Classroom Settings, Fall 2013–Winter 2014 (Traditional, $n = 53$; Flipped, $n = 127$; Error Bars = Standard Error; Significance * $p < .05$; ** $p < 0.01$)

After redesigning the course to a flipped format, Penn observed the following results:

- The mean final exam score increased from 73 to 75 percent.
- The averages of six of eight quizzes and the quiz average increased, three being statistically significant (Figure 2).
- Students performed better on the higher-level quiz questions.

The Student Experience

In an end-of-quarter survey, students were asked to rate MasteringMicrobiology assignments and practice items for their effectiveness in helping them to learn course content. The results show that the majority of students from the winter 2013 through 2014 quarters felt that MasteringMicrobiology assignments helped: on a three point scale with the highest being “significantly” and the lowest being “did not help”,

51 percent said they helped “significantly,” and 43 percent said they helped “somewhat” ($n = \sim 65$).

Penn also asked students for their feedback on the flipped-classroom approach. Student responses included the following:

- “The flipped class has helped me to not only learn the information, I retain it.” (Winter 2013)
- “This is the first time I’ve taken a class where the easy parts (reading, viewing lecture) are done at home and the hard parts (learning and understanding) are done in class. It gave me time to interact with my instructor, which definitely benefited me during the quarter.” (Spring 2013)

In the flipped format, students share strategies for reading, test taking, and problem solving; and are more likely to form study groups and hold online study sessions. As nearly all of Penn’s students are planning careers in allied health, they also benefit from the interpersonal communication gains of these activities.

Conclusion

An April 2014 study looks at 225 published and unpublished studies that compare the results of experiments documenting student performance in courses with at least some active learning versus traditional lecturing. The study, published in Proceedings of the National Academy of Sciences online, found that the results of these 225 studies “document that active learning leads to increases in examination performance.”¹ The results of this study show similar findings.

By using MasteringMicrobiology as a platform for learning outside the classroom, Penn has incorporated more active learning in the course, moving from a mostly traditional lecture format to a fully flipped format, and in fall 2014 she started using Learning Catalytics for some of the class activities. Now when she enters the classroom, students are often already talking about the content that was assigned for the day. She hears things like, “Did you understand...?” or “I think the hardest part was...” It is evident that they are engaged, working outside the class, and more prepared, which has resulted in higher levels of learning and success rates in the course.

¹Active learning increases student performance in science, engineering, and mathematics, Scott Freeman, University of Washington, Sarah L. Eddy, University of Washington, Miles McDonough, University of Washington, Michelle K. Smith, University of Maine, Nnadozie Okoroafor, University of Washington, Hannah Jordt, University of Washington, and Mary Pat Wenderoth, University of Washington. Edited by Bruce Alberts, University of California, doi: 10.1073/pnas.1319030111, <http://www.pnas.org/content/early/2014/05/08/1319030111>.

Conclusion

More than merely successful implementations, the courses, programs, and initiatives described in this report are victories. Behind the successful outcomes—in the forms of improved final exam grades, increased persistence, success in subsequent courses, college readiness, and other learning gains—are students who have become better equipped to pursue their academic goals and achieve their life dreams.

An Ongoing Process

We applaud the participating institutions for their efforts and determination. But those efforts are not over: a successful technology implementation is an ongoing process, ever evolving with the emergence of new and improved pedagogy, the entry of each unique cohort of students, and the increased amounts of information generated by the long-term tracking and measuring of student data.

Pearson's Faculty Advisor Network (FAN) is available to help you improve the teaching and learning experience in your courses. Visit the **FAN Web site** to meet and engage with a community of educators who are eager to share advice, tips, and best practices related to MyLab & Mastering products.

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Pearson offers solutions for all kinds of educational needs, for all types of courses, and for all of the ways those courses are taught and delivered. Combined with one of the many proven-successful best practices, the possible configurations of an effective MyLab & Mastering implementation increase exponentially. Let us help you:

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We look forward to hearing about your achievements, and we hope you'll want to include your experience in the next MyLab & Mastering report. To tell us about your success, contact Betsy Nixon, efficacy manager, at betsy.nixon@pearson.com.

