

Mastering Biology educator study reports on redesign at Fairfield University

<p>School name Fairfield University, Fairfield, CT</p> <p>Course name General Biology I</p> <p>Course format Face to face</p> <p>Course materials Mastering Biology with <i>Biological Science</i> by Freeman</p>	<p>Timeframe Fall 2010–Fall 2015</p> <p>Educator Shelley Phelan, Professor</p> <p>Results reported by Betsy Nixon, Pearson Customer Outcomes Analytics Manager</p>
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Key Findings

- The department started a redesign in 1999 and continued to evaluate results, monitor course costs, and stay up-to-date with educational technology, resulting in ongoing course changes to enhance learning.
- From 2010 to 2015, the group of students who averaged Mastering Biology homework scores above the mean had higher final exam averages than students who had lower Mastering homework scores.
- Students who averaged Learning Catalytics scores above the mean had higher final exam averages than students who averaged at or below the mean.

Setting

- Type: Private, liberal arts college
- Founded: 1942 as an all-male school with 300 students; became co-ed in 1947
- Enrollment: Approximately 5,000 (graduate and undergraduate)
- Undergraduate students attending full time: 93 percent
- [Female students](#): 60 percent
- Students classifying themselves as white: 76 percent
- [Four-year graduation rate \(2011 cohort\)](#): 79 percent
- [Six-year graduation rate \(2009 cohort\)](#): 82 percent

About the Course

Dr. Shelley Phelan is a molecular cell biologist who teaches General Biology I with Lab, Cell Biology with Lab, and a seminar course called Molecular Mechanisms of Disease. She has played a lead role in several initiatives for science students on campus, including the creation of the Peer Learning Group program for General Biology students, the founding of the Women in Science, Technology, Engineering and Mathematics floor, involvement in the Fairfield University Chapter of Sigma Xi, and the creation of the BASE summer science camp for inner-city high school students.

The introductory course for Biology covers the molecular and cellular basis of life, including cell structure and function, cell communication, inheritance, gene expression and regulation, and developmental genetics. The four-credit lecture and lab course is required of all Biology majors. Annual enrollment is approximately 120 students, putting the course among the highest enrolled classes at Fairfield. The course is primarily taken by Biology majors and minors, Biochemistry majors and minors, Psychology majors, and students pursuing all allied health studies. Almost one-tenth of all students at Fairfield major in Biology, the second largest major at the university.

Specific course goals include:

- To build a knowledge base and acquire the intellectual tools necessary to succeed as a biologist;
- To become comfortable with the scientific process that biologists use (formulating and testing hypothesis) as they attempt to answer questions about the natural world; and
- To appreciate why evolution is the core theme of biology.

Challenges and Goals

The Biology department started their initial course redesign in 1999. The lecture portion of the course relied upon passive learning—with little interaction among students—and focused on an approach that faculty believed was in need of modernization. Prior to that, lecture had been taught by a rotation of full-time faculty using the same syllabus. The course was taught as a traditional lecture with no group activities and a standard lab format.

The department felt the traditional course suffered from a number of deficiencies including a lack of a student-centered, inquiry-based pedagogy. Student surveys indicated a dissatisfaction with the existing approach, and preliminary data showed lower comprehension of material and lower retention of students than faculty expected. Both the lecture and lab focused on memorization rather than the application of scientific methodology and critical thinking skills. In addition, there was a lack of technology in the course to convey complex visual material and to demonstrate specific concepts. Finally, the department believed the cost-per-student had become too high due to redundancy in faculty teaching and the high cost of lab exercises.

The department implemented a course redesign with a goal of changing the focus of activity from memorization to a student-centered, inquiry-based pedagogy to create a more uniform experience for students and to increase retention. The plan for the redesigned course emphasized the application of scientific methodology and critical thinking skills and incorporated online resources to

increase student comprehension and retention of material. The planned redesign condensed all sections into a single, large-classroom format and included a lecture interspersed with group activities. Students worked in teams of two to three around laptops, utilizing digital materials that focused on inquiry-based instruction and independent investigations. Goals for students included:

- To improve their understanding of foundational concepts in biology;
- To increase their confidence in their knowledge;
- To appreciate the effectiveness of collaborative team efforts; and
- To develop higher-order cognitive skills.

For the department, goals included:

- To create significant cost savings from reducing faculty time in three major areas: 1) materials development for lectures; 2) out-of-class course meetings; and 3) in-class lectures and labs.
- To consolidate seven lecture sections to two and to introduce computer-based modules in the lecture and laboratory to reduce cost-per-student.

