Mastering Physics educator study

A look at strategies to engage students in learning at University of Utah

Key findings:

- The group of students who scored above average on Mastering™ Physics and on each individual Mastering item had significantly higher final exam scores than those who scored at or below average.
- A strong correlation was found between Mastering pre-lecture homework - designed to prepare students for in-class activities - and Learning Catalytics.
- The instructor is a strong proponent of active learning and uses demonstrations and different Mastering Physics resources to engage students both in and outside the classroom.

School name: University of Utah

Course name: General Physics I

Course format: Face to face

Course materials: Modified Mastering Physics for *College Physics: A Strategic Approach*, by Knight, Jones, Field

Timeframe: Spring 2018

Educator: Adam Beehler, Lecture Demonstration Specialist

Results reported by: Betsy Nixon, Pearson Results Manager

Setting

Institution type: Public
Founded: 1850
Enrollment: 24,635 undergraduate
Ethnicity: 69.3% White or unidentified; 26.1% Students of Color; 4.5% International
Full-time status: 77%

About the course

Adam Beehler is a lecture-demonstration specialist in the Department of Physics and Astronomy at the University of Utah. Having taught physics for more than 20 years, he also serves as an educational resource for others interested in teaching with in-class demonstrations. He is passionate about community engagement and outreach, having reached nearly 70,000 people (outside of the classroom) through his volunteer lecture-demonstration presentations and outreach activities. His demonstration activities have been published as national best practices and have been adopted by many peer institutions due to their effectiveness for increasing student engagement and learning. His dedication to science education was recognized in 2018 when he was awarded the Governor's Medal for Science and Technology in Higher Education.[1] Beehler rotates teaching a physics survey course and algebra- and calculus-based physics courses. In Spring 2018, he taught General Physics I (Gen Phys I), the first in a two-course algebra-based sequence taken by Life Science majors.

Gen Phys I is a study of motion and heat. The course includes one-dimensional and two-dimensional kinematics, Newton's three laws of motion, circular motion, work and energy, momentum, rotational kinematics and dynamics, periodic motion, the three laws of Thermodynamics, temperature, and heat transfer. There are two lectures and two recitations weekly, and the majority of students intend to enter medicine, dentistry, pharmacy, humanities, or the behavioral and social sciences. Students may register for a concurrent lab, but it is not required for all programs. Students must have a math prerequisite of basic algebra and trigonometry.

Challenges and Goals

Beehler focuses on how things work in his physics courses. He says, "My classes are ultimately about learning how to find answers for oneself by developing an understanding of the basic physical principles that underlie the world around us. I encourage students to learn how to critically think and apply general physical laws to specific phenomena. Demonstrations of many of the phenomena are performed in class. Physical and conceptual understanding are emphasized rather than memorization."

Beehler's teaching philosophy focuses on thinking about the physical aspects of nature, not just about facts, and helping students develop critical thinking and reasoning skills is an important aspect of that. He says the biggest course challenge is that students do not have good study habits and time management skills, which are needed because they are still learning how to do well in college and often have other competing commitments.

To help students develop better habits and time management, Beehler emphasizes to students that they will spend a lot of time outside of class contemplating and understanding the concepts, because simply regurgitating information on assignments and exams doesn't work. The homework assignments can take several hours to complete, but course credit has been set accordingly. He also tells students to do homework assignments as soon as they are available, not right before they are due, and to remember that homework is designed for learning, so they will likely struggle when working through new concepts.

Beehler used Mastering Physics in a conceptual physics course in the past and decided to adopt it for Gen Phys I in Spring 2018. He wanted to incorporate more active learning into the course and felt Mastering would facilitate that goal.

Implementation

For Spring 2018, the Gen Phys I course included the following course components:

In-class activities: Class time focused on the topics and principles introduced in the textbook and pre-lecture assignments. Rather than lecture, Beehler used demonstrations, class discussions, and other activities. He emphasized the importance of attending class to

students because much of the information they were exposed to may not have been covered in the text, and class activities helped them develop a conceptual understanding. To encourage class attendance, Beehler sometimes included class content on the exams and sometimes administered unannounced quizzes during class based on the pre-lecture homework.

Discussion sections: Teaching Assistants (TAs) and Learning Assistants (LAs) held weekly discussion sections. Students worked on graded discussion group assignments and quizzes and had support during the session if questions arose. Attendance was required to receive credit.

Mastering Physics (MP): For Spring 2018, Beehler used Modified Mastering Physics integrated with the University's Learning Management System, Canvas. Because he felt it was important for students to have diverse resources, he utilized many different resources within MP, both required for credit and optional for extra credit. In addition, he made remediation resources available to students and encouraged them to utilize those resources as needed. The MP resources he used included:

Dynamic Study Modules (DSM) math skills: Students were provided three optional DSM math skills assignments to ensure they had the math skills needed to do well in the course.

Primer: The required Physics Primer contained tutorial problems designed to refresh students' math skills in the context of physics and prepare them for success in the course.