HELPFUL PEARSON LINKS

Following is a list of links developed to inspire, support, and promote conversation among educators and to communicate the latest and most-effective practices across the industry. We hope you find them useful and urge you to share them with your colleagues and others committed to improving the teaching and learning experience.

MYLAB & MASTERING: 10 BEST PRACTICES

www.pearsonmylabandmastering.com/northamerica/educators/results/

MY COURSE REDESIGN COMMUNITY

<http://community.pearson.com/courseredesign>

COURSE REDESIGN

www.pearsoncourseredesign.com

FACULTY ADVISOR NETWORK

<http://community.pearson.com/fan>

RESULTS GALLERY

www.pearsonmylabandmastering.com/results

TEACHING AND LEARNING BLOG

www.pearsonlearningsolutions.com/blog/channels/college-career-readiness/ask-the-experts-course-redesign-to-boost-achievement-and-lower-costs-part-2

Publications and Proceedings

Instructors and researchers from universities around the globe are using their own strict analytic protocols to assess Mastering. They're presenting their results at educational technology conferences and publishing their research in peer-reviewed industry journals. If your Mastering experience has been presented or published, please contact your Pearson representative to have it added to our list.

Increasing Student Success Using Online Quizzing in Introductory (Majors) Biology

To determine the effect of utilizing testing as a learning event in the introductory biology classroom, instructors used MasteringBiology to give required quizzes throughout the course. Analysis of exam grades earned by those taking 100 percent of preexam quizzes indicates that this group had a significantly higher exam average than the group who did not take the preexam quizzes and a significantly higher exam average than the class average. The study concludes that pre-exam quizzing using MasteringBiology is a significant benefit for students of diverse academic abilities, is an effective way to increase student performance on exams, and enables class time to be utilized for teaching activities.

Increasing Student Success Using Online Quizzing in Introductory (Majors) Biology (2013) CBE: Life Sciences Education, by Rebecca Orr and Shellene Foster, Collin College, vol. 12 no. 3 509-514.

<http://www.pearsonmylabandmastering.com/northamerica/results/files/CBE-Life-Sci-Educ-2013-Orr-509-14.pdf>

Longitudinal Study of Online Statics Homework as a Method to Improve Learning

Students who completed MasteringEngineering homework showed an improvement of 0.7 (± 0.2) in effect size on the final exam when compared to written homework, and scored an average of 79 percent on the final exam. In comparison, students who completed written homework scored an average of 70 percent on the same final exam. These results held for the subsequent mechanics course and were statistically significant.

Longitudinal Study of Online Statics Homework as a Method to Improve Learning (2013), Manohar L. Arora, Colorado School of Mines; Yun Jin Rho and Claire Masson, Pearson Education, Journal of STEM Education, vol. 14, no. 1.

http://www.pearsonmylabandmastering.com/northamerica/results/files/MB_GRayner_paper.pdf

Engaging Distance Students through Online Tutorials

Regular and consistent engagement with the online system was practiced by students achieving high course marks; students with lower course outcomes exhibited inconsistent and bundled usage patterns. There is also a strong statistical association between the marks achieved for the tutorial series and final course results. Clear differentiation between usage patterns of high- and low-achieving students, coupled with correlation between tutorial results and exam results, suggests that the online tutorial usage patterns of high-achieving students are more effective in terms of overall course achievement.

Engaging Distance Students through Online Tutorials (2012), Jo Devine and Weena Lokuge, University of Southern Queensland, Toowoomba, Australia. Presented at Australian Association for Engineering Education 2012 Conference, Melbourne.

http://www.pearsonmylabandmastering.com/northamerica/results/files/MEngineering_Arora_STEM_1700-5845-1-PB.pdf

Using Online Assessment to Provide Instant Feedback

The authors explain why they chose a commercial e-assessment tool, discuss the types of assignments available and which types of assessments were found most effective, the steps needed to create a positive experience for students, the important lessons learned regarding the mechanisms of quality control that underlie the use of online mathematical assessments, and further developments that would make this type of rich assessment even more useful.