The [results from the redesign through 2002](#) can be found online at the National Center for Academic Transformation (NCAT) website. However, in response to the initial redesign successes, the department continued to evaluate course needs and technology changes and undertook an additional redesign to the entire introductory sequence for Biology majors. Prior to 2002, the department required four semesters of introductory biology course work from four different courses (two semesters of General Biology, one semester of Genetics, and one semester of Ecology). General Biology was a two-semester sequence taken in the freshman year, and the two additional biology courses were required in the sophomore year.

In 2003, the department expanded the General Biology sequence to three semesters and incorporated the two second-year courses within it. With the updated courses, students cover approximately the same amount of material in three semesters that previously required four. Two faculty team-teach each semester, each teaching the topics related to his/her area of expertise. This has reduced the number of faculty required for the course, freeing up faculty time for other activities or for teaching upper-level courses. This has also allowed for consistency in instruction for the students, since the same faculty are delivering the material to all of the students. The goals for the course continued to be: to enhance student learning; to administer the course in a cost-effective manner; and to stay current with technology. The department continued to evaluate results on a regular basis.

Implementation

In 2008, the department decided to make further redesign changes to provide additional resources to enhance learning and student success. The following changes were made:

- A weekly-required, peer-learning session was added.
- Mastering Biology was adopted to replace homework completed on the school's Learning Management System.

- In 2015, Learning Catalytics, which is part of Mastering Biology, was added for in-class activities, replacing traditional clickers.

A summary of the changes from the traditional course to the redesigned course are shown in table 1.

Traditional course	Redesigned course
14-week term	14-week term
4 required Biology courses	3 required Biology courses covering same content
3 lecture sections of 35–40 students each (taught by different faculty)	2 lecture sections of 60 students each (team taught by same faculty pair)
6 contact hours/week: <ul style="list-style-type: none"> • 3 (50-minute) lectures • 1 (3-hour) lab 	6 contact hours/week: <ul style="list-style-type: none"> • 2 (75-minute) lectures • 1 (3-hour) lab • 1 recitation session with team learning (8 recitation sessions/week of 12–16 students each)
3 faculty members each teaching one section	2 faculty members collaboratively teaching two sections

Table 1. General Biology Details for Traditional and Redesigned Course

Included below is additional information on the changes made from 2008 through 2015.

Mastering Biology: The department adopted Mastering Biology because they felt it was a more robust system that would provide automatic feedback and grading, along with additional interactive and study resources. With large lecture sections, it was difficult to grade and return homework in a timely manner. The automatic feedback not only facilitated grading for instructors, but Phelan felt it was an effective way for students to monitor their own progress and track what they understood and where they needed more help.

At the beginning of the course, students were required to do the Introduction to Mastering assignment and a pre-course assessment consisting of 20 multiple-choice questions with no hints. This provided insight into what concepts students had retained from high school which helped guide faculty's coverage of concepts during the semester. The pre-course assessment is not graded for credit and contains lower level questions. Students tend to earn average scores of around 50-60 percent. No post-test was given.

The first instructor to teach each semester set up the Mastering Biology homework for the first part of the course, and the second instructor added their homework for the second half. The homework was used as a template in subsequent semesters, but each instructor could make changes. For Phelan, there was one Mastering Biology homework due for each lecture. It was due post-lecture, and students had until the next lecture to complete each assignment.

Her Mastering homework consisted of a mix of question types including: activities, tutorials, and videos. Some questions selected had hints, but not all, and students had multiple, untimed attempts. Phelan told students homework was designed as a study aid, and they should use the book and resources to help them learn and understand the concepts to answer the questions. The formative assignments were designed to take students about 45 minutes to complete. Students were instructed not to collaborate or work with others on this homework.

Learning Catalytics: Clickers were added in 2008 to facilitate in-class activities. Beginning in Fall 2015, [Learning Catalytics \(LC\)](#) replaced clickers. LC is integrated in Mastering, and students may use it on any device, such as a laptop or smartphone. Students answered questions about two to four times during a typical lecture. Phelan believes students were more engaged and paying better attention in class after activities were added, and the answer feedback was useful during class to uncover any misconceptions that could then be corrected immediately.

Peer learning: Students were required to attend a weekly peer learning recitation session. The sessions were designed to be small learning communities to help students become more comfortable with the lecture material and to practice solving problems. The peer learning was led by upper-division Biology majors with problems selected by faculty. There were 12 different peer learning sections each week with 10–12 students in each, and students registered to attend the same one for the semester. If students attended every session and participated, they receive five points towards their course grade. Students did not use technology in the sessions, but did problem-solving with paper and pencil.

Exams: Paper-and-pencil exams were administered. Students were given four exams and a cumulative final exam. The first exam was worth slightly less than the other three unit exams at 8 percent, while the remaining unit exams were worth 9 percent.

