



MyLab<sup>®</sup> & Mastering<sup>®</sup>

# Science and Engineering

Educator Case Studies and Implementation  
Worksheets • January 2016



In a connected teaching model, classroom educators are fully connected to learning data and tools for using the data; to content, resources, and systems that empower them to create, manage, and assess engaging and relevant learning experiences; and directly to their students in support of learning both in and out of school.<sup>1</sup>

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## Welcome Letter

Dear Educator,

At Pearson, we define efficacy as a measurable impact on improving lives through learning. We are embarking on a global education initiative and dedicating ourselves to the pursuit of efficacy and improved learner outcomes.

On the following pages, you'll find the three-phase approach of Pearson's Ten Steps to a Successful Implementation, along with worksheets and data-driven implementation case study summaries that were codeveloped by educators and our Efficacy team. Educator participants are represented from both two- and four-year institutions, and each implemented a Mastering technology. Findings from these case studies help us and educators understand the positive impact these implementations have had on the learner, and they provide valuable insights into common teaching and learning challenges.

Looking for more case studies? Visit our **Results Library**, an online repository of more than 400 case studies, each documenting the impact that educator best practices had on student learning using our digital solutions. Filter by discipline, product, institution type, course format, or state/province to find a match.

We invite you to contact us with any questions about this report, as well as to share your ideas, your best practices, or your results using a Pearson digital solution. To learn more about partnering with us on a case study, please reference our new Efficacy Support—Partnering with Pearson document on page 4.

We look forward to hearing from you.

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## About This White Paper

Evidence demonstrates that technology-enhanced instruction can both increase student learning outcomes and lead to greater efficiencies in costs and other resources. As more schools adopt technology for their classrooms, educators must learn how to implement that technology to achieve their desired goals. Knowing how to use technology is not the same as knowing how to teach with it.<sup>2</sup>

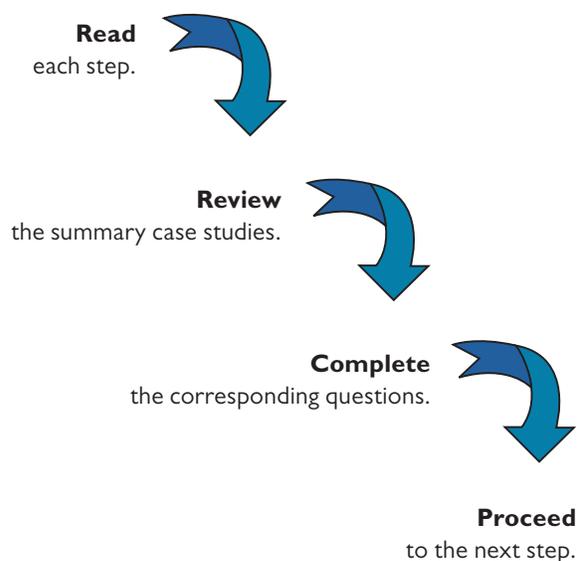
Using the three-phase approach of Pearson's Ten Steps to a Successful Implementation as a framework (page 6), this white paper is designed to help faculty learn how to effectively implement technology into their courses. Whether you are new to technology or a seasoned user, thoroughly understanding the importance of each phase and its related steps and then completing the corresponding worksheets can help you make informed decisions toward achieving your course goals and measuring both redesign and student success.

The three phases in this process are:

- **Phase 1: Plan.** This phase helps you identify the problems you want to address with technology, so when it comes time to measure outcomes, you know exactly how far you've come and what areas still need work. You also identify the technology features that best fit your course and support your stated goals.
- **Phase 2: Implement.** In this phase, you explore available resources and learn how to most effectively use them in your course. You look at customizing assignments, configuring your gradebook to align with your desired outcomes, and setting your students up for success.
- **Phase 3: Evaluate.** In this phase, you analyze student performance and predict future success, and devise strategies for student intervention and student performance issues. This phase also includes analyzing end-of-term data to correlate results with learner outcomes and course goals.

Highly successful implementations share common elements, including (1) instructors who identified issues and established clear goals at the onset, (2) a focus on creating active learning environments that integrate technology as part of the course content, and (3) a commitment to redesign as an ongoing process of evaluation and change. On the pages that follow, you will find summaries of successful technology implementations from a variety of colleges and universities, and links to their full versions. These examples describe how others are working toward achieving their goals and learner outcomes, and they can help guide you on your path. Finally, you'll find full versions of five exemplary case studies, starting on page 29.

We welcome your questions and feedback at any point in the process. Please contact Betsy Nixon, efficacy results manager, Science and Engineering, at [betsy.nixon@pearson.com](mailto:betsy.nixon@pearson.com).



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# Efficacy Support—Partnering with Pearson

At Pearson, we believe that learning is a life-changing opportunity and that education should have a measurable impact on learners' lives. We not only hold ourselves accountable for the products we make, we also work closely with educators to learn from, document, and share their learner experiences and outcomes via implementation and results case studies.

## What Are Implementation and Results Case Studies?

Implementation and results case studies share actual implementation practices and evaluate possible relationships between program implementation and student performance. The findings are not meant to imply causality or generalizability within or beyond these instances. Rather, they can begin to provide informed considerations for implementation and adaptation decisions in other user contexts. Mixed-methods designs are applied to all case studies, and the data collected include qualitative data from interviews, quantitative program usage analytics, and performance data. Open-ended interviews are used to guide data collection.

## Why Is Pearson Interested in Case Studies?

Case studies have helped educators over the past decade understand more about the teaching and learning experience, and use data to inform implementation modifications to improve learner outcomes and determine what is most relevant about their implementation and results. This in turn helps us improve our products and enables us to share blueprints of best practices with other educators seeking new ways to increase student success and continuously improve.

## Pearson Results Library

The Pearson Results Library is a comprehensive collection of evidence-based case studies. Each case study documents the impact of educator best practices and Pearson digital solutions on student learning. Visit the Results Library at [www.pearsonmylabandmastering.com/results](http://www.pearsonmylabandmastering.com/results).

Are you being asked to report on learner outcomes? Implementing a redesign? Wondering what impact your Pearson digital solution is having on program goals? **Pearson wants to partner with you.** Your results—and the best practices you used to achieve them—can be helpful and inspiring to your peers.

### Questions to Consider

- What issues and challenges are you trying to address?
- What quantifiable outcomes are you trying to achieve?
- How will you measure these outcomes?
- How will you implement your chosen Pearson digital product to generate results?

### What Quantitative Results Can Be Measured?

We can help you gauge the impact that your implementation, taken holistically, is having on your students' learning and course success. The results you measure with the full support of our data analysts may include but are not limited to:

- Relationship between homework completion and scores and final exams (or final course grades)
- Comparison of test averages, pass rates, success rates, or retention rates over semesters
- Accelerated completion of remedial courses
- Completion and achievement in subsequent courses

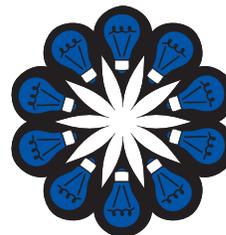
### Don't Forget about Qualitative Observations

- Students coming to class more prepared and more engaged
- Improved class discussions; students asking higher-level questions
- Student ownership of learning, demonstration of agency and purpose in pursuit of academic goals

## The Case Study Process—Partnering with Pearson

Every study project is unique. The process can take from two to nine months. Instructors interested in conducting studies should expect an interactive and rewarding partnership. To maintain objectivity, Pearson does not offer compensation for participation in case studies.

1. Overview call with Pearson efficacy results manager to discuss goals and research questions, identify measures of success, and agree on next steps.
2. Pearson provides planning guidelines, data collection tools, and sample surveys to share with students and faculty both at the start and end of your course.
3. Submission of quantitative and qualitative results and discussion of outcomes. Your Pearson efficacy results managers and data analysts are ready to assist with data analysis, to document implementation best practices, and to help define next steps.
4. Pearson completes the case study and sends it to the instructor for review and approval.
5. Pearson publishes the case study on its Results Library at [www.pearsonmylabandmastering.com/results](http://www.pearsonmylabandmastering.com/results).



### To learn more, contact your Pearson Efficacy Results Manager:

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# TEN STEPS

TO A SUCCESSFUL IMPLEMENTATION

## PLAN

- 1 Define the goals and outcomes you have for using Pearson technology in your classroom.
- 2 When choosing which features and assets to use, make sure they align with your goals, syllabus, and assessment plan.
- 3 Identify how you will measure your success.

## IMPLEMENT

- 4 Take advantage of Pearson's professional development and training opportunities to improve learner outcomes.
- 5 Customize the course to best meet your goals and outcomes.
- 6 Use your "Getting Started" resources to set your students up for success.

## EVALUATE

- 7 Monitor student performance throughout the term.
- 8 Improve student performance by using communication tools and other intervention methods.
- 9 Be open to making revisions during the term to improve your course effectiveness.
- 10 Review data to measure success and plan course revisions.

Retrace your steps for another successful term if you're teaching this course again.

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## Phase I: Plan

Planning is a key element to integrating technology. Blended learning inherently is about rethinking and redesigning the teaching and learning relationship. It is not enough to deliver old content in a new medium.<sup>3</sup>

To understand how to plan technology integration for your course, it's beneficial to think about the backward-design process. While many instructors adopt technology and then think about how to use it based on what they have been doing, backward design encourages planning that looks at the learning goals first and leaves specific teaching activities until the end. After all, you can't start planning how you're going to teach until you know exactly what you want your students to learn. The same applies to integrating technology—you can't select resources until you understand the role of technology in your course.

On the next few pages, you will work through the three steps of Phase I: Plan, and read examples of how other faculty developed plans for their technology implementations. You will then be able to outline your own thoughts in the provided worksheets.

Phase I includes the following three steps:

1. Define the goals and outcomes you have for using the technology.  
*What issues are you facing in your course? What are the goals for your course?*
2. When choosing which features and assets to use, make sure they align with your goals, syllabus, and assessment plan.  
*What will the course format be (e.g., face-to-face, hybrid, online)? What course model will you follow (e.g., flipped, supplemental)? What features will you use in the technology to address your issues and goals (e.g., Knewton Adaptive Follow-Up, Dynamic Study Modules)?*
3. Identify how you will measure your success.  
*What will a successful technology implementation look like?*

The planning phase may be the most time-consuming, but the time you invest in understanding your issues, identifying your goals, and putting a plan in place will go a long way toward helping you make the best decisions in Phase 2: Implement and Phase 3: Evaluate.

## Step 1 Define the goals and outcomes you have for using a learning technology.

Successfully implementing technology into your course requires that you first understand both the issues you want to address and the goals and outcomes you want to achieve. Example goals and outcomes include:

- Provide timely feedback for graded homework.
- Increase student preparedness to enhance participation in class activities and discussions.
- Increase retention rates and assessment scores.
- Help students develop critical thinking skills.

Think about your issues and goals as you read the following case study summaries—each of these instructors defined their goals before implementing their Pearson learning technologies. Then, outline your answers in the worksheet below.

### Case Study Summaries

#### University of Vermont, MasteringBiology

Lecturers Laura Almstead and Becky Miller found it difficult to grade and return in a timely manner frequent homework assignments in a course enrolling nearly 400 students each semester. After implementing MasteringBiology homework with automatic feedback and grading, they observed that students who consistently attempted homework tended to earn higher exam averages. They believe the automatic feedback helped students to identify misconceptions during the learning process, before the misconceptions took hold. The instructors also used student performance on specific questions to identify issues in order to inform their teaching. See the full case study [here](#).

#### Vanderbilt University, MasteringEngineering

Associate Professor Lori Troxel wanted to move toward a flipped classroom with the goal of more active learning. She observed that some students weren't prepared to work problems or discuss content in class when they were assigned only reading from the textbook. She added MasteringEngineering prelecture homework as a way to encourage increased preparedness and promote more-active problem solving during class. After adding prelecture homework (and continuing to assign postlecture assignments), Troxel observed that students performed better on exams. The MasteringEngineering homework also provided the data Troxel needed to address student misconceptions and enhance student problem-solving abilities during class. See the full case study on [page 45](#).

#### Muskegon Community College, MasteringA&P

Instructor Shawn Macauley believed that the first step to addressing his retention issue was to understand as early as possible which students may be most at risk, and to provide content throughout the course to enhance learning. In summer 2014, he assigned the diagnostic pretest from MyReadinessTest at the beginning of the semester to identify students with low prerequisite skill levels. He also adopted MasteringA&P and used its different resources and types of assignments throughout the semester to engage students and address individual learning needs outside the classroom. By identifying student learning deficits, both coming into the course and as the semester progressed, he was able to work toward the goals of increased learning and improved performance. See the full case study on [page 37](#).

STEP 1 QUESTIONS	YOUR ANSWERS
What are the main issues you want to address? What keeps you from achieving your course goals?	
What are the desired learner outcomes you want to achieve?	
What are the course goals that will lead to these learner outcomes?	

## Step 2 When choosing which features and assets to use, make sure they align with your goals, syllabus, and assessment plan.

When redesigning a course—whether to implement a new technology—such as Mastering, Learning Catalytics, or REVEL—or to redesign how technology is used, it is important that you take the time to thoughtfully select the course format and technology features that can help address your issues and desired goals.

Your redesign may include:

- Changing a face-to-face course to hybrid or fully online learning
- Modifying a traditional lecture course to incorporate more active learning and to flip the classroom
- Creating assignments that address specific issues, including preparedness, personalized learning needs, and knowledge gaps prior to assessments

The decisions you make at Step 2 are based specifically on the issues and goals you identified in Step 1. By understanding what technology resources are available, you can make informed decisions during this step.

“MasteringChemistry helped me work through problems, especially the ones with hints, otherwise I might not have tried and just given up.”

—Student, University of Hawai'i at Hilo

Technologies like Mastering include a wealth of features and resources, and offer different ways to implement them. We do not recommend that you use all of your program's features in the first semesters of your implementation. To learn more about your adopted technology's features and resources, visit its dedicated Web page (e.g., for MasteringBiology, visit [www.masteringbiology.com](http://www.masteringbiology.com)) and select the Features tab.

For more information about course redesign, course formats, and redesign models, see the National Center for Academic Transformation [website](#).

### Case Study Summaries

Following are examples of how instructors made decisions about integrating technology into their course redesigns.

#### Genesee Community College and West Kentucky Community and Technical College, MasteringA&P

Both Gary Glaser (Genesee Community College) and Joseph Gar (West Kentucky Community and Technical College) had been teaching traditional A&P courses when they were asked to develop new formats. Glaser was asked to develop a hybrid course; Gar was asked to develop a fully online course. Gar says that his biggest challenge was designing online content that addressed the needs of his online students and enhanced their opportunities for success. Gar piloted one online section with MasteringA&P and MyReadinessTest. As a result of the pilot's success, the school now offers both A&P I and II online. Gar believes that by offering content in different places and formats and by helping students identify what they need to study, these programs (1) helped increase students' potential to succeed in an online environment and (2) helped the school achieve its goal of offering an online option.

Glaser also piloted MasteringA&P in a hybrid section of A&P. Based on positive student feedback, the ability to customize material, and the extent of digital resources available in MasteringA&P, the department made MasteringA&P available in all traditional and hybrid A&P sections. See the full case studies [here](#) (Genesee Community College) and [here](#) (West Kentucky Community and Technical College).

#### University of Hawai'i at Hilo, MasteringChemistry

Instructor Natalie Crist believes that students need frequent problem-solving practice to learn chemistry concepts. She observed that while students seemed to understand the examples in class, they often struggled when doing problems on their own. She implemented MasteringChemistry to provide multiple opportunities for practice and feedback, and so students could self-identify where they needed further study. During class, Crist worked problems similar to assigned MasteringChemistry homework problems, offered personalized remediation with optional Knewton Adaptive Follow-Up assignments, and provided exam review during class using Learning Catalytics, all designed to help accomplish course goals. See the full case study [here](#).