Using Online Assessment to Provide Instant Feedback (2012), Niels R. Walet and Marion Birch, University of Manchester, United Kingdom, STEM Annual Conference 2012, April 12-13, 2012, Imperial College Higher Education Academy.

http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_University_of_Manchester_Walet_Birch_ES.pdf

Patterns, Correlates, and Reduction of Homework Copying

Submissions to an online homework tutor were analyzed to determine whether they were copied. The fraction of copied submissions increased rapidly over the semester as each weekly deadline approached and for problems later in each assignment. The majority of students copied less than 10 percent of their problems and worked steadily over the three days prior to the deadline, whereas those who copied 30 percent of their submitted problems exerted little effort early. The patterns of copying, free-response survey questions, and interview data suggest that time pressure on students who don't start homework in a timely fashion is the cause of copying. Changes in course format and instructional practices that previous self-reported academic dishonesty surveys and/or the copying patterns suggested would reduce copying resulted in a reduction of copying from 11 percent of electronic problems to less than 3 percent. Since repetitive copiers have approximately three times the chance of failing, this was accompanied by a reduction in the course failure rate. Survey results also indicate that students copy almost twice as much written homework as online homework.

Patterns, Correlates, and Reduction of Homework Copying (2010), Physics Education Research 6, 010104, David J. Palazzo, Massachusetts Institute of Technology and Department of Physics, United States Military Academy; Young-Jin Lee, Massachusetts Institute of Technology and University of Kansas; Rasil Warnakulasooriya, Massachusetts Institute of Technology and Pearson Education, Boston; David E. Pritchard, Massachusetts Institute of Technology. http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Palazzo_Lee_Warnakulasooriya_Pritchard_Patterns_Correlates.pdf

Evaluation and Student Perception of MasteringBiology as a Learning and Formative Assessment Tool in a First-Year Biology Subject

This paper describes the implementation of MasteringBiology into a first-year biology course with the goal of assisting those students without prior biology experience. Positive outcomes include significantly higher grades on routine assessments for students completing MasteringBiology and higher final exam grades. Further, in spite of the increased workload, a high proportion of students engaged with the process of integrating textbook readings with prelecture, online assessment.

Evaluation and Student Perception of MasteringBiology as a Learning and Formative Assessment Tool in a First Year Biology Subject (2008), Gerry Rayner, Monash University, Victoria, Australia. Proceedings, ATN Assessment Conference 2008: Engaging Students in Assessment, University of South Australia, Adelaide, Australia, pp. 1-11.

http://www.pearsonmylabandmastering.com/northamerica/results/files/Engaging_Distance_Students_Through_Online_Tutorials.pdf

Measuring Student Learning with Item Response Theory

An investigation of short-term learning from hints and feedback in a Web-based physics tutoring system. Both the skill of students and the difficulty and discrimination of items were determined by applying item response theory to the first answers of students who are working on for-credit homework items in an introductory Newtonian physics course. They show that after tutoring a shifted logistic item response function with lower discrimination fits the students' second responses to an item previously answered incorrectly. Student skill decreased by 1.0 standard deviation when students used no tutoring between their incorrect first and second attempts, while on average, using hints or feedback increased student skill by 0.8 standard deviation. A skill increase of 1.9 standard deviation was observed when hints were requested after viewing, but prior to attempting to answer, a particular item.

