

# Mastering Physics educator study reports on the success of using different assignment types at Temple College

## Key Findings

- Smaller, more frequent Mastering homework was assigned pre- and post-lecture to keep students engaged and to provide diverse learning opportunities.
- Over 85% of students attempted all 72 Mastering homework assignments each semester.
- Correlations between Mastering Physics homework and exam averages were moderately strong.
- Students earning a Mastering score higher than the mean had significantly higher exam averages than students with a Mastering score at or below the mean.

## Study Specifics

**School name:** Temple College, Temple, TX  
**Course name:** Elementary Physics I  
**Course format:** Face to face  
**Course materials:** Mastering Physics with *Conceptual Physics* by Hewitt

**Timeframe:** Fall 2016, Spring 2017, Fall 2017  
**Educator:** John McClain, Professor  
**Results reported by:** Betsy Nixon, Pearson Customer Outcomes Analytics Manager

## Setting

- Type: Community college with five campuses
- Enrollment: 4,946 (2016)
- Founded: 1926
- [Performance](#): 75% of students complete a course with a C or better (college level, 2016–17)
- [Ethnicity](#): 28% Hispanic; 15% African American

## About the Course

Professor John McClain has been at Temple College for eight years and teaches Physics and Astronomy courses, including Elementary Physics, a conceptual level survey course intended for liberal arts and other non-science majors seeking a general education science course. It is primarily taken by education majors and students who have not taken a prior science course. A lab is included, and the course covers principles that introduce classical mechanics and thermodynamics, motion, properties of matter and heat, and other related topics.

Elementary Physics I is part of a two-course sequence taken after completion of the Texas Success Initiative (TSI), a State legislatively mandated program to help ensure that students have the academic skills they need to succeed in higher education. The TSI requires testing of students' academic skills upon entry into public higher education and gives appropriate counseling, advice, and opportunities for improving those skills. Each college or university is responsible for determining when students have obtained the necessary skills to succeed in college and may continue with coursework.

## Challenges and Goals

Students who take Elementary Physics tend to have different backgrounds and skills and varying degrees of motivation, even though many need to successfully complete the course to pursue their intended programs.

McClain believes that the course is often taught from the perspective of “plugging and chugging” various mathematical equations, and answers are seen as the end result with little or no analysis to promote student understanding and relevance of the activities. He believes “that true learning begins when students start to think about the answers they obtain to understand the relevance of the problem. It is then that students develop a more critical and conceptual understanding by seeking alternate solutions, examining how changing parameters may affect the solution, and understanding the effects of initial assumptions.” This type of thinking can also help students develop a deeper appreciation of physics and life.

To address these challenges, McClain set the following goals for the course:

- Foster an active learning environment;
- Include physics education research in the classroom;
- Enhance quantitative reasoning skills through problem solving;
- Improve qualitative reasoning skills through conceptual understanding;
- Communicate the relevance of physics to everyday experiences; and
- Help students understand that learning can be both fun and rewarding.

To accomplish those goals, he focuses on doing the following:

- Keeping students actively engaged;
- Providing frequent and accurate forecasting of student performance;
- Linking everyday issues to course material;
- Dealing clearly with alternative student conceptions;
- Designing homework to promote the connection to real-world situations;
- Utilizing multiple strategies to address various student learning styles;
- Inspiring students to take ownership of their education; and
- Enabling students to teach themselves.

McClain adopted Mastering™ Physics as a resource to engage students through multiple types of interactive homework assignments, and to monitor learning and achievement by tracking students' progress by comparing their performance to national standards through the Mastering diagnostics.

## Implementation

**Unit exams:** There are six unit exams (one exam for three chapters) administered through Mastering Physics, and students may make up one missed exam by using the final exam grade to replace the missed exam. Exams are divided into two parts and each part has an immediate retake available. Part one tests memorization and contains approximately 40 questions that were on the Mastering Test Yourself homework assignments so students should recognize the questions if they did the homework. Part two contains approximately the same number of questions as the first part, but questions are from the test bank and include ones students have not seen before. Success on part one requires memorization, while success on part two requires critical thinking. The total exam grade is the average of both parts.