*Proceed to questions on the next page.*

STEP 2 QUESTIONS	YOUR ANSWERS
<p>What case studies are available that address similar issues and goals or have similar implementations? (See the Pearson Results Library at <a href="http://www.pearsonmylabandmastering.com/results">www.pearsonmylabandmastering.com/results</a>.)</p>	
<p>When do you plan to start integrating technology into your course(s)?</p>	
<p>Will you start with a pilot course? How many sections and instructors will be involved?</p>	
<p>What implementation model will you use (e.g., supplemental, flipped, hybrid, online, or buffet)?</p>	
<p>What percentage will the technology assignments contribute to a student's overall grade?</p>	
<p>What does your assessment plan look like? What type of formative and summative assessments will you use?</p>	
<p>What technology features do you plan to integrate into your course? Do they align with your intended outcomes?</p>	
<p>What are the potential hurdles to a successful implementation? How will you address them?</p>	
<p>What financial resources are available to support the implementation, if needed?</p>	

## Step 3 Identify how you will measure your success.

Understanding the effectiveness of your implementation can happen *only* if you first determine what a successful implementation will look like and how it will be measured both qualitatively and quantitatively. Possible measurements to consider include:

### Qualitative

- Observations about student participation during class
- Feedback from pre- and postsemester student surveys
- Number of students attending office hours and types of questions posed

### Quantitative

- Success and retention rates
- Exam and standardized test scores
- Homework participation and performance
- Correlations between homework and assessments

## Case Study Summaries

The following examples show how instructors have integrated measurement of success into their planning.

### College of the Sequoias, MasteringNutrition

Instructor Milli Owens uses MasteringNutrition in both hybrid and face-to-face large-enrollment classes to provide 24/7 access to course materials, increase engagement, monitor student performance, and interact with students.

In addition to evaluating quantitative results to understand student performance in both formats, Owens surveyed her students at the end of the semester. Feedback was largely positive, and one student comment offered insight into the challenges that some students face: “I’m a stay-at-home wife and mother of a five-month-old. [MasteringNutrition] helped me keep going to school and at the same time watch my baby. It helped me with all the side help it gives you . . . It also reminded me when my homework is due and reported my grade.” Owens says that student feedback and data analyses helped her better understand student performance and needs and will help her plan for future semesters. See the full case study on [page 29](#).

### Collin College, MasteringBiology

Rebecca Orr observed that students came to General Biology with a variety of backgrounds and skill levels. Orr was already using MasteringBiology, and added Knewton Adaptive Follow-Up to address this issue. She gathered data from a pilot in summer 2013 and spring 2014, and learned that students who were offered Adaptive Follow-Up assignments ended the semester with statistically significantly higher exam scores than students in the prior semester who were not offered Adaptive Follow-Up assignments. Orr also used student surveys to gain insight into student behavior, specifically regarding the Adaptive Follow-Up test-out option. See the full case study [here](#).

### City College of the City University of New York, MasteringChemistry

Professor Issa Salame and his colleagues set up an experimental study comprising two control semesters in which the course was taught without any changes, and two semesters in which MasteringChemistry was implemented. Student feedback was gathered via interviews and a Likert and short-answer questionnaire. In addition, student performance was measured. Results included increased student success rates during the semesters that MasteringChemistry was in use (Figure 1) and positive student feedback. The study results were published in the *Journal of Academic Perspectives*.<sup>4</sup> See the full case study [here](#).

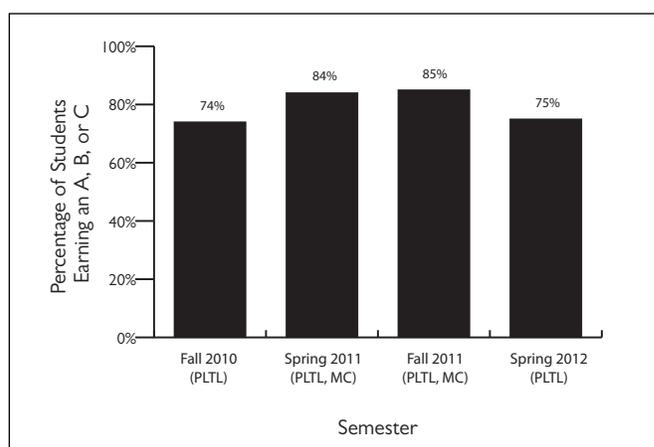


Figure 1. Peer-Led Team Learning (PLTL) and Combined Peer-Led Team Learning and MasteringChemistry (MC) Success Rates (A/B/C), Fall 2010–Spring 2012 (Fall 2010 + Spring 2012,  $n = \sim 400$ ; Spring + Fall 2011 with MasteringChemistry,  $n = \sim 400$ )

Proceed to questions on the next page.

STEP 3 QUESTIONS	YOUR ANSWERS
What quantitative measures will you use to evaluate the success of the implementation?	
What qualitative observations will indicate implementation success?	
Will you administer common assessments and tests across sections?	
Will you use historical data to measure the efficacy of your implementation?	
<p>Will you track attainment of student learning outcomes (SLOs)? If so, what outcomes will you track?</p> <p>How will you track and measure them?</p> <p>If you measure the homework and quizzes using the SLOs in Mastering, how will you evaluate the SLOs in other assessments?</p>	
<p>What is your goal for tracking SLOs?</p> <p>Will you track and compare SLOs across semesters?</p>	
How will you measure the achievement of short- and long-term goals and learning outcomes?	
<p>Will you share course data externally?</p> <p>If so, do you need Institutional Review Board approval?</p>	
<p>Would you like assistance analyzing your data and results? If so, contact your Pearson sales representative or Betsy Nixon, science and engineering efficacy results manager, at <a href="mailto:betsy.nixon@pearson.com">betsy.nixon@pearson.com</a>.</p>	

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## Phase 2: Implement

After understanding and articulating issues and goals in the first phase, you are ready to address the implementation process and increase your chance of reaching your goals.

In Phase 2: Implement, you will learn how to identify and use the available resources in your adopted technology to best implement the plan you developed in Phase 1. Researchers emphasize that the way educators implement digital learning may be one of the most important elements that impacts course outcomes. They make a strong case that implementation is directly connected to student learning and that improved learning outcomes are the products of effective innovations and effective implementation efforts.<sup>5</sup>

Before addressing the three steps of this phase, let's talk about the concept of *fidelity of implementation*. This will help you better understand each step's importance. Briefly, implementation with fidelity means:

- Using the curriculum and instructional practices consistently and accurately, as they were intended to be used.<sup>6</sup>
- Ensuring that protocols are used consistently and accurately with the intent of the implementation and product design and with the validation that was part of their development.<sup>7</sup>
- Understanding that a lack of student response may be due to student characteristics or may be due to how the instruction was implemented. Availability of technology alone does not necessarily guarantee the goal of fidelity: student success.<sup>8</sup>

On the next few pages, you will work through the following three steps of the implementation phase and read examples of how others have addressed these steps in their courses:

Step 4. Take advantage of Pearson's professional development and training opportunities to improve learner outcomes.

*Who will be responsible for managing the technology integration? How will you involve faculty in the process? How will users get trained? Who will design and set up the course?*

Step 5. Customize the course to best meet your goals and outcomes.

*How will you set up the technology to address your goals? What type of assignments will you give and how often? How will you use different features and resources of the learning technology?*

Step 6. Use your Getting Started resources to set your students up for success.

*How will you help students get started on the technology? What resources will you provide to help them register and log on? What information will you gather to help you understand if students are ready to use the technology during the semester?*

## Step 4 Take advantage of Pearson’s professional development and training opportunities to improve learner outcomes.

If your position is chair, course coordinator, or someone who is overseeing different instructors, you will need to ensure that all instructors are fully trained and comprehend how to implement the technology to offer both your redesign and your students the best chance of success. If you are an instructor, you should be aware of the resources available to you, this white paper included, to help you get trained and get started.

Research indicates a need for a systematic strategy and evaluation of technology’s role in education and faculty preparedness to best identify how to move forward in today’s classroom.<sup>9</sup>

Pearson resources include:

- Online planning resources: implementation guides, toolkits, and white papers (See page 49.)
- Live online training
- Training videos
- Campus training
- Faculty Advisor Network (FAN)

Technology implementation is an ongoing process—technology changes, program features are updated, and student needs vary. Consistent use of training resources can help you integrate your technology in the most effective way possible.

### Case Study Summaries

The following examples illustrate how other schools have started this step.

#### Robeson Community College, MasteringA&P, MasteringBiology, MasteringChemistry, MasteringMicrobiology

When the science department at Robeson Community College redesigned all of its science courses with Mastering, Chair Louis McIntyre worked with his Pearson rep to understand all the resources available, involved all faculty in the planning and implementation process, provided training opportunities to all of his instructors, and made sure new features and technology changes continued to be communicated. As a result, faculty were prepared to effectively use the technology to enhance learning in their courses. Since the initial redesign and technology implementations, the department continues to ensure faculty are updated about changes, and continues to have a positive experience using Mastering. In addition, the department has added other technology resources, including MyReadinessTest. See the full case studies [here](#) (MasteringA&P), [here](#) (MasteringBiology), [here](#) (MasteringChemistry), and [here](#) (MasteringMicrobiology).

#### San Antonio College, MasteringA&P

Instructor Thomas Yingst teaches A&P in both online and face-to-face formats. Beginning in fall 2015, the student learning objectives tracked in the course were changed to reflect the outcomes of the Texas Higher Education Coordinating Board. To integrate the new outcomes into his MasteringA&P homework, Yingst worked with Pearson to ensure that the homework mapped to his outcomes, thereby enabling him to run reports on student performance and for administrative reporting. In addition, he worked with the efficacy team at Pearson to begin to evaluate his results and to develop student learner outcomes reports. See the full case study [here](#).



Proceed to questions on the next page.

STEP 4 QUESTIONS	YOUR ANSWERS
Who is responsible for planning and managing the implementation? Who is on the implementation team?	
How will you ensure institutional leader support for the implementation?	
<p>What Pearson professional development and training resources will you use?</p> <p>If you coordinate others, what will be required of them to get trained on and started implementing their digital resources?</p>	
How will you inform the culture of involved faculty? How will you continue to communicate technology updates to faculty?	

Between July 20 and December 11, 2015, 79 instructors attended live online Mastering trainings. Of the 61 instructors who completed postworkshop surveys:

- More than 95% indicated that they *understood* or *confidently understood* the topic presented.
- More than 90% indicated that the training *met* or *exceeded* their expectations.

## Step 5 Customize the course to best meet your goals and outcomes.

Active technological engagement has never been more important than it is today. According to the US Office of Educational Technology, the challenge for our education system is to leverage technology to create relevant learning experiences that mirror students' lives and the reality of their futures.<sup>10</sup> Therefore, to effectively implement digital materials, educators must do more than just make it available; they must design technology-enabled learning opportunities that engage students, meet learning needs, and address course goals—all of which will help students move to the next step in their education.

In Step 5, you will establish how to implement technology resources to address student needs and meet course goals and outcomes. It builds on Step 2, where you chose a course model and design and began to understand your technology features.

Topics to consider include:

- **If you are assigning homework, determine why.** Is it for practice or to assess learning or understanding? This will impact the number of attempts and whether or not the assignment is timed.
- **Will you use the resources to prepare students for more active learning or flipping the classroom?** If so, a prelecture assignment could be important.
- **What learning technology features will you use?** Will you use Knewton Adaptive Follow-Up, Learning Catalytics, and/or Dynamic Study Modules? Why and how? If you have diverse students, consider Knewton Adaptive Follow-Up for personalized remediation. If you employ active learning, consider Learning Catalytics with peer learning in class.

It is not recommended that you use all available features during your first semesters. The decisions you make in Step 5 will be based on the issues you want to address and the goals you want to achieve.

### Case Study Summaries

Following are examples of how faculty designed technology implementations to meet specific goals and desired outcomes.

#### University of Texas at El Paso, MasteringEngineering

Calvin Stewart, assistant professor of statics, observed that there are bottleneck courses in mechanical engineering in which failure rates are high and low numbers of students attain the expected learner outcomes. After teaching face-to-face without technology, he sought a more effective way—one that engages students to enhance learning. He adopted MasteringEngineering and set up his assignments to move toward more in-class active learning. The following semester, he evaluated performance data and made changes to homework. As a result of his ongoing redesign and implementation planning, final exam averages and success rates increased, and there was a stronger correlation between MasteringEngineering homework and exam scores. See the full case study [here](#).

#### University of North Florida, MasteringChemistry

Associate Professor Michael Lufaso has been using MasteringChemistry in his General Chemistry course since 2007. His implementation has changed as he became more familiar with the content in MasteringChemistry, as new features were added to the program, and as his student needs have changed (Table 1). His implementation has evolved from employing one type of MasteringChemistry assignment to using multiple types, thereby enabling him to address different issues and goals. For example, he added prelecture assignments in 2012 to address student lack of preparedness and Knewton Adaptive Follow-Up assignments in 2013 to help students self-remediate. Lufaso advises new adopters not to use every available feature the first time. His comment underscores the importance of developing a plan based on specific issues and goals, and repeatedly evaluating both your results and how you are using the technology. See the full case study on [page 41](#).

Time Period	# of MC Postlecture HWs	# of MC Prelecture HWs	# of MC Practice Assignments (Optional)	# of MC Knewton Adaptive Follow-Up Assignments
2007–11	~10	0	0	0
2012	10	7	11	0
2013	10	19	11	5
2014	10	~19	~11	9

Table 1. MasteringChemistry Implementation, Fall 2007–Fall 2014

*Proceed to questions on the next page.*

STEP 5 QUESTIONS	YOUR ANSWERS
What type of assignments will you make available for your students outside of class? What is the purpose of each type?	
How will you set up each type of assignment (e.g., timed or untimed, hints or no hints or penalties for using hints)?	
What percent of the overall grade will each type of assignment be worth?	
How will you communicate with your students?	
<p>See these tools for help:</p> <ul style="list-style-type: none"> <li>• Mastering Implementation Guide</li> <li>• Modified Mastering Implementation Guide</li> <li>• Learning Catalytics Implementation Guide</li> <li>• Pearson Results Library</li> <li>• Pearson Efficacy website</li> </ul> <p>(See page 49.)</p>	

“The preassignments were a big help. They enabled us to listen to the lecture with some prior understanding.”

—Student, State University of New York  
College of Environmental Science and Forestry

## Step 6 Use your Getting Started resources to set your students up for success.

Most students need a guide to help them effectively use digital tools for learning and collaboration. In addition, most instructors acknowledge that students have a tendency to procrastinate doing homework. Getting started with technology often is no different. Step 6 increases your student's chance for success. It provides them with a functional knowledge of the technology early on, so when their workloads increase over the semester—as workloads invariably do—your students will already be registered on and confident with the technology.

Each Mastering product website contains resources to help your students get registered and ensure that their computers are ready to use the digital resources you have adopted. For more information, see your product home page (e.g., [www.MasteringPhysics.com](http://www.MasteringPhysics.com)), select the Support tab, click Instructor Support, and then the Get Your Students Started button.