Measuring Student Learning with Item Response Theory (2008), Physics Education Research 4, 010102, Young-Jin Lee, David J. Palazzo, Rasil Warnakulasooriya, and David E. Pritchard, Massachusetts Institute of Technology.

http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Lee_Palazzo_Warnakulasooriya_Pritchard_Measuring_student_learning.pdf

Time to Completion of Web-based Physics Problems with Tutoring

The authors studied students solving multipart physics problems with interactive tutoring on the Web. They extracted the rate of completion and fraction completed as a function of time on task by retrospectively analyzing the log of student-tutor interactions. About 65 percent of the students solved the problem in real time after multiple interactions with the tutorial program, primarily receiving feedback to submitted wrong answers and requesting hints. This group displayed a sigmoidal fraction-completed curve as a function of logarithmic time. The authors argue that students who respond quickly (about 10 percent of the students) are obtaining the answer from an outside source, and that the remaining 25 percent of the students are those who interrupt their solution, presumably to work offline or obtain outside help.

Time to Completion of Web-based Physics Problems with Tutoring (2007), Journal of the Experimental Analysis of Behavior 2007, vol. 88, 103-113 no. 1 (July), Rasil Warnakulasooriya, David J. Palazzo, and David E. Pritchard, Massachusetts Institute of Technology.

[http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Warnakulasooriya_Palazzo_Pritchard_Time_to_Completion_\(2007\).pdf](http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Warnakulasooriya_Palazzo_Pritchard_Time_to_Completion_(2007).pdf)

Evidence of Problem Solving Transfer in Web-based Socratic Tutor

The authors demonstrate learning and problem-solving transfer within MasteringPhysics by considering time to completion, the number of hints requested, and the number of incorrect responses given. The group of students who were prepared by a prior related problem solves a related follow-up problem in ~14 percent less time on average compared to an unprepared group. In addition, the prepared group requests ~15 percent fewer hints and makes ~11 percent fewer errors on average than the unprepared group.

Evidence of Problem-Solving Transfer in Web-Based Socratic Tutor (2005), Rasil Warnakulasooriya, David J. Palazzo, and David E. Pritchard, Massachusetts Institute of Technology. *Proceedings of the 2005 Physics Education Research Conference*, pp. 41-43.
http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Warnakulasooriya_Palazzo_Pritchard_Evidence_of_Problem_Solving.pdf

Learning and Problem-Solving Transfer between Physics Problems Using Web-based Homework Tutor

Two equally skilled groups of students taking introductory mechanics use MasteringPhysics to solve related physics problem pairs in reverse order with respect to each other. For problems containing help in the form of requested hints, descriptive text, and feedback, twice as many students were able to complete problems correctly in real time compared to problems that did not provide any help. The group that did a problem second (prepared group) in a given related pair was able to solve it in ~15 percent less time on average compared to the group that did the same problem first (unprepared group). In addition, the prepared group requested 7 percent fewer hints on average than the unprepared group. The study concludes that learning and problem-solving transfer is facilitated by skill building and self-tutoring problems, which also are pedagogically superior to end-of-chapter problems.

Learning and Problem-Solving Transfer between Physics Problems Using Web-based Homework Tutor (2005), Rasil Warnakulasooriya and David E. Pritchard, Massachusetts Institute of Technology; *EdMedia: 2005 World Conference on Educational Multimedia, Hypermedia, and Telecommunications*, pp. 2976-2983.
http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Warnakulasooriya_Learning_and_Problem_Solving.pdf

Time to Completion Reveals Problem-Solving Transfer

Two equally skilled groups of students taking introductory mechanics use MasteringPhysics to solve related physics problem pairs in reverse order with respect to each other. In tutorial problems containing help in the form of requested hints, descriptive text, and feedback, twice as many students were able to complete problems correctly in real-time compared to problems that did not provide any help. The prepared group in a given related pair was able to solve it in ~15 percent less time on average compared to the unprepared group. In addition, the prepared group requested ~7 percent fewer hints on average than the unprepared group. The study concludes that shorter completion times and problem-solving transfer are facilitated by tutorial problems.