Exams usually contain conceptual questions which may involve simple calculations. Most questions can be readily answered without the aid of a calculator by using proportional reasoning, as the focus is on physics and not mathematics. Formulas are not provided to students as they are the mathematical representation of the physics being learned. McClain feels that more frequent exams help keep stress levels down by allowing students to be assessed on smaller chunks of material. He believes that students tend to stay more engaged knowing that an exam is continually around the corner.

**Final exam:** The final exam is comprehensive with questions from the Mastering test bank. Students may opt to use the unit exam average as their final exam score if the Mastering homework assignment average after the last unit exam is greater than or equal to 85%. The final exam grade can replace the lowest exam grade if it benefits the student. Most students are able to opt out of the final exam.

**Mastering Physics:** The four types of Mastering Physics assignments described below enable McClain to evaluate understanding on different levels and help students develop critical thinking skills. Homework is as follows:

- **Reading quizzes** should be done first and are completed usually after a worksheet that encourages the students to become immersed with the chapter contents. These pre-lecture assignments help introduce the material that will be discussed from the chapter. The assignments may be reset one time up to one week before the last day of class. Assignments completed after the due date incur a 2% penalty per day with a maximum of 20 points deducted.
- **Checkups** should be completed ideally just after the material is presented in class. It serves to reinforce the basic concepts in the chapters and identify points that need further study. The assignments may be reset one time up to one week before the last day of class. Assignments completed after the due date incur a 2% penalty per day with a maximum of 20 points deducted.
- **Activities** should be done after the checkups as they center on application of the material, moving past the memorization stage and guiding student as they move into the critical thinking stage. By this time students should be able to start putting concepts together in coherent thought streams. These assignments include vocabulary, ranking, sorting, interactive figures, and other activity questions. The assignments may be reset one time up to one week before the last day of class. Assignments completed after the due date incur a 2% penalty per day with a maximum of 20 points deducted.
- **Test Yourself assignments** are to be completed in preparation for the exam and are designed so students apply the major themes of the chapter, giving them an opportunity to practice answering questions typically seen on the exam. The assignments are generally done in class or in groups, and group participation is observed as part of the assignment grade. The groups are often set to compete against one another to encourage engagement and add personal investment in doing the work. Questions are from the test bank and are the same questions that make up part one of the exams. The goal is for students to arrive at the correct answers and then understand why it was correct so that they can successfully work the problems that are given in the second part of the exam. The assignments may be reset one time up to one week before the last day of class. If they are completed after the due date, there is a 2% per day penalty with a maximum of 20 points deducted.

Students are told they need to register in Mastering Physics by the second class meeting. To promote peer learning, they are encouraged to form study groups outside of class. Some Mastering assignments have a target due date to assist students in managing their time, but all Mastering assignments are due by the respective exam date. Homework turned in after the final due date incurs a penalty based on the time elapsed since the assignments may be turned in as late as the night of the last unit exam. Students are also encouraged to keep a journal of questions that arise while doing the homework so they can discuss those with other students or in class.

McClain believes that the Mastering assignments serve different purposes and should be completed at different times during the learning process. Assigning smaller, more frequent assignments encourages students to not leave questions blank since each question appears to count more because there are fewer in each assignment. In addition, students engage with the content more frequently, and they have a sense of accomplishing more

(i.e, finishing five assignments with 12 questions rather than one assignment with 60 questions). He feels students know when they sign up for his course that they will be challenged and engaged, but will need to participate and do the work to succeed. No individual extra credit opportunities are given, and all Mastering assignments are normalized upward by a multiplicative factor if necessary. Other assignments in the class include:

**Laboratory:** Lab reports are due the same day they are attempted in lab, and lab worksheets are usually done as a group activity. They can be made up at reduced credit.

**Paper-and-pencil reading quizzes and exercise worksheets:** Worksheets are usually done as a group activity and serve as an introduction to the chapter. Students who do not participate fully in the activity may have their score reduced. Worksheets can be made up at a reduced credit.