Although students may be surrounded by technology at home, it is dangerous to assume that they know how to use it for learning.<sup>11</sup>

One of the most pivotal Mastering best practices is to require completion of the Introduction to Mastering assignment, a standard item available in all Mastering programs, during the first week of class. The assignment is not designed to cover course concepts; rather, it explains how hints work, how to enter answers, and how assignments will be graded. Students

must register and log on to complete the assignment—a step that benefits students by ensuring that they are on task prior to the due date of a higher-stakes homework assignment. While the score on this introductory assignment does not indicate subject knowledge, it can offer pivotal information about a student's motivation and preparedness for the course.

### Case Study Summary

The following summary explains how one instructor analyzed data from the Introduction to Mastering assignment to learn more about student behavior and performance.

#### Georgia Southern University, MasteringPhysics

For fall 2010, spring 2011, and fall 2011, Associate Professor Delena Gatch assigned the Introduction to Mastering assignment as the first required assignment. For subsequent semesters, she added math review content to the introductory assignment.

Analysis of the course data showed that students who scored higher on the introductory assignment did significantly better on the final exam than did students who scored lower on or skipped the introductory assignment. Gatch noted, “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.” She also believed that the assignment's tutorial math problems may have helped students review the math skills they needed for the course. It is not possible to tell why students earned a lower score on the assignment, but based on the results, requiring the assignment and monitoring the results could be one way for instructors to identify early in the course students who may be at risk. See the full case study [here](#).

STEP 6 QUESTIONS	YOUR ANSWERS
What resources will you provide to ensure students register and sign in to the technology?	
What other resources will you offer students to ensure a successful start?	

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## Phase 3: Evaluate

In this final phase, you will analyze student performance data, determine if intervention strategies are needed to increase success, and devise strategies to address remaining issues or new goals as you move forward. You'll also analyze end-of-term course and learner data to correlate results with your intended goals and learner outcomes, and explore how to use data and analytics to continuously improve the teaching and learning experiences.

Faculty who consistently track and measure learning gains are able to make informed decisions about course content and programmatic shifts and to increase their abilities to demonstrate learner outcomes and institutional effectiveness, meet accreditation standards, track quality-enhancement plans, and fulfill grant requirements. Higher education institutions are beginning to use analytics to improve the services they provide and to increase student grades and retention. The US Department of Education's National Education Technology Plan, as one part of its model for 21st-century learning powered by technology, envisions ways of using data from online learning systems to improve instruction.<sup>12</sup>

Diagnostic reports, such as those in Mastering, can help you evaluate course results and learner outcomes. Reasons this is important are:

- Understanding misconceptions and concepts students are struggling with so that those issues may be addressed during lecture, activities, or homework
- Identifying individual student needs for remediation
- Determining if the current implementation is addressing the issues and goals set in place
- Providing data needed for administrative reporting

Over the next few pages, you will address the remaining four steps and read examples of how others have done the same in their technology implementations.

The steps in Phase 3 are:

Step 7. Monitor student performance throughout the term.

*How will you use the technology's gradebook and diagnostics to monitor student progress and performance throughout the semester?*

Step 8. Improve student performance by using communication tools and other intervention methods.

*How will you communicate with students and use the technology to inform students to help them move forward with learning?*

Step 9. Be open to making revisions during the term to improve course effectiveness.

*What adjustments and changes will you make with the information provided during the semester?*

Step 10. Review data to measure success and plan course revisions.

*How will you evaluate data from the semester to make decisions for future semesters?*

## Step 7 Monitor student performance throughout the term.

To determine if your goals are being met, evaluate results on an ongoing basis. Evaluating results would not be complete without discussing assessment as part of the strategy. In general, there are two types of assessment: summative and formative.

Summative assessments are used to evaluate student learning, skill acquisition, and academic achievement at the conclusion of a defined instructional period. Formative assessments are generally designed to determine whether students have learned what they were supposed to learn and to inform subsequent instruction needed to close gaps in understanding.

Instructors often use homework for formative assessment. Studies emphasize that formative assessment is most effective when teachers use it to provide specific and timely feedback on errors and suggestions for improvement, when students understand the learning objectives and assessment criteria, and when students have the opportunity to reflect on their work.<sup>13</sup> Specifically, homework that is designed for learning and practice, or formative assessment, can provide valuable information to both students and instructors throughout the semester, including:

- How prepared students are coming into the course
- How well students are understanding the concepts covered
- What misconceptions they maintain
- How students are doing compared to national student performance

This information can be used to inform instructors before an exam so that weak areas of understanding or misconceptions can be further covered. Using the gradebook and diagnostic information within a learning technology platform, such as Mastering, can make this task much easier for instructors to accomplish. In addition, students also are able to track their learning through technology to help them identify areas they need to remediate.

Instructors embarking on Step 7 will choose how to best assess their students, how to gather and monitor that data during the semester, and what steps to take based on the information learned.

### Case Study Summaries

The following summaries show how other faculty have successfully addressed Step 7.

#### Mercy College, MasteringA&P

Ferdinand Esser is the A&P coordinator and teaches the course himself. His department was struggling with a high D/F/W rate in A&P I, and sought a way to earlier identify at-risk students, with the goal of providing remediation and improving retention and success rates.

By implementing the Getting Ready for A&P diagnostic test, a feature within MasteringA&P, the department was able to use its data to understand student performance and identify who might be at risk at the start of the semester. After collecting and evaluating data for one year, the department added a no-credit, optional problem-solving recitation. Using data from the Getting Ready for A&P diagnostic test, the department can advise students who may be at risk based on low performance on the diagnostic test, and offer them additional help. Faculty continue to collect and evaluate results, with the goal of making data-driven decisions at both course and program levels. See the full case study [here](#).

#### Metropolitan State University of Denver, MasteringPhysics

Professor Jeff Loats adopted MasteringPhysics in 2009 to offer students an opportunity to practice and learn in a low-stakes environment via formative homework with immediate, error-specific feedback. He believes that repetition and practice, accompanied by effective feedback, are key to learning and improving skills. Loats surveyed his students and asked about the impact of using MasteringPhysics on their learning. With a scale of 1 being very harmful and 5 being very helpful, the average response to each question was more than 4. Participating students felt that MasteringPhysics was helpful to their learning. See the full case study [here](#).

*Proceed to questions on the next page.*

STEP 7 QUESTIONS	YOUR ANSWERS
<p>What measures will you use to assess the effectiveness of your technology implementation? What key indicators will you be tracking?</p>	
<p>What data will you use to monitor student performance? How will you use it?</p>	
<p>How will you track and assess student understanding and performance? How would you use the following?</p> <ul style="list-style-type: none"> <li>• Gradebook alerts</li> <li>• Gradebook exports</li> <li>• Mastering diagnostic charts</li> <li>• Student Learning Outcome reports</li> <li>• Dynamic Study Modules reports</li> <li>• Other grades (exam or assessment data not in the Mastering gradebook)</li> </ul>	
<p>Will you use the available gradebook filters to monitor student performance? How?</p>	
<p>At the end of the semester, determine the following:</p> <ul style="list-style-type: none"> <li>• To what degree were your technology resources sufficient to implement your plan effectively? What do you still need?</li> <li>• To what extent was your plan implemented as intended? What changes occurred along the way?</li> <li>• Did your plan achieve expected short-, mid-, and long-term outcomes?</li> </ul>	

## Step 8 Improve student performance by using communication tools and other intervention methods.

Research has confirmed what most teachers already knew: providing students with meaningful feedback can greatly enhance learning and improve student achievement.<sup>14</sup>

Most educators agree that the following five research-based tips provide students with the kind of feedback that increases motivation, builds on existing knowledge, and helps them reflect on what they've learned<sup>15</sup>:

1. Be as specific as possible.
2. The sooner the better.
3. Address the learner's advancement toward the goal.
4. Present feedback carefully.
5. Involve learners in the process.

While it is critical that instructors communicate with students, it is important to note that technology can enable communication with students by providing immediate feedback based on individual performance. Examples of using a learning technology to facilitate the communication process are:

- Diagnostic tests, such as MyReadinessTest, given at the beginning of the semester can help students understand areas of weakness coming into the course, and can provide remediation via a Study Plan based on individual performance. As students work through the Study Plan, they are informed of their progress immediately.
- In Mastering, students get automated grading, hints, and wrong-answer-specific feedback at the moment they need it: while they are doing their homework.
- Knewton Adaptive Follow-Up generates assignments based on student performance on the Mastering parent homework that is specifically designed to address individual gaps in learning.

Understanding and building technology features into your communication plan can help you provide students with the information they need to enhance their chances for success in your course.

### Case Study Summaries

Following is an example of how an instructor used technology to communicate information to his students.

#### Minneapolis Community and Technical College, MasteringBiology

Because Principles of Biology is offered in a variety of formats, a digital resource was needed that would enable instructors of all formats to monitor and evaluate student performance and participation, as well as to provide a way for students to do homework and receive timely feedback and guidance. Mitch Albers, science division coordinator and instructor for the course, observed that by combining MasteringBiology homework assignments that include automated grading, hints, and wrong-answer feedback, with Knewton Adaptive Follow-Up exercises, which are generated for each student to fill in knowledge gaps, students could immediately understand what they knew, what they missed, and where to focus their study efforts.

Albers observed that students were better prepared for lectures and exams after they had completed MasteringBiology assignments. Student feedback from this study supports his claims, and provides evidence that students used MasteringBiology resources to enhance their learning. One student wrote [about Knewton Adaptive Follow-Up], "There are more of the questions that focus on what I didn't get right [on the MasteringBiology parent assignment], so I understand it better." See the full case study on page 33.

"[MasteringBiology] forced me to study the material every week, which helped me to keep up in class."

—Student, Minneapolis Community and Technical College

Proceed to questions on the next page.

STEP 8 QUESTIONS	YOUR ANSWERS
<p>What features will you use to help students assess their content understanding and identify areas of weakness?</p> <ul style="list-style-type: none"> <li>• MyReadinessTest</li> <li>• Tutorials and hints (Mastering)</li> <li>• Knewton Adaptive Follow-Up</li> <li>• Dynamic Study Modules</li> </ul>	
<p>Depending upon the technology in use, will you use the following to communicate with students? If so, how?</p> <ul style="list-style-type: none"> <li>• Announcements</li> <li>• Discussion boards, chat/ClassLive (Modified only)</li> <li>• Jing and Camtasia video how-tos</li> <li>• Notes in the eText</li> <li>• Learning Catalytics</li> </ul>	
<p>Will you use any of the following for intervention? If so, how?</p> <ul style="list-style-type: none"> <li>• Gradebook alerts</li> <li>• Mastering diagnostic charts</li> <li>• Dynamic Study Modules reports</li> <li>• Student Learning Outcome reports</li> <li>• Learning Catalytics for real-time feedback, active learning, and peer instruction</li> <li>• Email</li> <li>• Knewton Adaptive Follow-Up for remediation material</li> </ul>	

## Step 9 Be open to making revisions during the term to improve your course effectiveness.

Once faculty better understand their students' comprehension and misconceptions, the question becomes what to do with that information to improve learner outcomes.

Formative assessment is a constantly occurring process . . . In order for formative assessment to have an impact on instruction and student learning, teachers must be involved every step of the way and have the flexibility to make decisions throughout the assessment process.<sup>16</sup>

The diagnostics and data generated in a learning technology can help instructors identify what concepts students understand and what misconceptions remain. Instructors can then use this information to make informed, ongoing decisions about homework content, classroom discussions and activities, and additional resources students may need to remediate. According to Stephen and Jan Chappuis in *Formative Assessment*, feedback in a [formative]-assessment-for-learning context occurs while there is still time to take action. It functions as a global positioning system, offering descriptive information about the work, product, or performance relative to the intended learning goals.<sup>17</sup> In this way, instructors are able to make decisions when they can most impact student learning, rather than following a summative exam, which may be too late for some students.

### Case Study Summaries

The following example shows how one instructor used the information and diagnostics available to her to make decisions throughout the semester.

#### Shoreline Community College, MasteringMicrobiology

Instructor Judy Penn uses the information she gathers from MasteringMicrobiology's diagnostics and gradebook to identify student issues and misconceptions prior to class meetings. This means she needn't lecture on all concepts, but, rather, can focus on those topics students need help to understand. She uses valuable class time to review problem areas and then provides students with additional active-learning exercises to apply the concepts.

After redesigning the course to a flipped format with active learning using MasteringMicrobiology, Penn observed that more students earned As and Bs (Figure 1). By incorporating information learned from student performance on MasteringMicrobiology homework, Penn was able to focus on topics designed to enhance student learning and help them develop higher-level thinking skills. See the full case study [here](#).

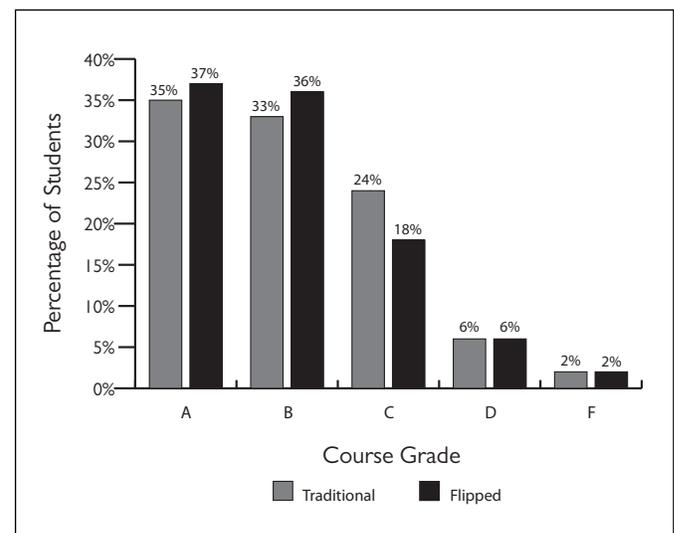


Figure 1. Comparison of Grade Distribution in Traditional and Flipped Classroom Settings, Fall 2012–Winter 2014 (Traditional, Fall 2012–Winter 2012,  $n = 54$ ; Flipped, Winter, Spring, Fall 2013, Winter 2014,  $n = 132$ )

Proceed to questions on the next page.

STEP 9 QUESTIONS	YOUR ANSWERS
How will you use Gradebook data to modify next-class presentations so they include the homework material that students struggled with most?	
If you are using Learning Catalytics, will you edit your modules to include questions that cover what students struggled with most on their homework?	
Did you make a copy of your course to practice in/include changes as the semester passes?	
Do you teach multiple sections of the same course? If so, have you considered having all sections enroll into the same course for easier course management?	
How would you set up your course differently next time?	
What other information do you need next time to better assess your students?	
What other feature(s) might you like to learn about or use?	

## Step 10 Review data to measure success and plan course revisions.

Your data collection should be both quantitative and qualitative to best understand student learning and learner outcomes, as well as student engagement and subjective experiences.

### Qualitative assessments

For qualitative assessment, a chair or course coordinator may conduct faculty surveys or interviews. Course instructors may survey students to better understand their experience with the technology. Consider conducting surveys both pre- and postsemester to gauge attitude changes and learn more about students' experiences with the digital materials.

Classroom observations are also an important way to assess student engagement and learning, and observations can be documented throughout the semester.

In-class observations may include the following<sup>18</sup>:

**In teacher-directed learning, notice if students are**

- Paying attention (alert, tracking with their eyes)
- Taking notes
- Listening (as opposed to chatting or sleeping)
- Asking questions (content related and what level of question)
- Responding to questions
- Following requests
- Reacting

**In student-directed learning, notice if students are**

- Reading critically (with pen in hand)
- Writing to learn, creating, planning, problem solving, discussing, debating, and asking questions
- Presenting, inquiring, exploring, explaining, evaluating, and experimenting
- Interacting with other students, gesturing, and moving

### Quantitative results

In addition to qualitative feedback and observations, it is important to evaluate quantitative results. Because technology, such as Mastering, also gathers student performance and participation data, the resources are readily available to help instructors better understand student learning and outcomes.