Time to Completion Reveals Problem-Solving Transfer (2004), Rasil Warnakulasooriya and David E. Pritchard, Massachusetts Institute of Technology. *Proceedings of the 2004 Physics Education Research Conference*, pp. 205-208.
http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Warnakulasooriya_Pritchard_Time_to_Completion.pdf

What Course Elements Correlate with Improvement on Tests in Introductory Newtonian Mechanics?

In a calculus-based, introductory Newtonian mechanics course at the Massachusetts Institute of Technology, the authors study the effectiveness of electronic and written homework, collaborative group problems, and class participation. They measure effectiveness by the slope of the regression line between a student's score on a particular course element and his normalized gain on various assessment instruments. The results show that interactive course elements are associated with higher gains on assessment instruments.

What Course Elements Correlate with Improvement on Tests in Introductory Newtonian Mechanics? (2004), Elsa-Sofia Morote and David E. Pritchard, Massachusetts Institute of Technology; *American Journal of Physics*, vol. 77, no. 8 (August 2009).
http://www.pearsonmylabandmastering.com/northamerica/results/files/MasteringPhysics_Massachusetts_Institute_of_Technology_Warnakulasooriya_Pritchard_Time_to_Completion.pdf

Best Practices: 11 Steps to Mastering Success

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 11 recommended best practices that will help both you and your students get the most out of your Mastering implementation.

- 1. Attend Mastering trainings and follow best practices.** Work with Pearson to ensure all users are trained. For peer-to-peer support, consult with an expert Mastering user via the "Ask an Expert Mastering User" link on your course home page. Implementing and following best practices will help you obtain the best results.
- 2. Communicate clear expectations to your students and help them get started.** Introduce your students to Mastering on the first day of class and walk them through the registration process. Talk to them about the importance of time on task and the correlation between time spent working in Mastering and higher grades. Persevere—many students put more time into Mastering after the first exam.
- 3. Require the Introduction to Mastering assignment.** This important introductory assignment teaches students how hints work, how to enter answers, and how they will be graded. The assignment automatically appears 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 a mix of tutorials and other items and employ personalized learning.** Studies show that personalized learning experiences maximize study efficiency and improve long-term retention. Achieve this by assigning tutorials and coaching-type activities with immediate, answer-specific feedback and hints; adding Knewton Adaptive Follow-Up (when available) to detect concept gaps and provide remediation before misconceptions take root; and encouraging practice with Dynamic Study Modules (when available).
- 6. Facilitate active class discussion and student preparedness by assigning prelecture homework.** Prelecture assignments introduce students to core concepts *before* lecture, thereby helping them identify misconceptions and activate prior knowledge. Instructors who assign prelecture homework have more class time for interactive learning and higher-level critical thinking activities, and their students are more engaged and more likely to participate.
- 7. Shorten assignments and increase their frequency.** Frequent, short assignments offer students more opportunities to practice and receive feedback, and encourage them to complete the assignments in a timely manner.
- 8. Offer both formative and summative assessments throughout the learning process.** Summative assessment (testing) alone is not sufficient—your students' success also depends on their motivation and commitment to learning. Formative assessments provide students with valuable feedback that can be used to guide and promote ongoing improvement.
- 9. Use Mastering's default grading policy.** Mastering's default grading settings are based on educational research and extensive experience from professors using the system.
- 10. Use Mastering's one-click Gradebook diagnostics.** Mastering can help you identify each assignment's most difficult topics and common student misconceptions. Instructors use this information to inform their lectures, quantifiably assess their students' skill levels and mastery of learning outcomes, and compare course performance to the system average.
- 11. Measure and track results.** Evaluate your course results after implementing Mastering, and before and after any course redesign. Contact your Pearson representative for help evaluating your course results—Pearson has resources to help you gain the most insight into the impact Mastering has on your students' learning and success and to show you how to take your results to the next level.

Glossary

To ensure clear and consistent understanding of the terms used in this report, we define several of them here. The definitions are only for the purposes of this report and do not necessarily reflect either official or dictionary-true versions.