**In-class discussion/participation:** Credit is given for participation and discussion in class. Students are not automatically awarded points for attending if they do not contribute during activities. McClain uses various methods to assess student learning. Most chapters are initiated with a group activity which gets the students oriented with vocabulary and concepts. It affords the students the opportunity to interact with others in their group, fostering teamwork and peer learning. Class discussion follows the completion of the group activity and alternative answers are often shared.

**Video reviews:** Videos are often used in class. Students are required to do video write-ups or may be required to complete worksheets or electronic assignments related to the video.

## Assessments

- 23% Unit exams (6 total)
- 15% Final exam
- 14% Laboratory work
- 8% Mastering Physics reading quizzes
- 8% Mastering Physics activity homework
- 8% Mastering Physics checkups
- 8% Mastering Physics test yourself
- 8% Paper-and-pencil reading quizzes/worksheets
- 4% In-class discussion/participation
- 4% Video reviews

## Results and Data

Because McClain's sections tend to be small, he evaluated three semesters of results for Elementary Physics I. First, a correlation analysis was conducted for Mastering homework to the exam average. 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. The corresponding  $p$ -value measures the statistical significance/strength of this evidence (the correlation), where a  $p$ -value  $<.05$  shows the existence of a positive correlation between these two variables. For the three semesters combined, the correlation was moderately strong, and was significant at  $p<.001$  (Figure 1).

### Correlation of Mastering Physics average to exam average

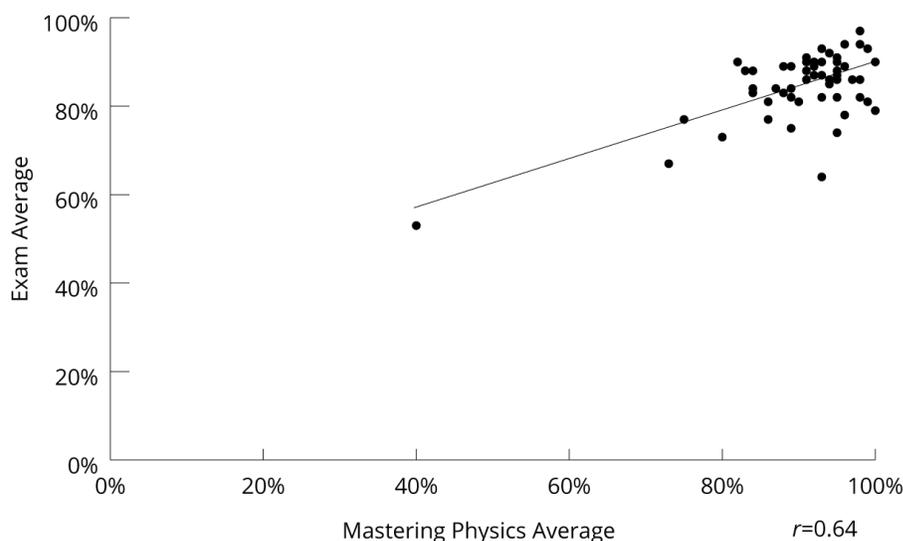


Figure 1. Correlation of Mastering Physics Average to Exam Average, Fall 2016, Spring 2017, and Fall 2017 Combined ( $N=59$ )

There were 72 Mastering assignments during the semester. To better understand student performance, an analysis was completed looking at Mastering homework participation with a skipped homework considered to be one with a score of zero. The homework performance by semester was as follows (Table 1):

#### Mastering Physics homework performance

	Fall 2016	Spring 2017	Fall 2017
<b>Average number of Mastering homework skipped</b>	0.6	2.4	0.4
<b>Percent of students attempting all assignments</b>	85%	88%	91%
<b>Average Mastering score</b>	90%	90%	91%

Table 1. Mastering Physics Homework Performance, Fall 2016 ( $n=20$ ); Spring 2017 ( $n=17$ ); Fall 2017 ( $n=22$ )