**Education is too important to be run on hunches. Effective data use takes the guesswork out of education decisions. It guides informed choices at all levels.<sup>19</sup>**

While technology will provide data, it is up to you to evaluate and understand what the data are telling you. As well-known librarian Rutherford D. Rogers stated, "We're drowning in information and starving for knowledge." Reviewing and understanding the qualitative and quantitative data together allows for more-informed decisions both in the short term during the semester and in the long term for course design and format.

## Case Study Summaries

The first two summaries, Rochester Institute of Technology and Butler University, highlight instructors who have used Mastering over several years, who have repeatedly evaluated course results and learner outcomes to understand student performance, and who have stayed informed about technology changes and new features. This information has helped these instructors sustain successful student results over the long term by continuously improving their course designs and technology implementations. The third summary, Binghamton University, features an instructor who recently evaluated student performance and will be making changes to both his Mastering assignments and course assessments based on his findings.

### Rochester Institute of Technology, MasteringBiology

Assistant Professor Sandra Connelly first implemented MasteringBiology in 2009 as an optional resource. Today it is an integral part of her course. She continues to evaluate results and redesign her course each semester. Recent changes include increasing the active-learning component and putting a heavier emphasis on building critical-thinking skills and assessing qualitative items. The trend in course results shows both an increase in and a tightening of exam scores. Standard deviation and ranges are decreasing, and the average time students spend on assignments is increasing. Table 1 shows the changes that Connelly made to the course through spring 2015, when Knewton Adaptive Follow-Up was added.

Connelly's future plans include staying informed about new features in MasteringBiology and evaluating course results to ensure that her technology implementation addresses defined issues and helps accomplish course goals. See the full case study [here](#).

### Butler University, MasteringChemistry

Professor Robert Pribush has used MasteringChemistry since 2007 for graded homework and to glean diagnostic data on student performance and misconceptions. He uses that information to evaluate overall learning both during and at the end of the semester. By monitoring MasteringChemistry data, Pribush can immediately address student misconceptions and areas of weakness in class, adjust his implementation to enhance student learning, and more easily understand the impact of pedagogical changes on student learning. In this study, he compared his students' performance on the American Chemical Society (ACS) exam with the national averages. Data showed a trend toward higher ACS exam scores since implementation of MasteringChemistry. In addition, student feedback revealed the key role MasteringChemistry played in modifying student work ethics and performance in his class. See the full case study [here](#).

### Binghamton University, MasteringAstronomy

Instructor Christopher Taylor uses MasteringAstronomy in a large-enrollment lecture course. He evaluated student performance and behavior and found a strong positive correlation between average MasteringAstronomy scores and average lecture and lab course scores. However, he also found that there was a significant drop in attendance after exam 2 because of his assessment implementation. Based on his findings, future course changes include increasing use of MasteringAstronomy by adding more-challenging materials and changing the course grading format. Taylor will continue to evaluate course results to learn what impact these changes have on student performance and behavior, and he will make additional changes as needed. See the full case study [here](#).

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 MasteringBiology parent homework and vary from student to student.

*Proceed to questions on the next page.*

STEP 10 QUESTIONS	YOUR ANSWERS
How many faculty were involved in this project? Do you foresee that changing in the next semester? How so?	
What did you learn from the quantitative data collected? How did exam and course scores change? To what degree did the plan improve student success metrics? (Be specific. E.g., are you targeting D/F/W rates or percent successfully completing the course?)	
Using your qualitative data, did student engagement/attitudes change? How did students say they were using the technology? Does this feedback match performance and behavior? What changes, if any, will you make based on it?	
Did you and the teaching staff have a sufficient amount of professional development or training?	
What will you do differently next time? Should your objectives be worded more specifically? What new issues arose?	

On the previous pages, we deconstructed the technology implementation process. We walked you through each phase and each step involved, offered summary case studies to highlight specific aspects of the process, and facilitated strategic decision making for your course redesign via targeted worksheets at each step. On the following pages, you'll find five full case studies that illustrate what can happen when faculty are thoughtful about their course goals and learner objectives, remain focused on the precise resources that can best serve their redesigns and their students, and take the time to track and evaluate course results in order to refine their implementations when needed.

College of the Sequoias (CA), MasteringNutrition .....	29
Minneapolis Community and Technical College (MN), MasteringBiology .....	33
Muskegon Community College (MI), MasteringA&P, MyReadinessTest.....	37
University of North Florida (FL), MasteringChemistry.....	41
Vanderbilt University (TN), MasteringEngineering .....	45

# MasteringNutrition

School Name College of the Sequoias, Visalia, CA  
Course Name Nutrition  
Course Format Face-to-face, hybrid

**Key Results** Survey feedback indicated that study participants had a positive experience with MasteringNutrition and used program information to monitor their progress. In addition, course outcomes showed both a strong positive correlation between MasteringNutrition homework and exam scores, and a trend of higher exam scores for students attempting more MasteringNutrition assignments.

**Submitted by**  
Milli Owens, Chair

**Course materials**  
MasteringNutrition and *Nutrition and You* (custom), Joan Salge Blake

## Setting

College of the Sequoias is a two-year community college serving primarily the residents of Tulare and Kings Counties. Established in 1925, the school's 2013/14 enrollment was more than 14,000 students: approximately 65 percent attended part time, 67 percent were under age 24, and 58 percent identified as Hispanic. For the 2007/08 cohort, 43 percent of students completed a degree, certificate, or transfer-related outcome within six years of starting their higher education.<sup>1</sup>

Milli Owens, chair of consumer and family sciences, teaches the introductory Nutrition course. She has been teaching at College of the Sequoias for about 20 years, and has also worked as a hospital registered dietitian and a consulting registered dietitian. She also has held various other part-time positions that helped her to stay current in the field. She has taught introductory Nutrition in all course formats.

Approximately 400 students take Nutrition each semester, and it is taught by two full-time instructors and four to six adjuncts. The course has 10–12 sections, one of which is a large lecture of 180–200 students. The majority of sections are face-to-face, and typically five are hybrid.

The average fall fill rate for this course is 101 percent (2012–14).<sup>2</sup> Students who take the course include those seeking to enter the nursing program, those taking it as a general education course with plans to transfer, and associate degree students

with a science requirement, such as law enforcement students. Associate degree nursing students are not required to take Nutrition; however, most associate degree RNs plan to pursue a BS, RN, and Nutrition is a required course for that program.

Nutrition is a three-credit, one-semester course. It presents a scientific study of basic chemical, biological, and physiological principles and concepts of human nutrition. The course also includes the application of these principles to the individual and the translation of this knowledge into food choices throughout life. It has no lab component. The hybrid format requires six on-campus class meetings during the semester.

Course learning outcomes include the following:

- Students will be able to identify sources of carbohydrate and fiber.
- Given direction on and access to diet analysis software, students will be able to enter their foods for at least three days, demonstrate understanding of printout recommendations, and identify their most pronounced problem areas.
- Students will be able to identify sources of lipids and cholesterol.

## Challenges and Goals

The large enrollment makes it difficult for instructors to interact with students on a regular and individual basis. Because of that issue, instructors sought interactive online materials that could provide students with feedback and help when they needed it and promote more-frequent engagement with course materials. Owens adopted MasteringNutrition because it offered students 24/7 access to course materials, it increased course interactivity via audio and visual resources, and it provided a platform whereby both instructors and students could monitor student performance.

<sup>1</sup><http://www.cos.edu/About/Research/Pages/Fact-Book.aspx>.

<sup>2</sup><http://www.cos.edu/About/Research/Program%20Review%20Narratives/2014-Nutrition-Foods.pdf>.

Owens engaged in this study to begin to evaluate and measure the relationship between engagement with course materials in MasteringNutrition and course performance. To begin to measure how her students engaged in practice and homework, Owens collected data related to MasteringNutrition assignments that she believed would be helpful for and aligned to the course learning outcomes.

## Implementation

In spring 2015, Owens taught both face-to-face and hybrid sections. Because of differences in how MasteringNutrition was implemented in the two sections, the study examined the data for each section separately.

The face-to-face section consisted of the following assignments:

- **MasteringNutrition chapter quizzes.** Optional, untimed practice quizzes for extra credit.
- **MasteringNutrition MyPlate assignment.** A required, three-part assignment due midway through the semester. Two parts of the assignment were interactive NutriTools activities, and the remaining part comprised multiple-choice questions relating to the placement of foods in the MyPlate system.
- **Diet analysis project.** A required, semester-long project that required students to track their diet analysis needs. Students recorded what they ate for three days, used MyDietAnalysis in MasteringNutrition to analyze nutrient content, and completed a written assignment. They then used what they learned from this information to create a modified menu.

Six paper-and-pencil exams were administered. Exam 6 was a comprehensive exam, and the lowest exam grade was dropped. Exams comprised a mix of Pearson test bank and instructor-written questions. Course instructors do not use the same exams, but they do tend to share test questions to ensure that their exams are at a similar level.

For the hybrid section, the majority of course work was done in MasteringNutrition and consisted of the following assignments:

- **Homework assignments.** Required chapter homework comprised a variety of assignments and activities, primarily in MasteringNutrition, including NutriTools (interactive), animations, videos, and multiple-choice questions. Paper-and-pencil homework included an assignment to compare and contrast students' choices of cereal labels, and another to review local health department restaurant reviews.
- **MasteringNutrition chapter quizzes.** Unlike in the face-to-face section, untimed quizzes were required homework in the hybrid section.

- **MyPlate assignment.** A required assignment due midway through the semester (the same assignment as in the face-to-face section).
- **Diet analysis project.** A required, semester-long project that required students to track their diet analysis needs (the same assignment as in the face-to-face section).

Five exams were given in the hybrid section (the same exams as the first five given in the face-to-face section). There was not a comprehensive exam 6 offered in the hybrid section, and no exam grades were dropped.

### Assessments

#### Face-to-face

500 points	Exams (six, lowest dropped)
125 points	MasteringNutrition diet analysis assignment (multiple parts)
50 points	MasteringNutrition MyPlate assignment
15 points	Activities and quizzes

#### Hybrid

1,000 points	Exams (five)
300 points	Homework (MasteringNutrition and paper and pencil)
130 points	MasteringNutrition chapter quizzes
125 points	MasteringNutrition diet analysis assignment (multiple parts)
90 points	MasteringNutrition discussion
30 points	Attendance

## Results and Data

A study of spring 2015 Nutrition course data was conducted with 78 students in the hybrid section and 179 students in the face-to-face sections taught by Owens. Although MasteringNutrition quizzes were given in both formats, quizzes in the hybrid section were required as part of the grade, and the same quizzes in the face-to-face section were optional for extra points. Since quizzes were a common resource available to students, this analysis looked at quiz data compared to average exam performance in each section.

For the face-to-face students, the mean number of optional MasteringNutrition quizzes attempted by all students was 6 out of 13 (46 percent). Thirty-one students out of 179 (17 percent) attempted all optional MasteringNutrition quizzes, and 38 students (21 percent) attempted no MasteringNutrition quizzes (considered in this analysis to be one with a score of zero).

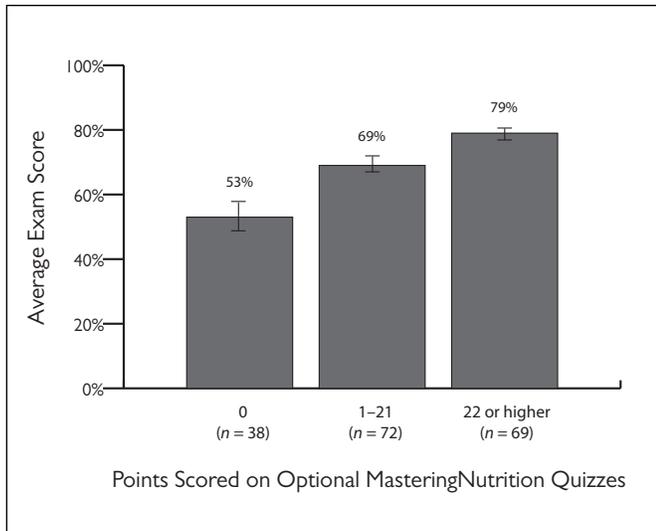


Figure 1. Exam Scores Based on MasteringNutrition Quiz Performance, Face-to-Face Section, Spring 2015 ( $n = 179$ )

Exam averages were analyzed by grouping students based on the number of points earned on the quizzes: students who had zero, students who scored 1–21 points, and students who scored more than 21 points. The average number of points for students who attempted at least one quiz was 21. Students who earned higher than the mean score of 21 had a statistically significantly higher exam average ( $M = 79\%$ ;  $SD = 11\%$ ;  $N = 69$ ) ( $p < 0.001$ ) (one-tailed  $t$ -test with unequal variances) than students who earned 1–21 points ( $M = 69\%$ ;  $SD = 15\%$ ;  $N = 72$ ). Likewise, students who earned 1–21 points had a statistically significantly higher exam average ( $p < 0.001$ ) (one-tailed  $t$ -test with equal variances) than students who did not attempt any quizzes ( $M = 53\%$ ;  $SD = 26\%$ ;  $N = 38$ ) (Figure 1).

Because the MasteringNutrition quizzes were optional, there may be variables, such as motivation, that impacted student participation. Further research is needed to investigate this relationship between quiz completion and performance and exam performance.

Feedback from the end-of-semester survey of traditional students about the optional quizzes included the following comments:

*“I was able to study by myself because the study guides and practice quizzes were available.”*

*“MasteringNutrition helped me learn during the course, because it provided a place to take practice quizzes and videos to show a demonstration of what we were learning in class.”*

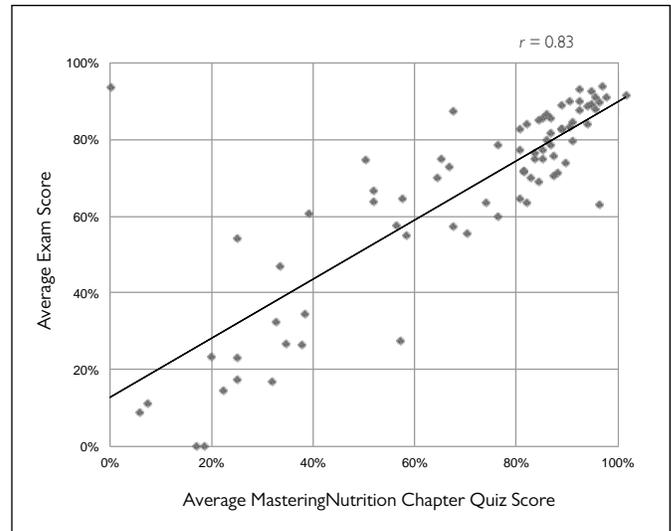


Figure 2. Correlation between Average MasteringNutrition Quiz Scores and Average Exam Scores, Hybrid Section, Spring 2015 ( $n = 78$ )

*“The extra-credit quizzes really helped because by taking those quizzes I knew what would be on the test, and it also helped me see what I needed to study more.”*

*“I learned better with the quizzes I took for Nutrition.”*

*“The quizzes we took helped me before each exam. I think that helped me get better grades on the tests.”*

For the hybrid section, MasteringNutrition quizzes were required assignments. Since this was a required activity, a correlation of the MasteringNutrition quiz scores to the exam average was calculated and showed a very strong positive correlation, with  $r = 0.83$  (Figure 2). A correlation of the average score for the MasteringNutrition chapter homework assignments that were required prior to MasteringNutrition quizzes also showed a strong positive correlation of  $r = 0.80$  to the exam average.