Active learning is the procedure of implementing learning activities that engage students in a meaningful, hands-on way with course content.

Adaptive follow-up activities support continuously adaptive learning. They are generated for each student and are presented immediately following regular Mastering (parent) assignments. Activities are recommended based on a student's response to items in the current and previous assignments.

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.

Course redesign is the process of restructuring how content is delivered. It generally involves redesigning a whole course (rather than individual classes or sections)—to achieve better learning outcomes at a lower cost. It is typically accomplished by taking advantage of technology's capabilities and is most effective in large-enrollment courses.

Drop/fail/withdraw 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, respectively) in the course.

Flipping the classroom or flipped classroom means that students gain first exposure to material outside of class, usually via reading or videos, and then use class time to assimilate that knowledge, often via problem-solving activities, discussion, or debates.

Hybrid course is a course that has both face-to-face classroom and online learning components.

Integrated use refers to an instructor's making a MyLab & Mastering product a part of the syllabus and assigning work to be completed by students.

Lagging indicators measure the success and consequences of activities that have already taken place and measure achievement of the desired outcomes.

Leading indicators provide early signals of progress toward academic achievement and measure conditions that are prerequisite to the desired outcomes.

Online course is a course wherein students do not have regular face-to-face class meetings and need not maintain a regular presence on campus. Most if not all learning is conducted online.

Pass rate is the percentage of students whose final grades are A, B, C, or D.

Peer-led team learning is a model of teaching science, math, and engineering courses that introduces peer-led workshops as an integral part of a course.

Students who do well become peer leaders, who meet with groups of six to ten students to engage in problem-solving activities related to course material.

Prelecture assignments are due before lecture and cover that lecture's content. They enable students to become familiar with basic concepts prior to class time, so class can be spent on interactive learning or other higher-level activities.

Required use means an instructor requires that students use a MyLab & Mastering product for an individual grade that is part of the final course grade.

Retention rate is the percentage of students who registered for a course and completed the course through the final exam. It excludes students who officially dropped (withdrew from) the course.

Student engagement refers to the amount of time and effort students put into their studies and other educationally purposeful activities. It extends to the level of motivation they have to learn and progress in their education.

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

Success rate is the percentage of students who registered for the course and earned a final course grade of A, B, or C.

Pearson Results Library: Mastering Case Studies

Looking for user-provided evidence to support your implementation? The Pearson Results Library is a searchable, online archive of evidence-based case studies, white papers, and journal articles conveniently referenced by course format, discipline, institution type, and state/province. Visit www.pearsonmylab.com/results to download any of the following Mastering and MyReadinessTest case studies.

Address Diverse Students and Skill Levels

Chabot College
Collin College
Lone Star College—Cy Fair (both)
Montgomery County Community College
Roane State Community College
Rochester Institute of Technology
Shoreline Community College
Tarrant County College
University of Arizona
University of Hull
Walters State Community College
West Kentucky Community and Technical College

Boost Success and Retention Rates

Andrews University
Bowling Green State University—Firelands College
Brigham Young University
Butler University
Chabot College
City College of the City University of New York
Clinton Community College
Collin College
Florida State College at Jacksonville (both)
Genesee Community College
Georgia Institute of Technology
Georgia Southern University
Hudson Valley Community College
Lone Star College—Cy Fair (both)

McHenry County College
Missouri University of Science and Technology
Montgomery County Community College
North Carolina Agricultural and Technical State University
Roane State Community College
Rochester Institute of Technology
Shoreline Community College
State University of New York College of Environmental Science and Forestry
Tarrant County College
Texas A&M University
Texas State University
University at Buffalo, State University of New York
University of Colorado
University of Essex
University of Houston
University of Kentucky
University of Mississippi
University of North Carolina Wilmington
University of Ottawa
University of the Sciences in Philadelphia
University of Vermont
Ventura College
Vincennes University
Walters State Community College
West Kentucky Community and Technical College
Western Illinois University