Dynamic Study Modules (DSMs): The DSMs were required for credit and due before the exam. They were assigned to help students study and assess their understanding of course concepts and to help students review for exams.

Pre-lecture homework: The required, for-credit pre-lecture assignments were designed to encourage students to come to class prepared with an understanding of concepts that were to be presented in class. They were due before the lecture, and the lowest pre-lecture homework score was dropped at the end of the semester. The assignments were comprised of mainly videos and reading questions introducing the concepts, and the content covered one to two chapters per week. Beehler reviewed the diagnostics prior to class to better understand what concepts students were confused about or needed further clarification.

Chapter homework: The required, for-credit MP chapter homework was designed to provide students with practice to develop their understanding of the course concepts and included qualitative and quantitative questions involving the application of physics concepts. Beehler selected problems that required critical thinking, not just math. Homework was due the weekend after the lecture in which the material was covered. Students were allowed multiple attempts but received a deduction for wrong answers and could earn partial credit. The items included both activity questions and problems, and the lowest assignment score was dropped at the end of the semester.

Adaptive Follow-Up (AFU): The AFU assignments were optional for extra credit and were generated based on each student's performance on the MP chapter homework.

Learning Catalytics (LC): LC is an interactive, student response tool that uses mobile devices (such as smartphones, tablets, and/or laptops) and is accessed via MP. LC was used for in-class activities, and students earned 80% for participation and 20% for correctness. The goal of incorporating LC activities during class is for learning rather than assessment.

Quizzes: A weekly paper-and-pencil quiz was administered in the discussion sections and served as an inventory check to ensure that students understood the fundamental concepts. The first part of the quiz was taken individually, and the second part of the quiz was taken in groups.

Midterm exams: Four paper-and-pencil midterm exams were administered with questions similar to the type students completed in the MP homework, discussion sections, or as seen in the textbook. The lowest midterm exam score was dropped. Students could use one reference sheet during the midterm exams and a calculator. Students could choose to earn extra credit on midterm exams by correcting certain missed problems for the first three exams. The midterm exam corrections were due approximately one week after the graded exam was returned.

Final exam: A comprehensive paper-and-pencil final exam was administered that was similar to the midterm exams but included more questions and problems. Student could use one reference sheet and a calculator during the exam, but no corrections were permitted after the exam was completed.

Assessments

- 31% Midterms (4)
- 14% MP chapter homework
- 10% Final Exam
- 9% Quizzes
- 9% Learning Catalytics
- 9% MP Pre-lecture homework
- 9% MP Dynamic Study Modules
- 9% Discussion group assignments

Results and Data

Because Beehler wanted to emphasize learning, he provided multiple types of assignments in Mastering and made MP worth 41% of the course grade. To understand the impact, the following analysis was conducted. The average score for each Mastering item and the overall MP average were calculated. Students were then grouped either above the MP class average or at or below the average. The group of students earning above average scores on each MP item had a significantly higher final exam average than the group of students who scored at or below the MP class average. A two-tail t-test was used to calculate significance at $p<.05$.

Beehler assigned MP pre-lecture homework with the goal of holding students accountable for coming to class prepared. To understand the impact of the pre-lecture homework, a correlation analysis was done looking at the MP pre-lecture homework and Learning Catalytics, which was used to answer questions for the in-class activities. Correlations do not imply causation but instead measure the strength of a relationship between two variables, where r is the correlation coefficient. The closer the r-value is to 1.0, the stronger the correlation. Results show a strong correlation with $r=0.60$, and it is significant at $p<.05$.

The Student Experience

Beehler says that he loves physics and loves sharing it, and it seems his students are learning and enjoying the environment he has created. One student provided feedback on www.RateMyProfessors.com about this course and noted that there is lots of homework, but said:

> "...easily one of my favorite professors at the U[tah]. If you want to actually learn physics, he's the one! Physics is no easy topic to teach but [Beehler] masters the art of breaking it down in a way that is extremely easy to understand. I'd HIGHLY recommend taking his class!"[2]
>
> —Student, University of Utah

Conclusion

Beehler has focused his course on engaging students through class demonstrations and implementing different interactive Mastering resources, both inside and outside the classroom. In an analysis of his Spring 2018 course data, the results showed that the groups of students who scored above average on the Mastering assignments had significantly higher final exam scores than those who scored at or below average on MP. In addition, as part of the implementation strategy, Beehler assigns MP pre-lecture homework so students come to class prepared. The correlation was strong with Learning Catalytics, and the majority of students had both high pre-lecture and LC scores, indicating students were coming to class prepared and participating. After using MP in Gen Phys I for the first time, Beehler plans to continue with it in the future, along with using demonstrations for active learning in his course.

---

[1]Lisa Potter, "Physics is Fun," @TheU
https://attheu.utah.edu/facultystaff/physics-is-fun/

[2]Adam Beehler, Rate My Professors
https://www.ratemyprofessors.com/ShowRatings.jsp?tid=1876480