For the hybrid section, 50 students out of 78 (64 percent) attempted all required MasteringNutrition quizzes, and only one student attempted no quizzes. The average number of quizzes skipped by all students was 2 out of 14. The fact that quizzes were required likely impacted the participation rate for students in the hybrid section, compared to the optional assignment for face-to-face students.

In the hybrid section, students were expected to work more independently. As such, they were provided with more required MasteringNutrition homework. Student feedback from the hybrid section included the following comments about their experience using MasteringNutrition:

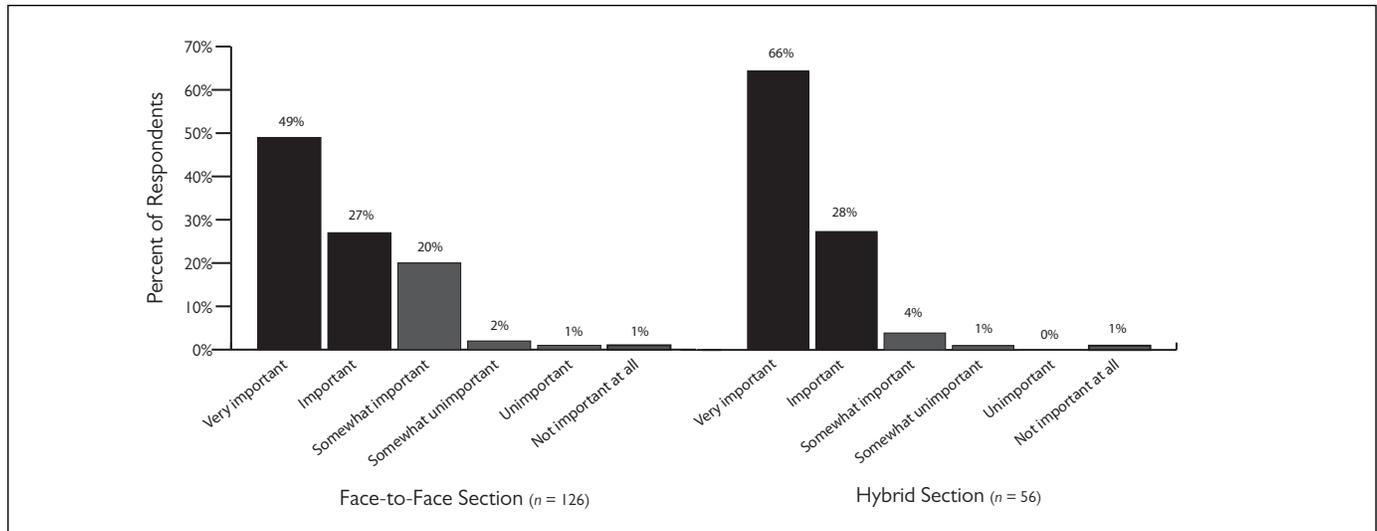


Figure 3. End-of-Semester Survey Responses to the Question, How important do you think the MasteringNutrition homework was to your success in this course? Spring 2015 (n = 182)

*“MasteringNutrition had many resources for me to go to and get help. [It] usually always answered my question.”*

*“It kept me in the habit of checking for assignments, due dates, and also how to get familiar with online courses for future classes.”*

*“MasteringNutrition helped clarify areas in which I was not familiar by providing videos, charts, animations, [and] gamelike ways of learning. It is almost as if I had the professor there guiding me.”*

### The Student Experience

In spring 2015, an end-of-semester survey was offered to each section. In the hybrid section, 72 percent of students participated; in the face-to-face section, 70 percent of students participated. A majority of respondents from both sections indicated that MasteringNutrition was very important to their success in the course. For the hybrid section, 94 percent of respondents said it was very important or important, as did 76 percent of the face-to-face respondents (Figure 3). The reliance on more online work in MasteringNutrition for the hybrid component may have impacted the responses.

In the same survey, students were asked to describe how using MasteringNutrition impacted their learning. Comments included:

*“It was extremely easy to use. When it comes to logging on and finding my assignments, I wasn’t frustrated and could start my homework with a calm head. In another [program], I dropped the class because the website was a pain.”*

*“I’m a stay-at-home mother of a five-month-old. [MasteringNutrition] helped me go to school and at the same time watch my baby. It helped me with all the side help, the study guides, and eText. It also reminded me when homework was due and reported my grade.”*

Students were also asked to describe the three most important things they learned in this class. While the answer topics varied, a few specifically mentioned MasteringNutrition, including:

*“(1) How to use my time wisely. (2) Pick up better study habits. (3) Watching the videos from MasteringNutrition helped tremendously.”*

*“(1) To use MasteringNutrition. (2) How to eat healthy. (3) Maintain a good weight.”*

### Conclusion

Nutrition at the College of the Sequoias is a consistently filled, large-enrollment course offered in both face-to-face and hybrid formats. Owens believes that providing all students with online, interactive resources to access at their convenience helps them engage with course content and offers them the opportunity to learn on their own—something particularly important for hybrid-course students. As one student said, “[MasteringNutrition] made learning easier.”

## MasteringBiology

School Name Minneapolis Community and Technical College, Minneapolis, MN

Course Name Principles of Biology

Course Format Face-to-face, hybrid, online

**Key Results** Evidence from this study showed that the students who did better in the course had attempted more MasteringBiology assignments and had a higher rate of testing out of or scoring 100 percent on personalized Knewton Adaptive Follow-Up assignments.

### Submitted by

Mitch Albers, Professor and Course Coordinator

### Course materials

MasteringBiology and *Campbell Biology*, Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, and Robert B. Jackson

### Setting

Minneapolis Community and Technical College is a public two-year college located in downtown Minneapolis, serving nearly 15,000 credit students a year. Created in 1996 as part of the Minnesota State Colleges and Universities system, the college is the result of the merger of two institutions: a technical college with a history of vocational education dating from 1914 and an open-enrollment community college established in 1965. The average student is 28 years of age; 26 percent of students are considered first generation; and 76 percent of students receive some type of financial aid.<sup>1</sup>

Mitch Albers has taught biology in the Minnesota State Colleges and Universities system for 27 years—26 of them at Minneapolis Community and Technical College. Albers has served as dean of the math and science division and was science division chair for 12 years. For more than 20 years, he has been integrating technology into his courses. At the time of this study, he taught all formats of Principles of Biology and coordinated the course.

Principles of Biology is a four-credit lecture and lab course for biology, nursing, and other science-related majors. It is also appropriate for liberal arts students seeking general education credits. The course presents the main concepts of biology. Students who successfully complete the course are able to demonstrate an understanding of the scientific method, basic biochemistry, cell biology, bioenergetics, reproduction,

development, genetics, biotechnology, evolution, and ecology. The course includes two hours of required lab per week. Introduction to Chemistry or high school chemistry with a grade of C or higher is a prerequisite for the course.

Principles of Biology is offered in three formats: traditional face-to-face, hybrid, and online. The most popular options are the face-to-face and online sections. Typically, students who can't get into one of those two formats enroll in the hybrid sections. Only the lecture portion is offered online. All students must attend lab on campus.

### Challenges and Goals

Because the course is offered in several formats, a digital resource was needed to help instructors monitor and evaluate student performance and participation, and to help students complete homework and receive timely feedback and guidance across formats. Instructors found that students weren't reading the book or preparing for the course on a regular basis. The instructors sought a way to encourage students to more frequently engage with course materials outside of class. They chose MasteringBiology to address these challenges.

To determine how well the challenges and goals are addressed with MasteringBiology, Albers engaged in a study to test and measure the relationship between engagement with MasteringBiology and performance on assessments and in the course itself. To evaluate the extent and the ways in which students engaged with MasteringBiology's learning resources, Albers collected data related to the MasteringBiology assignments that he believed would be helpful for and aligned to the course's learning outcomes.

<sup>1</sup><http://www.minneapolis.edu/About-Us/Fact-Sheet>.

*Albers used MasteringBiology assignments to prompt students to read their textbooks and prepare for lecture exams and lab quizzes.*

### Implementation

In order to address diverse learning styles, lecture presentation materials in a variety of formats are provided to all students. Fall 2014 lecture resources included:

- **Online video lectures.** A comprehensive series of interactive video lectures.
- **Instructor's detailed lecture outlines by chapter.** Complete lecture notes taken from the textbook.
- **Instructor's lecture slides.**
- **Instructor's in-class lecture notes.** Archives of lecture notes from face-to-face lecture classes.
- **Instructor's prelecture questions.** Chapter-specific questions that challenge thinking and understanding of concepts.
- **Instructor's PowerPoint presentations by chapter.**
- **Multimedia resources, including animations.**

While students were encouraged to *explore* all of the resources, they were told they didn't need to *use* them all. Instead, they could select only those that matched their learning styles.

The implementation of MasteringBiology evolved from an optional resource in prior semesters to required assignments in fall 2014, when the following MasteringBiology homework was assigned:

- **Required weekly MasteringBiology chapter homework assignments.** Due every Monday at 10:00 p.m. prior to lecture on that content. Assignments included a mix of tutorial, end-of-chapter, and multiple-choice questions; they were not timed.
- **Required weekly Knewton Adaptive Follow-Up (AFU) homework assignments.** Generated based on each student's performance on MasteringBiology parent (chapter) homework. Students could test out of AFU assignments by scoring 95 percent or higher on the parent homework. Those students automatically received full credit for the AFU assignment. Students who scored less than 95 percent had to complete AFU assignments to receive credit.

Albers used MasteringBiology assignments to prompt students to read their textbooks and prepare for lecture exams and lab quizzes. He also used MasteringBiology diagnostics to identify the concepts students were challenged by and what misconceptions they held so that he could address the issues in class or online.

Four required exams were administered each semester, each worth 100 points. Exam questions covered all six levels of Bloom's taxonomy, but were focused on testing levels 1 through 3. Thirty percent of the questions on the final exam covered cumulative semester content; 70 percent was on content from chapters covered after exam 3. Although the same exams were used for all sections, the question order and choices were scrambled.

All students were required to take two of the four exams on campus. Online and hybrid students were allowed to take the other two exams online. All students took the final exam on campus.

### Assessments

400 points	Lecture exams (four)
100 points	Lab quizzes/lab writing assignments
50 points	MasteringBiology homework assignments
50 points	Online lecture quizzes

Students were required to receive a passing grade (at least 70 percent) in the lecture portion of the course in order to receive a grade of C or higher in the overall course. Students who earned less than 70 percent in the lecture portion of the course, prior to adding laboratory points, received a D or F in the course (even if addition of the laboratory grade brought the total percentage to above 70). Passing grades were determined by percentages of the 600 total possible points (55% = D, 70% = C, 80% = B, 90% = A). Students who were absent more than three times (300 minutes) from the lab had to withdraw by the deadline or received an F in the course.

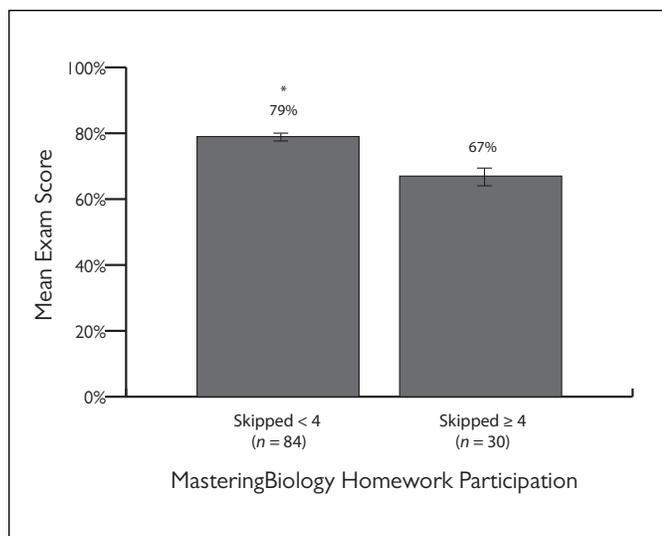


Figure 1. Average Exam Score per MasteringBiology Homework Participation, Fall 2014 ( $N = 114$ )

Err Bars = Stand Err; \* $p < 0.01$

## Results and Data

Course data from fall 2014 was analyzed to better understand the relationship between the use of MasteringBiology and learning and course outcomes. Data from four sections was combined: one face-to-face, one hybrid, and two online. All courses covered the same content and gave the same exams. The number of students enrolled after the official withdrawal period for all sections was 114; 38 students officially withdrew. There were 37 MasteringBiology assignments: Introduction to Mastering, 18 chapter assignments, and 18 Knewton Adaptive Follow-Up assignments. For the purposes of this analysis, a skipped homework in MasteringBiology was considered to be one with a score of 0; the mean number of assignments skipped by all students was four (11 percent of the total number of assignments). Because the final exam was only partially cumulative, the average of all four semester exams was used for analysis.

The initial analysis examined MasteringBiology homework participation by grouping students who skipped fewer than the mean of four skipped MasteringBiology assignments and comparing them to students who skipped four or more. Figure 1 shows that students who skipped fewer MasteringBiology homework assignments ( $M = 79\%$ ;  $SD = 11\%$ ;  $N = 84$ ) had significantly higher exam averages than did students who skipped more MasteringBiology homework assignments ( $M = 67\%$ ;  $SD = 20\%$ ;  $N = 30$ ). A one-tailed  $t$ -test assuming equal variance was performed showing  $p = 0.002$ .

Course Grade	Average AFU Score	Average Number of AFU Assignments with a Score of 100% per Student*	$n$
A	93%	14	39
B	98%	11	41
C	67%	8	18
D	57%	5	11
F	31%	2	5

Table 1. Average Knewton Adaptive Follow-Up Score and Average Number of Adaptive Follow-Up Assignments with a Score of 100 Percent per Final Course Grade, Fall 2014 ( $n = 114$ )

\*A score of 100% on an AFU can be achieved by earning a 100% taking the assignment or scoring a 95% or higher on the MasteringBiology parent homework, thereby testing out of the AFU and earning full credit.

Average AFU Score	Exam Average	$n$
0–24	59%	7
25–49	58%	11
50–74	72%	15
75–100	81%	81

Table 2. Average Exam Scores per Knewton Adaptive Follow-Up Score Quartile, Fall 2014 ( $n = 114$ )

Knewton Adaptive Follow-Up assignments are generated based on a student's knowledge as identified by MasteringBiology chapter homework. An analysis was conducted to investigate the relationship between performance on AFU assignments and average exam scores. Students who did better in the course also had a higher average number of AFU assignments on which they scored 100 percent or tested out (a score of 95 percent or higher on MasteringBiology parent homework) compared to students who earned lower course grades (Table 1). Students who earned an A in the course had an average AFU score of 93 percent, and earned a 100 percent or tested out of an average of 14 out of 18 AFU assignments. Students who earned a C in the course had an average score of 67 percent on AFU assignments, and earned a 100 percent or tested out of an average of 8 out of 18 assignments.

A separate analysis of exam averages was conducted by grouping students into quartiles based on average Knewton AFU scores. The results showed that students who earned higher average AFU scores tended to have higher exam averages (Table 2). There were a high number of students who scored in the 75–100% quartile for AFU scores. However, when comparing students who scored 25–49% on the AFU homework ( $M = 58\%$ ;  $SD = 6\%$ ;  $N = 11$ ) to students who scored 50–74% on AFU homework ( $M = 72\%$ ;  $SD = 3\%$ ;  $N = 15$ ), data show that the students in the higher quartile had a statistically signifi-

Survey Question	Strongly Agree	Agree	Disagree	Strongly Disagree
My understanding of the course material increased as a result of using MasteringBiology.	40%	54%	4%	2%
MasteringBiology provided additional resources that helped me learn more than I could with paper-and-pencil homework.	51%	40%	8%	1%

Table 3. Student Survey Responses, Fall 2014 ( $n = 85$ )

cantly higher exam average ( $p = 0.03$ ) using a one-tailed  $t$ -test with unequal variances than the students in the 25–49% range.