While a high number of smaller Mastering homeworks were assigned, the majority of students attempted all assignments. On average, more assignments were skipped for Fall 2016 and fewer students attempted all of the homework. However, the individual breakdown of skipped homework shows that each semester one student impacted the average and skipped a higher number of assignments than other students:

- In Fall 2017, two students skipped one or more assignments. Of the two that skipped an assignment, one student skipped one and one student skipped eight (11% of homework).
- In Spring 2017, two students skipped one or more assignments. Of the two that skipped an assignment, one student skipped one and one student skipped 39 (54% of homework).
- In Fall 2016, two students skipped one or more assignments. Of the two that skipped an assignment, one student skipped one and one student skipped five (7% of homework).

An additional analysis was done grouping students based on the mean Mastering score each semester. Each semester, the group of students earning above the Mastering mean had a significantly higher exam average than students earning at or below the mean. Figure 2 shows the results for Fall 2017, with students who averaged above the mean having a significantly higher exam average. The results were similar for the other two semesters.

### Exam average based on Mastering Physics average, Fall 2017

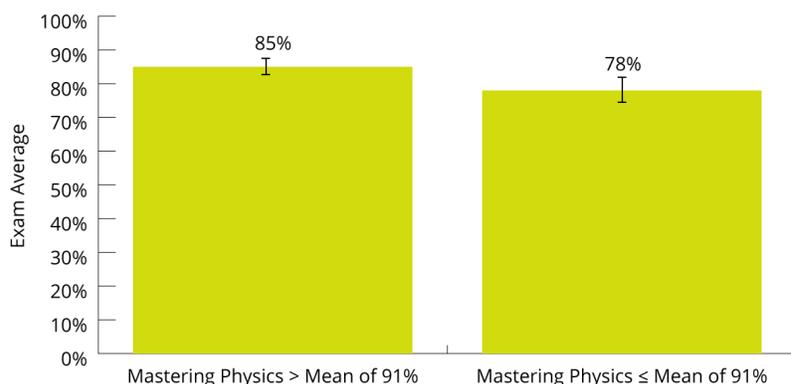


Figure 2. Exam Average Based on Mastering Physics Score Greater than the Average of 91% ( $n=15$ ) and Less than or Equal to 91% ( $n=7$ ) Error bars=Stand Err,  $p<.05$

### The Student Experience

McClain was asked about student feedback around the number of Mastering assignments. He said, “I really think you can get away with asking your students to do a lot of work if they see the benefit. I don't keep my students guessing about what is expected from them.” He added, “I am convinced that physics can be taught in such a way that the student, upon completion of the course, can look back on their accomplishments with a sense of pride and empowerment. It is far more important to me that my students have a mind-expanding experience as opposed to a mind-clogging experience.” His course has a high retention rate, and he reports receiving positive feedback from students. While McClain did not solicit formal written feedback, he reported, “One of my students told me she would miss my class over Spring break, and another told me this was the most fun course she had taken at the college.”

Participation rates for Mastering homework are high, with the majority of students attempting all homework, indicating they are engaged in the course. At the online website, Rate My Professors, one student stated, “I really learned what we were doing and not just memorizing it. Made physics interesting...” By providing interactive resources, making class active, and helping students connect physics to the real world, McClain sees students develop an appreciation for learning science — one of his course goals.

### Conclusion

McClain has used Mastering for several years in different physics and astronomy courses as a tool to engage students. He assigns multiple types of homework at different points in the learning process and uses different question types in Mastering to keep it interesting and to teach different solution strategies. His results show a moderately strong correlation between Mastering and exam averages, and students who score better on Mastering homework also tend to have higher exam averages.

He continually evaluates his results and his technology implementation strategies so he can make any necessary changes to improve the course and revamp assignments to better meet students' needs. McClain enjoys being in the classroom and has chosen to teach at a two-year college because it's where he feels he can be the most effective in helping the largest number of individuals. He added, “I want my students to be successful, not only in my classroom, but also in life. I want them to carry the reasoning skills learned inside the classroom to the bigger world outside the classroom.”