Enable Early Intervention

Beijing Normal University
Brigham Young University
Butler University
Clinton Community College
Collin College
Florida State College at Jacksonville (both)
Fullerton College
Genesee Community College
Georgia Southern University
Louisiana State University
Missouri University of Science and Technology
Roane State Community College
Rollins College
State University of New York College
of Environmental Science and Forestry
Tarrant County College
Texas State University
University of Arizona
University of Kentucky
Walters State Community College

Enhance Critical-Thinking and Problem-Solving Skills

Andrews University
Beijing Normal University
Butler University
City College of the City University of New York
Collin College
Florida State College at Jacksonville (both)
Lone Star College–Cy Fair (both)
Metropolitan State University of Denver
North Carolina Agricultural and Technical State University
Roane State Community College
Rochester Institute of Technology
University of Colorado
University of Mississippi
University of the Sciences in Philadelphia
University of Vermont
Vincennes University

Increase Interactive Learning/Flipped Classroom

Bowling Green State University–Firelands College
Chabot College
Collin College
Florida State College at Jacksonville (both)
Genesee Community College
Georgia Institute of Technology
Hudson Valley Community College
Metropolitan State University of Denver
Rochester Institute of Technology
Shoreline Community College
Texas A&M University
Texas State University
University of Manchester
Vincennes University
Western Illinois University

Increase Student Engagement

Bowling Green State University–Firelands College
Butler University
Chabot College
Clinton Community College
Collin College
Florida State College at Jacksonville (both)
Fullerton College
Genesee Community College
Georgia Institute of Technology
Georgia Southern University
Hudson Valley Community College
Lone Star College–Cy Fair (both)
Metropolitan State University of Denver
Missouri University of Science and Technology
Montgomery County Community College
North Carolina Agricultural and Technical State University
Roane State Community College
Robeson Community College (all)
Rochester Institute of Technology
Santiago Canyon College
Shoreline Community College
State University of New York College of Environmental
Science and Forestry

University of Essex
University of Houston
University of Hull
University of Manchester
University of the Sciences in Philadelphia
Vincennes University
Walters State Community College
West Kentucky Community and Technical College
Western Illinois University

Improve Completion Rate of Assigned Reading and Homework

Andrews University
Butler University
Florida State College at Jacksonville (both)
Fullerton College
Georgia Southern University
Hudson Valley Community College
Roane State Community College
Robeson Community College (all)
Rochester Institute of Technology
Rollins College
Shoreline Community College
State University of New York, College of Environmental Science and Forestry
Texas State University
University of Arizona
University of Mississippi
Vincennes University
Walters State Community College

Improve Test-Taking Skills

University of Ottawa
Walters State Community College

Integrate Personalized Learning with Knewton Adaptive Follow-Up

Collin College
Hudson Valley Community College
West Kentucky Community and Technical College

Reduce Time- and Labor-Intensive Homework Grading

Brigham Young University
Chabot College
Fullerton College
North Carolina Agricultural and Technical State University
Robeson Community College (all)
Rochester Institute of Technology
Texas A&M University
University of Houston
University of Hull
University of Mississippi
University of Vermont

Redesign Multiple Courses or Change Course Format

City College of the City University of New York
Florida State College at Jacksonville (both)
Genesee Community College
Lone Star College–Cy Fair (both)
Missouri University of Science and Technology
Montgomery County Community College
Robeson Community College (all)
Rochester Institute of Technology
Shoreline Community College
University of the Sciences in Philadelphia
Vincennes University
West Kentucky Community and Technical College

Track and Quantify Learning Outcomes

Butler University
Florida State College at Jacksonville (both)
Missouri University of Science and Technology
Robeson Community College (all)
Santiago Canyon College

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Collin College

Judy Meier Penn

Shoreline Community College

Robert Pribush

Butler University

Justin Walguarnery

University of Hawaii at Manoa

Chad Wayne

University of Houston

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