The study's findings do not include all the variables that can impact student performance, such as motivation. Based on the performance of students in this study, however, those who did better on exams and in the course tended to have attempted more MasteringBiology homework, had higher scores on the Knewton Adaptive Follow-Up assignments, or tested out of more AFU assignments than other students. Further research is needed to test what the initial data seem to suggest is a relationship between completion of and performance on MasteringBiology assignments and performance in the course.

### The Student Experience

Students were surveyed on their homework habits and experiences with MasteringBiology; 85 of 114 students (75 percent) responded. The majority of students agreed or strongly agreed that their understanding of course material increased as a result of using MasteringBiology and that MasteringBiology provided more resources to help them learn than did paper-and-pencil homework (Table 3).

In the same survey, students were asked how likely they were to recommend MasteringBiology to another student. On a scale of 1 (not very likely) to 10 (extremely likely), the average response was 7.72.

Finally, students were asked to comment on their experiences using MasteringBiology. Their comments include the following:

#### About Knewton Adaptive Follow-Up

*“There are more of the questions that focus on what I didn’t get right [on the MasteringBiology parent assignment], so I understand it better.”*

#### About MasteringBiology resources

*“MasteringBiology helped me tremendously by forcing me to learn difficult concepts and get a sense of where I was struggling. It’s the difference between actively and passively learning.”*

*“I enjoyed the visuals and different ways of learning by the varying methods of diagrams, multiple-choice, matching, etc. and the use of videos, hints, etc.”*

*“It helped me visualize the concepts and learn them in ways I couldn’t have learned if I was submitting paper homework without an interactive part.”*

#### About the benefit of scheduled assignments

*“[It] forced me to study on schedule and use the textbook.”*

*“It forced me to study the material every week, which helped me to keep up in class.”*

### Conclusion

Albers implemented MasteringBiology to encourage students to engage with course content across different formats, more frequently, and with automatic feedback as they worked—all things he felt were very important for student success and learning. He says that students were better prepared for lecture and exams because they completed MasteringBiology assignments. He also observed that because students could test out of Knewton Adaptive Follow-Up assignments, they were motivated to work harder on chapter homework, and he believes students put more effort into their homework. Student feedback from the study supports his observations, and provides evidence that students are using MasteringBiology resources to enhance their learning.

## MasteringA&P, MyReadinessTest

School Name Muskegon Community College, Muskegon, MI

Course Name Anatomy and Physiology I

Course Format Face-to-face

**Key Results** Data from this study tentatively showed that scores from the MyReadinessTest diagnostic test identified students who may be at risk because they are less prepared at the onset of the course. Data also showed a strong positive correlation between MasteringA&P homework and exam scores ( $r = 0.62$ ).

**Submitted by**  
Shawn Macauley, Professor

**Course materials**  
MasteringA&P, MyReadinessTest, and *Visual Anatomy and Physiology*, Frederic Martini

### Setting

Muskegon Community College, initially founded as a junior college, officially became a community college in 1951. According to the *2013 Integrated Postsecondary Education Data System Data Feedback Report*, 25 percent of the school's nearly 7,500 students attended full-time. Of those, 57 percent received financial aid. For the 2009 cohort, the graduation rate was 15 percent, and the transfer rate was 42 percent of the cohort as a percent of total entering students.<sup>1</sup>

Professor Shawn Macauley received his PhD in medical sciences, and has been teaching at Muskegon for seven years. He teaches all formats of anatomy and physiology, including face-to-face, hybrid, and online. He is interested in research on the effective use of technology in teaching introductory science classes, and currently teaches Anatomy and Physiology (A&P) I and II.

Anatomy and Physiology I is a four-credit lecture and laboratory course designed to meet the needs of students in nursing and other health-related fields. The course has no required prerequisites, but Macauley recommends that students complete Introduction to Chemistry, Introduction to Biology, and Medical Terminology before enrolling in A&P I. While students may take the lecture portion of the course online, all students are required to attend face-to-face labs on campus.

The course covers the normal structure and function of organs and organ systems of the body, including cell biology, histology,

and introductory anatomy and physiology of the integumentary, skeletal, muscular, nervous, digestive, lymphatic, cardiovascular, respiratory, urinary, endocrine, and reproductive systems. Upon successful completion of the course, students are allowed to enroll in Anatomy and Physiology II.

### Challenges and Goals

Approximately 450 students per year take the course, and it has historically had a high failure and repeat rate: approximately 60 percent of students pass the course the first time. The lack of prerequisites or a required placement test contributed to a high number of students taking the course who were not prepared for the level of work required to succeed.

Macauley believed that the first steps to addressing the course's retention issue were to identify which students may be most at risk as early as possible and to provide content throughout the course that could enhance learning. To address these challenges and goals, he adopted MyReadinessTest for A&P and MasteringA&P in summer 2014. His plan was to administer the MyReadinessTest diagnostic test at the onset of the semester in order to gather data that would help identify students whose prerequisite skill levels were low. In addition, to address learning needs outside the classroom and thereby enhance student engagement and learning, Macauley implemented MasteringA&P with a variety of different types of assignments and activities throughout the semester.

Macauley began this study to start to test and measure the relationship between (1) performance on the MyReadinessTest diagnostic test and MasteringA&P assignments and (2) exam and course scores. In addition, as a way to measure how his students engaged with MasteringA&P resources, Macauley collected data related to the MyReadinessTest and MasteringA&P assignments. He believed that this data would help him further understand the relationship between student behavior and performance during the semester and course outcomes and completion rates.

<sup>1</sup><http://www.muskegoncc.edu/PDFFiles/Institutional%20Research/IPEDS-2013-Data-Feedback.pdf>.

## Implementation

Macauley implemented MasteringA&P resources in a variety of ways in order to provide students with multiple opportunities to assess their understanding, and so they could use that information to guide study efforts. He set up the class so that students would do three or four MasteringA&P chapter assignments, take a MasteringA&P quiz, and then attempt an exam on that content. This format offers students several opportunities to engage with content before being assessed on it.

Following are the course components for the period of this study:

**MyReadinessTest diagnostic pretest.** Assigned during the first week of class, the diagnostic assignment comprised 70 questions that provided detailed information on each student's mastery and application of essential reading, writing, and math skills, and of core skills in anatomy and physiology, chemistry, and physics. A Study Plan was automatically generated for each student based on assignment performance. Use of the Study Plan was optional; students could use it on their own time if they wished to remediate on the topics that they missed.

**MasteringA&P chapter assignments.** Assignment questions were randomized and pooled. For this study, all assignments were due three or four days prior to the applicable exam. Students then had an opportunity to review the answers before the quiz and exam. Homework assignments included chapter questions and some of the Dynamic Study Modules, a new feature for fall 2014. Macauley changed this implementation for fall 2015: he planned to assign individual due dates for each MasteringA&P homework. He observed that when multiple assignments were due on the same date, students tended to procrastinate. The new due dates are designed to force students to stay on schedule and engage with course content on a regular basis.

**Lecture quizzes.** One MasteringA&P quiz was administered for each exam during the semester. Quizzes typically were due two days before the corresponding exam, and provided a benchmark score to help students prepare for exams. Students were allowed one attempt, but the quizzes were not timed. Results were available once the quiz closed.

**MasteringA&P Practice Anatomy Lab (PAL) assignments.** Two MasteringA&P PAL quizzes were due before the two lab practical exams. The goal of these assignments was to prepare students for the lab exams.

**Take-home exam.** Administered in MasteringA&P, this exam included any additional content that Macauley was unable to cover in lecture. Material included basic concepts presented in a straightforward way so students could learn it on their

own. The take-home exam was open book, open resource, and untimed.

**Lecture exams.** Five paper-and-pencil lecture exams evaluated student understanding of lecture material. Question formats included multiple-choice, fill in the blank, matching, true/false, case studies, diagrams, and short answer/essay.

**Final exam.** Content on the paper-and-pencil final exam was 25 percent cumulative. The remainder of questions covered content delivered after the last lecture exam.

**Madison assessment test.** Students were required to complete this test in the school's Testing Center within the first two weeks of class. It is a standardized science literacy and reasoning test. Its results are being analyzed and studied by Muskegon.

### Assessments

#### Lecture

375 points	Lecture exams (five)
100 points	Final exam
60 points	MasteringA&P quizzes (six)
50 points	Take-home exam
50 points	Research paper
35 points	MasteringA&P homework
5 points	MyReadinessTest diagnostic quiz

#### Lab

200 points	Lab practical exams
50 points	Lab quizzes
50 points	Prelab assignments (due before each lab, a combination of paper assignments from the lab manual and MasteringA&P assignments)
20 points	MasteringA&P PAL assignments

## Results and Data

Because Macauley was interested in investigating the relationship between student performance on the MyReadinessTest diagnostic test and course performance, an analysis of data collected during the fall 2014 and winter 2015 semesters was conducted (Table 1).

To understand if MyReadinessTest could identify at-risk students, diagnostic test scores were used to group students and assess exam performance. All students who completed the course were included in the analysis. If they did not take the diagnostic test, the score used in the analysis was a zero.

Semester	MyReadinessTest Average	MasteringA&P Average	Exam Average	Enrollment	# Students Not Taking MyReadinessTest
Fall 2014	50%	70%	75%	38	4
Winter 2015	46%	71%	71%	107	12

Table 1. MyReadinessTest Diagnostic Test and Course Performance, Fall 2014–Winter 2015 (N = 145)

Final Course Grade	% of Total Enrollment	% Not Taking MyReadinessTest	% Scoring Less Than 50% on MyReadinessTest	% Scoring 50–69% on MyReadinessTest	% Scoring 70% or Higher on MyReadinessTest
A, B, or C	79%	8%	40%	42%	10%
D or E	21%	22%	48%	30%	0%

Table 2. MyReadinessTest Diagnostic Test Performance per Final Course Grades, Winter 2015 (n = 107)

The mean MyReadinessTest score was 46 percent in fall 2014 and 50 percent in winter 2015. For the analysis, students were split into two groups: those who scored below 50 percent on the MyReadinessTest diagnostic test and those who scored 50 percent and higher, since 50 percent was the midpoint range for the MyReadinessTest assignment. The same analysis was conducted for fall 2014 grouping students based on a cutoff of 50 percent on the MyReadinessTest diagnostic score (Figure 1). An analysis grouping students at the fall 2014 mean of 46 percent resulted in the same findings but are not shown here.

Students scoring 50 percent or higher on the MyReadinessTest diagnostic test had a statistically significantly higher exam average than students who scored below 50 percent (Figure 1).

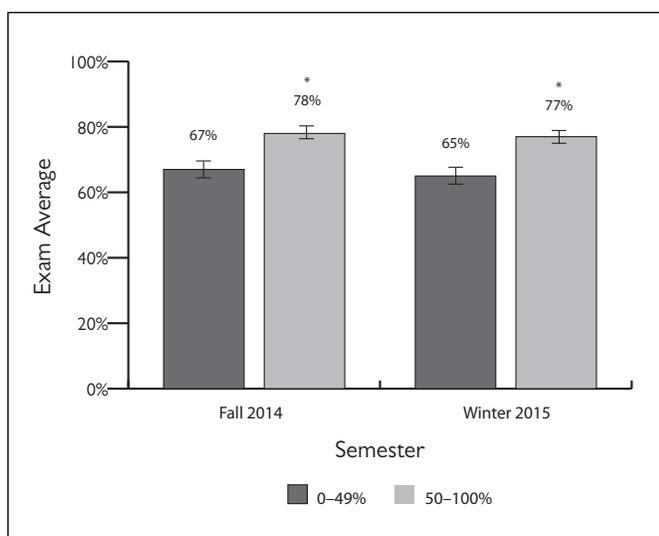


Figure 1. Exam Averages Based on MyReadinessTest Diagnostic Scores, Fall 2014–Winter 2015 (Fall 2014: 0–49%,  $n = 12$ ; 50–100%,  $n = 26$ ; Winter 2015: 0–49%,  $n = 51$ ; 50–100%,  $n = 56$ ) Err Bars = Stand Err; \* $p < 0.05$

- In fall 2014, students who scored below 50 percent on the MyReadinessTest diagnostic test ( $M = 67\%$ ;  $SD = 10\%$ ;  $N = 12$ ) had a statistically significantly lower score on exams than did students who scored 50 percent or higher ( $M = 78\%$ ;  $SD = 12\%$ ;  $N = 26$ ) with  $p < 0.01$  using a one-tailed  $t$ -test assuming equal variance. Approximately 32 percent of students scored below 50 percent on the MyReadinessTest diagnostic test.
- In winter 2015, students who scored below 50 percent on the MyReadinessTest diagnostic test ( $M = 65\%$ ;  $SD = 19\%$ ;  $N = 51$ ) had a statistically significantly lower score on the exams than students who scored 50 percent or higher ( $M = 77\%$ ;  $SD = 16\%$ ;  $N = 56$ ) with  $p < 0.001$  using a one-tailed  $t$ -test assuming equal variance. The number of students in the two groups was almost evenly split: 48 percent of students scored below 50 percent.

Student performance on the winter 2015 MyReadinessTest diagnostic test was further evaluated based on final course grades (Table 2). Winter 2015 was used because of its higher enrollment compared to fall 2014.

Data shows that a majority of students who earned an A, B, or C in the course scored higher than 50 percent on the MyReadinessTest diagnostic test compared to students who earned a D or E in the course. However, Macauley found that students who scored below 50 percent did not all earn a D or E in the course. For example, the three students who earned As in the course and had MyReadinessTest diagnostic scores below 50 percent earned an average score of 81 percent on their MasteringA&P homework. On the contrary, the five students who earned an E in the course and had MyReadinessTest diagnostic scores below 50 percent, had an average MasteringA&P homework score of 24 percent. More analysis would need to be done to better understand and further test these preliminary

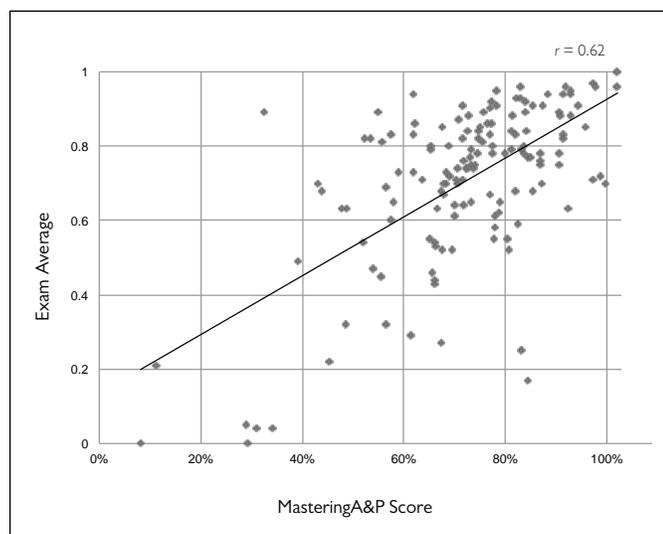


Figure 2. Correlation between MasteringA&P Scores and Exam Averages, A&P I, Fall 2014–Spring 2015 ( $n = 145$ )

findings, but the MyReadinessTest diagnostic score can provide information at the start of the semester for both students and instructors about student readiness. As a result, each can make decisions about how to proceed. Based on the finding that students who do poorly on the MyReadinessTest diagnostic test may also do poorly in the course, instructors can use the diagnostic test scores as an indicator as to who may be at risk and may need additional remediation to succeed.