Phelan shared some of the lessons learned during their long-term course redesign:

1. Making recitation optional didn't work because few students attended, and those students going to the optional recitation tended to be top-performing students.
2. Keeping and passing out departmental laptops was a time-consuming task that took away time for activities. Students are now required to bring their own devices and can use either computers or phones to do the Learning Catalytics questions. Phelan reports they have never had a student say they don't have a device to use in class.
3. When the department first implemented virtual labs in lieu of in-class labs, they found it cut costs, but student engagement and interest also declined, particularly when dissections were completed virtually. Following this discovery, students were required once again to attend weekly labs in person.
4. They found that students came to the course with varying skill sets. Some had previously taken AP courses; others had not. Since some students struggled with doing pre-lecture homework from the assigned reading, they decided to only assign post-lecture Mastering homework so all students could hear the concepts explained at least once during lecture.

Assessments

- 35 percent Exams (4)
- 25% Final exam
- 25% Lab
- 8% Mastering Biology
- 5% Peer learning recitation group work
- 2% Learning Catalytics

Results and Data

While the redesign has been ongoing since 1999, and Mastering Biology was added in 2008, the available data for this study covered the semesters from 2010 through 2015. During this period, the only change was the addition of Learning Catalytics in 2015. To evaluate the impact of Mastering, an analysis was done grouping students based on Mastering homework performance combining data from Fall 2010–2015. The Mastering mean score for this period was 85 percent. Figure 1 shows that students who scored above the mean Mastering score had a significantly higher final exam average than students who scored at or below the mean ($p < .05$), with a difference of 12 percentage points.

Final exam average based on Mastering Biology homework performance

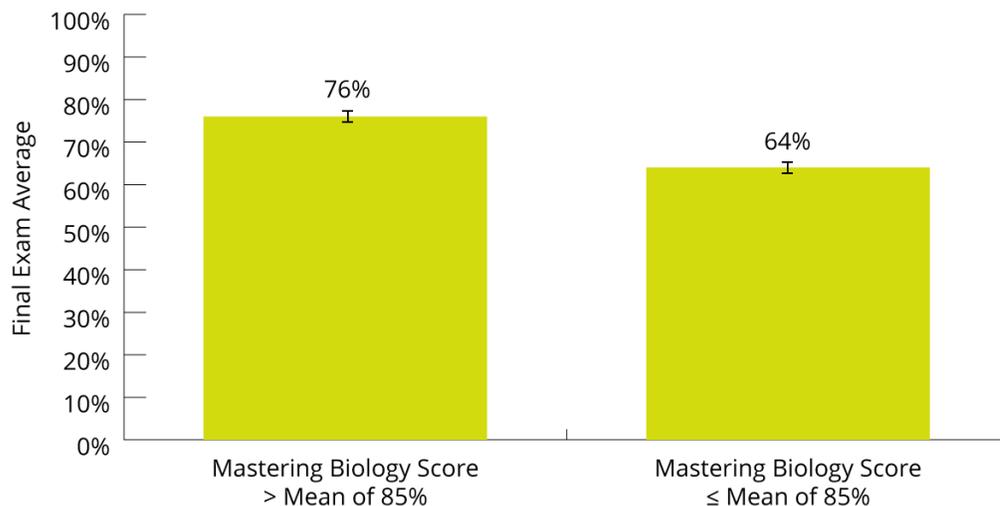


Figure 1. Final Exam Average Based on Mastering Biology Homework Performance, Fall 2010–Fall 2015; Mastering Biology >85% ($n=488$); Mastering Biology $\leq 85\%$ ($n=260$)

While other factors that are difficult to measure, such as motivation and study skills, may impact the analysis, the results show that students who scored higher on Mastering Biology homework had higher final exam averages. Because Learning Catalytics (LC) was added in Fall 2015, the same analysis was done. Figure 2 shows those results. Students who had LC scores above the mean of 77 percent had a significantly higher final exam average than students who averaged at or below the mean.