To start to investigate the relationship between performance in MasteringA&P and exams, a correlation was calculated for all students in the study. Figure 2 shows that there was a strong positive correlation between MasteringA&P homework scores and exam averages, with  $r = 0.62$ .

The study's findings do not account for the unmeasured influence of variables that can impact student performance, such as motivation. However, based on the initial analysis of Macauley's results, the data from students in this study indicated that student exam performance and course grades were lower for students who scored lower on the MyReadinessTest diagnostic assignment and that a strong positive correlation existed between MasteringA&P scores and exam scores. Further research is needed to test these initial findings.

## The Student Experience

In winter 2015, students were asked to answer an end-of-semester survey. Forty-two students out of 107 (39 percent) participated. In response to the question, How did using MasteringA&P impact your learning in the course? participating student responses included the following:

*"It was additional study information at my fingertips when I was on the go and without my textbook."*

*"The PAL 3.0 was awesome! Being able to have models of fetal pigs at the click of a button was very beneficial."*

*"MasteringA&P really did help me because if I didn't get it the first time, doing it repeatedly reinforced something for me."*

*"MasteringA&P helped [me] recognize what the important concepts are that I should pay close attention to in my learning. I also learned a lot from the PAL 3.0 from the highlighted model parts."*

## Conclusion

"Gross Davis suggested an initial exam during the first three to four weeks of a course provides a good opportunity to assess students' level of understanding of course materials and possibly identify at-risk students. Actually, an initial exam or other graded assignment may serve a two-fold purpose to (a) identify the skills and deficiencies of students early on, and (b) convey instructors' academic expectations to students."<sup>2</sup> Because the MyReadinessTest diagnostic test provided an assessment of the concepts students need to understand to enhance their chance for success in A&P I, Macauley found that this diagnostic assignment at the beginning of the semester provided additional information about incoming students during this study. Macauley believes by being more informed about student performance using MasteringA&P and MyReadinessTest scores, he can better identify learning deficits, either coming into the course or as the semester progresses, and use that information to make decisions to enhance student learning with the goal of increasing student success.

The department and institution are currently analyzing the results of the study and evaluating options for possibly conducting a placement test as a requirement for A&P I in the future.

<sup>2</sup><https://www.psychologicalscience.org/index.php/publications/observer/2009/december-09/helping-failing-students-2.html>.

## MasteringChemistry

School Name University of North Florida, Jacksonville, FL

Course Name General Chemistry

Course Format Face-to-face

**Key Results** Students in this study who skipped fewer MasteringChemistry assignments tended to do better on the final exam than students who skipped more assignments, and there was a strong positive correlation ( $r = 0.61$ ) between average MasteringChemistry homework scores and final exam scores.

### Submitted by

Michael Lufaso, Associate Professor

### Course materials

MasteringChemistry and *Chemistry: The Central Science*, Theodore E. Brown, H. Eugene LeMay, Bruce E. Bursten, Catherine Murphy, Patrick Woodward, and Matthew E. Stoltzfus

### Setting

The University of North Florida is a four-year public university that was established in 1972 and today serves approximately 16,500 students. Between fall 2008 and fall 2012, first-year retention rates ranged from 81 percent to 84 percent for those starting at the school. Graduation rates for the same period ranged from 46 percent to 49 percent.<sup>1</sup> From 2010 to 2012, at the undergraduate level, 32 percent of the degrees awarded were in areas of strategic importance to the local economy, including degrees in health sciences and STEM.<sup>2</sup>

Associate Professor Michael Lufaso has been teaching General Chemistry I since he started at the school in 2006. He has taught General Chemistry II since 2009.

General Chemistry II is a three-credit course, and the second course in a two-semester sequence taken primarily by biology and chemistry majors. The course covers the chemistry of gases, liquids, and solids; thermodynamics; electrochemistry; aqueous equilibria; and reaction rates. The one-credit lab is a separate course, which most students take concurrently with lecture. It is suggested, but not required, that students take the lab as a corequisite.

General Chemistry II is taught only as a face-to-face lecture. Approximately 175 students take the course per semester

during the academic year, and an additional 100 students take the course during the summer semester. The majority of students who take the course are required to do so for their program, so successful completion is important. The biology program is limited access, so students must successfully complete this course to be admitted to that major. Other majors that take this course include nursing, nutrition, and premedical. This study includes data from Lufaso's sections only.

Lufaso incorporates the following learning objectives.

- Know the world.
- Demonstrate knowledge of the natural sciences.
- Apply knowledge to real-world situations.
- Recognize the inevitable limits of your own perception and understanding. Think critically.
- Read, analyze, and understand complex texts or quantitative information.
- Solve problems.
- Locate, evaluate, and/or use research sources.
- Formulate and/or apply models to evaluate problems and draw conclusions.

### Challenges and Goals

Students who take this course tend to have a diverse set of skills and bring a variety of backgrounds; some have gaps of time between General Chemistry I and II. Since chemistry is a cumulative subject and new material builds upon a series of linked concepts, Lufaso believes that concept repetition and practice are critical for student achievement. Because many students must complete this course to move forward in their program, Lufaso sought a way to both identify areas of weakness and misconceptions and provide resources that would enable students to fill

<sup>1</sup>[http://www.unf.edu/acadaffairs/accreditation/Student\\_Achievement.aspx](http://www.unf.edu/acadaffairs/accreditation/Student_Achievement.aspx).

<sup>2</sup>[http://www.unf.edu/uploadedFiles/aa/acadaffairs/accreditation/SACS/2015\\_Fifth-Year\\_Review/4.1-1e%20President%27s%20Self-Report%202012-13%20%28pp%208-10%29.pdf](http://www.unf.edu/uploadedFiles/aa/acadaffairs/accreditation/SACS/2015_Fifth-Year_Review/4.1-1e%20President%27s%20Self-Report%202012-13%20%28pp%208-10%29.pdf).

*Lufaso's [MasteringChemistry] implementation has changed as new features were added to the program and he became more familiar with its resources.*

knowledge gaps and provide needed practice to succeed. He adopted MasteringChemistry in 2007 to address those needs.

As a result, Lufaso engaged in this study to begin to test and measure the relationship between (1) engagement in ongoing repetition and practice to fill knowledge gaps and (2) performance. To begin to measure the ways his students engaged in this type of prelecture and postlecture practice, Lufaso collected data related to MasteringChemistry assignments that he believed would be helpful for and aligned to the learning outcomes of the course.

### Implementation

Since first adopting MasteringChemistry in 2007, Lufaso's implementation has changed as new features were added to the program and he became more familiar with the resources. He believes that the primary roles of homework are to provide an opportunity for students to review and remediate the concepts covered in the lecture and textbook and to give students a chance to practice and test their understanding in preparation for exams. He also uses the diagnostic feedback to monitor the questions missed most frequently, so he can address them in-depth during class.

During the first few years of MasteringChemistry use, Lufaso assigned only postlecture chapter homework. Table 1 shows the implementation changes through fall 2014, including the addition of prelecture, optional Knewton Adaptive Follow-Up, and optional practice assignments.

For the fall 2014 semester, MasteringChemistry assignments included the following:

**Prerequisite knowledge assignment.** The first required assignment of the semester covered concepts from General Chemistry I. An optional Knewton Adaptive Follow-Up assignment was available so students could remediate any missed prerequisite concepts.

**Prelecture assignments.** These required assignments were designed to encourage reading before lecture. They included a few short questions, usually for extra credit, and generally comprised reading questions. They were not timed, were due before lecture, and multiple attempts were allowed. For multiple-choice, the standard deduction applied ( $100\% / [\# \text{ of answer options} - 1]$ ) to discourage students from guessing. All other questions were typically a deduction of 8 percent per incorrect answer.

Prior to lectures, Lufaso reviewed the diagnostics from the completed prelecture assignments in order to better understand what concepts students struggled with and to focus on those during class time. He also used diagnostic information to improve lecture notes and to plan in-class activities that enhanced understanding of challenging concepts. These activities helped students understand misconceptions prior to attempting postlecture chapter assignments.

**Postlecture chapter assignments.** These required assignments were due one week after chapter content was addressed in lecture. Assignments included tutorial and activity questions, along with other question types. Typically, a tutorial question was followed by an end-of-chapter question. The maximum number of allowed attempts was six, and they were not timed.

Time Period	# of MC Postlecture HWs	# of MC Prelecture HWs	# of MC Practice Assignments (Optional)	# of MC Knewton Adaptive Follow-Up Assignments
2007–11	~10	0	0	0
2012	10	7	11	0
2013	10	19	11	5
2014	10	~19	~11	9

Table 1. MasteringChemistry Implementation, Fall 2007–Fall 2014

**Knewton Adaptive Follow-Up assignments.** Optional Adaptive Follow-Up assignments were intended to address knowledge gaps. They were generated by MasteringChemistry based on each student's performance on postlecture chapter homework. Assignments were due two days after the chapter assignment for extra credit. Students who earned a 95 percent or higher on the MasteringChemistry chapter assignment tested out of the optional assignment and automatically earned full extra credit.

**Practice assignments.** Optional chapter problems were available for additional practice.

Three exams and a comprehensive final were administered. The exam format typically consisted of multiple-choice conceptual questions and problems, multiple-part problems (multiple-choice format), matching, fill in the blank, drawing/sketching/graphing, and short-answer problems.

Exam questions were combinations of Pearson test bank and instructor-written questions. Term exams were 75 minutes, and the final exam was 110 minutes. Exam questions were similar to MasteringChemistry homework questions. When providing answer keys after exams, Lufaso noted which questions were similar to specific MasteringChemistry problems.

#### Assessments

450 points	Term exams (three)
275 points	Final exam
250 points	MasteringChemistry homework
25 points	MasteringChemistry prerequisite knowledge assignment

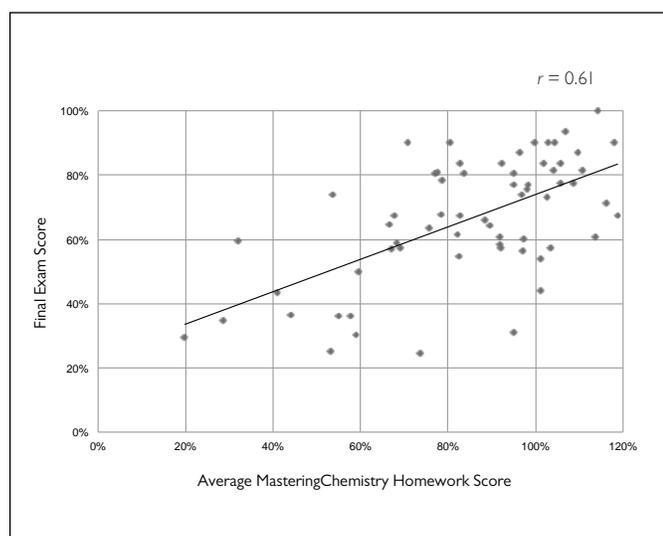


Figure 1. Correlation between Average MasteringChemistry Scores and Average Final Exam Scores, Fall 2014 ( $n = 64$ )

## Results and Data

Fall 2014 data was analyzed to understand the relationship between use of MasteringChemistry and learning and course outcomes. Seventy-one students were enrolled after the official withdrawal period. Seven students (10 percent) neither completed the course nor officially withdrew.

Of the seven students who did not complete the course, one did not take any of the four exams, and another student stopped after exam 1. Four other students stopped after exam 2. Another student did not take the final exam. Because these students did not complete the final exam, their data were excluded from the following analyses. For purposes of this analysis, a skipped MasteringChemistry homework is one with a score of zero.

Results show a strong positive correlation between MasteringChemistry scores (including all required and optional assignments), and the final exam score, with  $r = 0.61$  (Figure 1).

Because Lufaso was interested in investigating the relationship between completion of MasteringChemistry assignments and course performance, an analysis was done using exam 1 as a baseline. Students were divided into two groups based on the exam 1 median score of 74: low exam 1 (LEI) for students scoring less than the median and high exam 1 (HEI) for students scoring higher than the median (Table 2).

MasteringChemistry homework participation was calculated based on the number of skipped assignments out of the 38 total required and optional assignments (prerequisite knowledge, prelecture, chapter, and Knewton Adaptive Follow-Up).

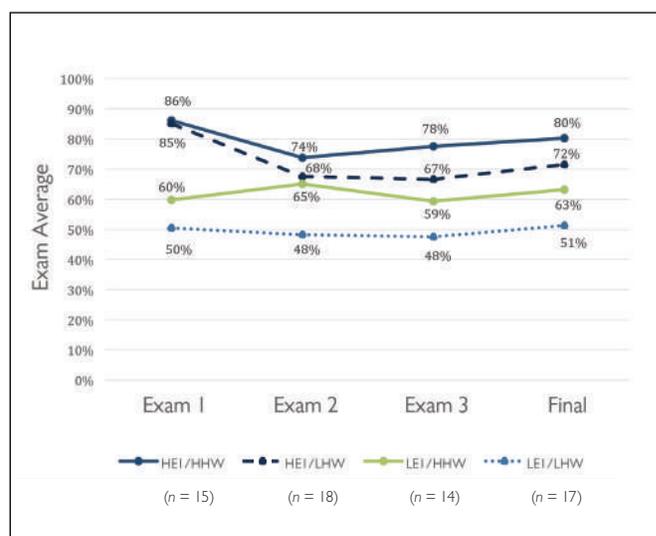


Figure 2. Comparison of Average Exam Scores based on MasteringChemistry Participation, Fall 2014 ( $n = 64$ )

The average number of skipped homework assignments was 8.5. Students were assigned to groups based on whether they skipped fewer (high homework, HHW) or more (low homework, LHW) than the average of 8.5 skipped.

HEI/HHW	High exam I/high homework participation
HEI/LHW	High exam I/low homework participation
LEI/HHW	Low exam I/high homework participation
LEI/LHW	Low exam I/low homework participation

Table 2. Exam Performance/Homework Participation Groups

Figure 2 shows the exam averages by homework participation groups. Data indicated the following:

- HEI/HHW and HEI/LHW exam I scores were statistically equivalent. HEI/HHW ( $M = 86\%$ ;  $SD = 8\%$ ;  $N = 15$ ) and HEI/LHW ( $M = 85\%$ ;  $SD = 7\%$ ;  $N = 18$ ).
- By the final exam, HEI/HHW scores were 8 percentage points higher than the scores for HEI/LHW, a statistically significant difference ( $p < 0.05$ ): HEI/HHW ( $M = 80\%$ ;  $SD = 14\%$ ;  $N = 15$ ) and HEI/LHW ( $M = 72\%$ ;  $SD = 14\%$ ;  $N = 18$ ).
- LEI/HHW exam I scores were 10 percentage points higher than LEI/LHW scores, a statistically significant difference ( $p < 0.05$ ): LEI/HHW ( $M = 60\%$ ;  $SD = 11\%$ ;  $N = 14$ ) and LEI/LHW ( $M = 50\%$ ;  $SD = 15\%$ ;  $N = 17$ ).
- LEI/HHW final exam scores were 12 percentage points higher than LEI/LHW scores, a statistically significant difference ( $p < 0.05$ ): LEI/HHW ( $M = 63\%$ ;  $SD = 17\%$ ;  $N = 14$ ) and LEI/LHW ( $M = 51\%$ ;  $SD = 19\%$ ;  $N = 17$ ).
- The difference between HEI/LHW and LEI/HHW was 25 percentage points on exam 1. It decreased to 2 percentage points on exam 2, and the gap was 9 percentage points on the final exam.