Final exam average based on Learning Catalytics performance

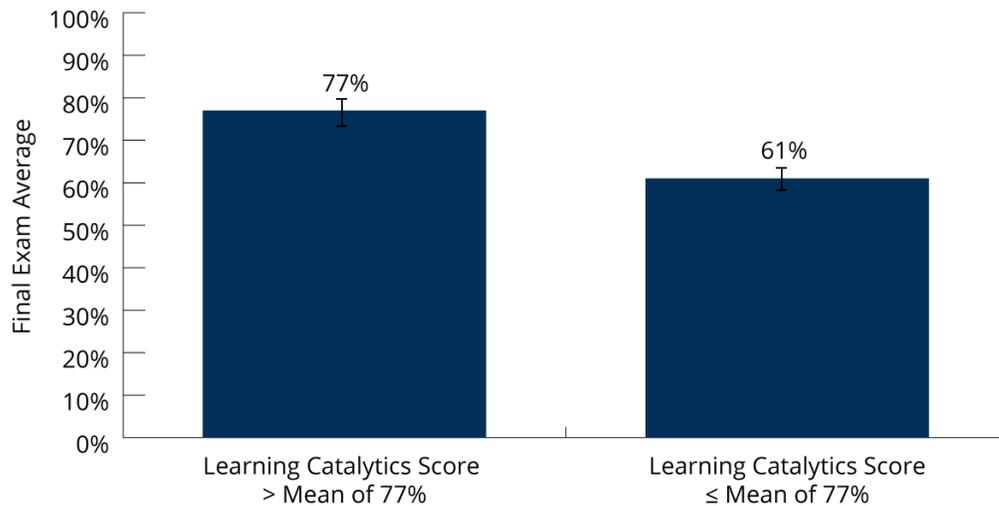


Figure 2. Final Exam Average Based on Learning Catalytics Performance in Fall 2015, Learning Catalytics >77% (n=55); Learning Catalytics ≤77% (n=44)

A correlation analysis was also done for the average LC score to the average of all exams. 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.

Correlation of Learning Catalytics score to final exam average

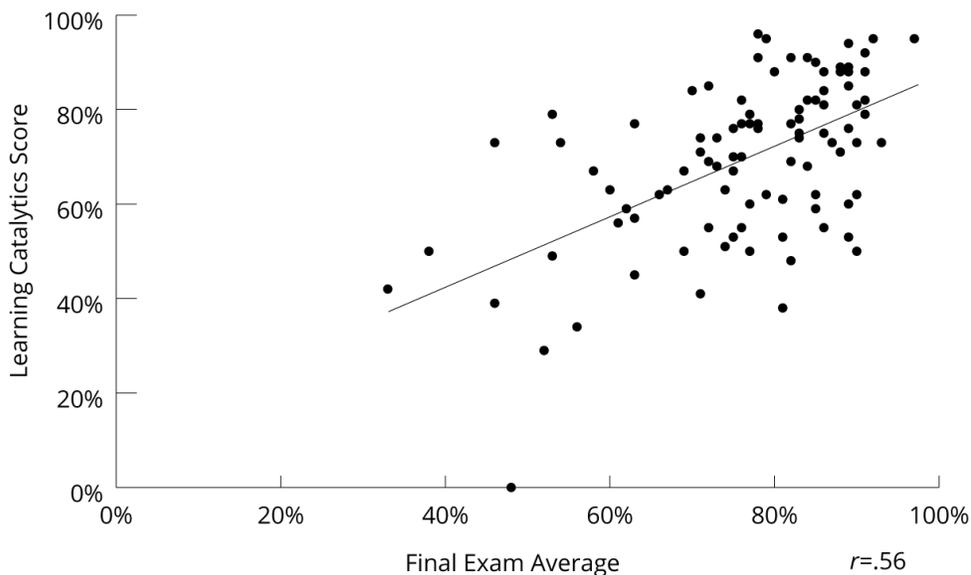


Figure 3. Correlation of Learning Catalytics Score to Final Exam Average in Fall 2015 (n=99) $p<.05$

The Student Experience

Since the redesign, instructors have received positive student feedback and observed an increase in student engagement. Instructors tell students that Mastering is to help them learn the concepts, and student feedback indicates they like the activities and videos available to them in the program. On course evaluations, many students cite Mastering Biology or Learning Catalytics in response to the question, *“What aspects of the course were most helpful to your learning?”*.

Phelan also said that they saw students changing from passive to active learners as they added group work and activities in class. They initially thought they could use Learning Catalytics to assess understanding at the end of class, but they now use it throughout class and for group activities, and they see students more engaged and involved. Student feedback indicates it was incredibly useful because it helped them see what they understood. Any misconceptions were addressed immediately in class, and anecdotally, the instructors found that students who attended class did better.

Conclusion

The Biology department at Fairfield University started a course redesign in 1999, but have continued to evaluate results, stay current with educational technology, and make ongoing changes to enhance learning and efficiently use departmental resources. The course was restructured not only to make it more efficient for teaching, but to create a more active environment to engage students.

In 2008, the department adopted Mastering Biology because they believed it was a more robust digital homework program than using their LMS. It still allowed for automated grading for homework, but also provided additional interactive resources for students. In 2015, they moved from using clickers to Learning Catalytics and integrated LC questions throughout class and during activities to monitor student understanding and address topics for which students showed any misconceptions.

The results from their initial course redesign were published in a study for the National Council of Academic Transformation (NCAT). This current study evaluates results from 2010–2015, a period that Mastering Biology was in use and Learning Catalytics was added. Results show that students who earned higher average Mastering homework scores had significantly higher final exam averages. The same was true for LC, and there was a moderately strong correlation between LC scores and the final exam. Instructors observed that students were more engaged during class, and they feel this has helped with overall course performance. The department will continue to evaluate results, and were working on a redesign of their labs.