Study findings do not include the unmeasured influence of variables that can impact student performance, such as motivation. However, based on the performance of Lufaso's students, the students in each group who attempted more MasteringChemistry homework performed better on the comprehensive final exam than students in the same group who attempted fewer assignments. In addition, students in the

LEI group who attempted more MasteringChemistry homework narrowed the gap on each subsequent exam with those in the HEI group who attempted less homework. Further research is needed to test what the initial data seems to suggest is a relationship between (1) attempting MasteringChemistry assignments and engaging in optional resources and (2) course performance.

## The Student Experience

Students report that they like MasteringChemistry and the opportunity to do its different types of activities. On the course evaluation, one student wrote, "The MasteringChemistry homework online really did help me improve my work. Making it mandatory for students to do is a good decision. This way they are forced to learn what they wouldn't do on their own leisure time."

## Conclusion

Since adopting MasteringChemistry in 2006, Lufaso has continually redesigned his implementation with additional activities and assignments designed to address individual student needs and diverse skills and knowledge levels. "MasteringChemistry has impacted my teaching in a positive way," he says. "It enables me to obtain information about student learning more readily. I use that information to make changes to my lecture, in-class activities, notes, homework assignments, and exams."

By better understanding student performance during the course, he is able to address issues as they arise, and then use the data to make informed decisions for future semesters.

Lufaso recommends that instructors who are starting to use MasteringChemistry take advantage of the educator support to get trained, and use the implementation guide as a resource to plan the course around the instructor's specific issues and goals. He explains that by designing the MasteringChemistry course wisely and following best practices, the program can help instructors achieve the best results. Finally, he advises instructors to not immediately use every available feature, but to start with those that best address course goals. Evidence from Lufaso and his students suggests that thoughtful implementation of MasteringChemistry has helped create a positive course experience for himself and his students.

# MasteringEngineering

School Name Vanderbilt University, Nashville, TN

Course Name Statics

Course Format Flipped face-to-face

**Key Results** In this study, average exam scores increased after MasteringEngineering prelecture tutorial homework assignments were added to the curriculum.

**Submitted by**  
Lori Troxel, Associate Professor

**Course materials**  
MasteringEngineering and *Engineering Mechanics: Statics*,  
R. C. Hibbeler

## Setting

Vanderbilt University is a private research university serving approximately 6,500 undergraduates and 5,300 graduate and professional students. The majority of students attend full-time, and approximately 65 percent receive some type of financial aid.<sup>1</sup> The School of Engineering was started in 1886, and today enrolls approximately 1,300 students. Bachelor of engineering degree programs are offered in biomedical engineering, chemical engineering, civil engineering, computer engineering, electrical engineering, and mechanical engineering and are accredited by the Engineering Accreditation Commission of the Accreditation Board for Engineering and Technology (ABET).<sup>2</sup>

Lori Troxel is an associate professor of the practice of civil and environmental engineering with teaching responsibilities in the area of structural engineering and sustainable infrastructure. She has completed the ExCEED<sup>3</sup> teaching course and implemented many innovative teaching strategies. Troxel has taught Statics for 10 years.

Statics is a three-credit, introductory course required in the civil engineering curriculum. It is taught only in a face-to-face format. The course presents civil engineering students with the basics of engineering mechanics, including applications to systems of forces in two and three dimensions (particles and rigid bodies),

resultants, equivalent systems, and equilibrium, vector notation, introduction to shear and moment diagrams, moments of inertia, friction, and three-dimensional representation. Calculus II is a corequisite for the course.

The primary learning objective of the course is to develop problem-solving skills as applied to engineering mechanics problems. Additional outcomes are related to the following ABET program outcomes:

- Graduates will demonstrate an ability to apply knowledge of mathematics, science, and engineering.
- Graduates will demonstrate an ability to identify, formulate, and solve engineering problems.<sup>4</sup>

## Challenges and Goals

Because problem solving is a key skill that engineering students need to succeed in both the course and the program, it is critical that students can independently work problems. Solutions manuals are readily accessible, and when used in the correct way can be beneficial to the learning process. However, Troxel believes it's not unusual for students to attempt to find solutions for homework in lieu of working the problems themselves.

Troxel sought a way to administer homework assignments that would minimize the use of solutions manuals for copying homework answers and not doing the work. She also was interested in moving toward a more active class with the goal of flipping the classroom. She observed that students didn't seem prepared to work problems or discuss content in class when they were assigned reading from the textbook. When students weren't prepared with a basic understanding of concepts, the type of activities or problem solving that could be done during class time was affected.

Troxel implemented MasteringEngineering about five years ago to address these issues. In the first year, she required that all homework be due online; nothing was due by paper and pencil.

<sup>1</sup><http://www.vanderbilt.edu/about/facts/>.

<sup>2</sup><http://engineering.vanderbilt.edu/about/statistics.php>.

<sup>3</sup><http://www.asce.org/exceed/>.

<sup>4</sup><http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2015-2016/#outcomes>.

*By using MasteringEngineering tutorials to help students learn basic concepts on their own, time previously spent covering those concepts in lecture could then be used for in-class problem-solving activities.*

But she had concerns that many students were getting the answers without fully working the solutions. Troxel stopped using MasteringEngineering at the year's end and went back to all paper-and-pencil homework.

A year later, Troxel realized she was still facing the original issues. She reimplemented MasteringEngineering, but this time required online homework with paper-and-pencil solutions. She believed the class benefited from the MasteringEngineering homework features, including tutorials, hints, and feedback that facilitated learning, and she could ensure that students were completing the correct steps to arrive at the answers.

MasteringEngineering also enabled her to move toward flipping the classroom. By using the tutorials to help students learn those concepts on their own, time previously spent covering basic concepts in lecture could then be used for in-class problem-solving activities.

Given these challenges and goals, Troxel engaged in this study to begin to test and measure the relationship between engagement in prelecture activities with online materials and exam performance. To begin to measure the ways Troxel's students engaged in this type of prelecture activity, she collected data related to MasteringEngineering assignments that she believed would be helpful for and aligned to the learning outcomes of the course.

## Implementation

Troxel's goal for homework was for students to learn how to set up and solve a problem, an essential skill for this course. She taught them the following steps to the process:

1. Think about what is being asked.
2. Understand what is known.
3. Determine what can be found out.

Up to and including fall 2013, MasteringEngineering homework was done after lecture with some required paper-and-pencil problems. The course was redesigned for fall 2014, moving toward a flipped classroom with MasteringEngineering homework assigned both pre- and postlecture.

Following are the fall 2014 course components:

- **MasteringEngineering tutorial and coaching problems.** Prelecture assignments designed to familiarize students with basic concepts before a topic was covered in class. No deduction was made for use of hints, and no points were awarded for not using hints. Since the goal was for preparation and learning, not assessment, assignments were for either zero points (practice) or a small number of points.
- **MasteringEngineering problem-solving homework.** Postlecture, end-of-chapter problems that were usually randomized. Written solutions were required to be done on engineering paper and turned in following the format provided by the instructor. The format for written problems had to include a problem statement, a sketch, the given problem information, a goal, and the solution steps. Homework was not timed, students were allowed multiple attempts, and the two lowest scores were dropped. Late homework was not accepted. Default MasteringEngineering settings were left in place for scoring. This process was in place for both semesters in the study.
- **Class participation.** Similar to her course before redesign, students were expected to actively participate in problem-solving activities during class. The participation grade was based both on the instructor's observations and on answers to specific problems.
- **Projects.** Consistent with her course design before fall 2014, projects were open-ended problems with real-world examples and applications. Students were required to use engineering paper and the problem-solving algorithm provided by the instructor.
- **Notebooks.** Students were required to use notebooks to take notes in class, collect graded project reports, and take tests. Notebooks were collected at the end of the semester.
- **Exams.** Three paper-and-pencil tests and one comprehensive final exam were administered. No makeup tests were allowed. Students had to pass the final exam in order to pass the class. If a student scored less than 60 percent on the final exam, then the final exam grade was used as the grade for the course. Exams comprise 10 percent short-answer questions and 90 percent problems.

*Based on the course performance of Troxel's students, those who took the redesigned course and were assigned MasteringEngineering prelecture homework had higher exam averages than students who took the course before the redesign and were assigned only postlecture homework.*

- **Extra credit.** Students could earn five bonus points for each Engineering Society general meeting attended (not officer meetings). The extra-credit points were added to the total points for MasteringEngineering and the written solutions.

#### Assessments

30 percent	Exams (three)
20 percent	MasteringEngineering homework and written solutions (two lowest dropped)
20 percent	Projects
15 percent	Final comprehensive exam
10 percent	Class participation
5 percent	Notebook

#### Results and Data

An analysis of results from fall 2013 and fall 2014 compared exam scores. The same number of exams was given, and although exam content was not identical, Troxel maintains that the level of question difficulty was comparable. In fall 2014, MasteringEngineering prelecture tutorial homework was added after exam 1. Students in fall 2014 had prelecture assignments for the chapters covering exams 2 and 3 and the final. Only postlecture homework was assigned for the first unit, which was also the case in fall 2013.

Figure 1 shows a comparison of exam scores by semester. It shows that in fall 2013 and fall 2014, the average score was the same on exam 1 when only MasteringEngineering postlecture homework was given. After MasteringEngineering prelecture homework was added, results show that the average exam scores for fall 2014 were higher than the comparable exam scores for fall 2013 without prelecture tutorial homework.

For exam 2, students in fall 2014 ( $M = 84\%$ ;  $SD = 10\%$ ;  $N = 88$ ) had higher scores than students in fall 2013 ( $M = 81\%$ ;  $SD = 15\%$ ;  $N = 50$ ), but it was not statistically significantly higher, with  $p = 0.11$ , with a one-tailed  $t$ -test assuming unequal variance.

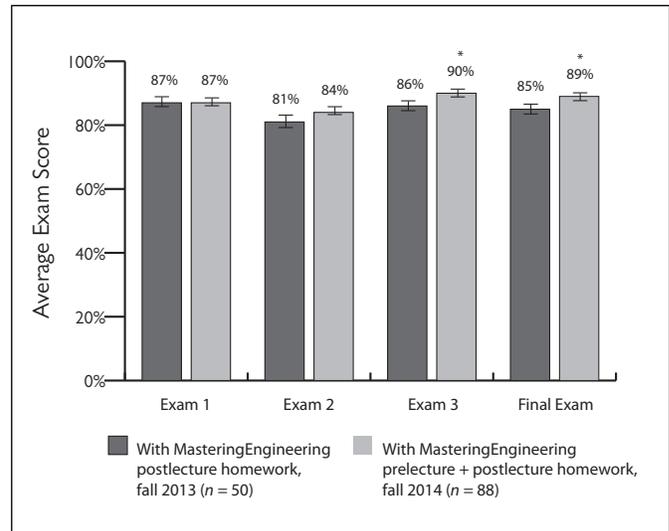


Figure 1. Average Exam Scores, Fall 2013–Fall 2014 ( $N = 138$ )

Err Bars = Stand Err; \* $p < .05$

(Note: In fall 2014, prelecture assignments were added after exam 1.)

In fall 2014, scores for both exam 3 ( $M = 90\%$ ;  $SD = 8\%$ ;  $N = 88$ ) and the final exam ( $M = 89\%$ ;  $SD = 7\%$ ;  $N = 88$ ) were statistically significantly higher than scores on both the fall 2013 exam 3 ( $M = 86\%$ ;  $SD = 13\%$ ;  $N = 50$ ) and the final exam ( $M = 85\%$ ;  $SD = 14\%$ ;  $N = 50$ ), with  $p < 0.05$  with the one-tailed  $t$ -test assuming unequal variance.

The study's findings do not account for the unmeasured influence of variables that can impact student performance, such as motivation and study skills. However, based on the course performance of Troxel's students, those who took the redesigned course and were assigned MasteringEngineering prelecture homework had higher exam averages than students who took the course before the redesign and were assigned only postlecture homework. Further research is needed to test what the initial data seems to suggest is a relationship between assigning MasteringEngineering prelecture assignments and exam performance.

## The Student Experience

A 2011 National Study of Student Engagement survey found that engineering students tended to study, on average, five hours more than their counterparts studying social science or business. This disparity in study habits might not reflect a more demanding workload, but rather a difference in the type of studying required.<sup>5</sup> Because students often lack problem-solving skills or need practice to reinforce and develop those skills for the type of work done in engineering, problem-solving homework is a key component in Statics.

Troxel found that after the course change to using both pre- and postlecture MasteringEngineering assignments, students came to class better prepared to do problem-solving activities. She also observed that students asked questions, which showed a better understanding of basic concepts and a deeper level of thinking, and that they seemed to be more engaged and get more out of class discussion.

## Conclusion

Between 2010 and 2014, every engineering occupation added jobs—a statistic that indicates the demand for quality graduates in the engineering field.<sup>6</sup> In order to enter the workforce, students must first succeed in the introductory Statics course, which requires developing problem-solving skills, gaining an understanding of the concepts, and practicing problems. Students in this study performed better on exams, which were 90 percent problems, after MasteringEngineering prelecture homework was implemented in the redesigned course, thereby affording them more time in class for active problem solving. This change enabled Troxel to use class time to better address misconceptions, answer specific questions, and focus on enhancing students' problem-solving abilities. Students completed additional practice on postlecture homework, giving them multiple opportunities to develop the skills needed to succeed in the course and move forward in their programs.

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<sup>5</sup><http://college.usatoday.com/2011/11/23/study-reveals-engineering-majors-spend-significantly-more-time-studying-2/>.

<sup>6</sup><http://www.forbes.com/sites/emsi/2014/09/12/the-most-in-demand-and-oldest-engineering-jobs/>.

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## Conclusion

The implementations, 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 deep insights gathered from long-term tracking and measuring of student data.

Pearson offers a community of educators teaching with Pearson digital products who are both passionate and willing to share their experiences, advice, tips, and best practices with other educators. This community, known as the Faculty Advisor Network (FAN), is available as a peer-to-peer resource to support and enhance your own teaching and learning experiences. Visit the [FAN website](#) to meet and engage with this community of educators using MyLab & Mastering products.

### Pearson Family of Solutions

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 the many classroom-tested best practices, the possible configurations of an effective Pearson digital implementation increase exponentially. We can help you:

- **Increase achievement.** Instant access to reliable data can help in the development of personalized learning, assessment, and instruction and can provide a blueprint for faculty and institutional effectiveness.
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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 results manager, at [betsy.nixon@pearson.com](mailto: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/](http://www.pearsonmylabandmastering.com/northamerica/educators/results/)

#### MASTERING IMPLEMENTATION GUIDE

[www.pageturnpro.com/Pearson-Education/52317-Mastering-%28all-courses%29-Instructor-Training-Guide/index.html](http://www.pageturnpro.com/Pearson-Education/52317-Mastering-%28all-courses%29-Instructor-Training-Guide/index.html)

#### MASTERING TOOLKIT

[https://media.pearsoncmg.com/long/CEPM.selfpaced/Curriculum/IPT/PT\\_Science.pdf](https://media.pearsoncmg.com/long/CEPM.selfpaced/Curriculum/IPT/PT_Science.pdf)

#### LEARNING CATALYTICS IMPLEMENTATION GUIDE

<https://learningcatalytics.com/pages/training>

#### FACULTY ADVISOR NETWORK

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

#### RESULTS GALLERY

[www.pearsonmylabandmastering.com/results](http://www.pearsonmylabandmastering.com/results)

#### TEACHING AND LEARNING BLOG

<http://www.pearsoned.com/blog/>

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