

Mastering Biology

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 Mastering Biology assignments and had a higher rate of testing out of or scoring 100 percent on personalized Adaptive Follow-Up assignments.

Submitted by

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Course materials

Mastering Biology 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.¹

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 Mastering Biology to address these challenges.

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

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

Albers used Mastering Biology 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 Mastering Biology evolved from an optional resource in prior semesters to required assignments in fall 2014, when the following Mastering Biology homework was assigned:

- **Required weekly Mastering Biology 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 Adaptive Follow-Up (AFU) homework assignments.** Generated based on each student's performance on Mastering Biology 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 Mastering Biology assignments to prompt students to read their textbooks and prepare for lecture exams and lab quizzes. He also used Mastering Biology 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 I 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	Mastering Biology 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.

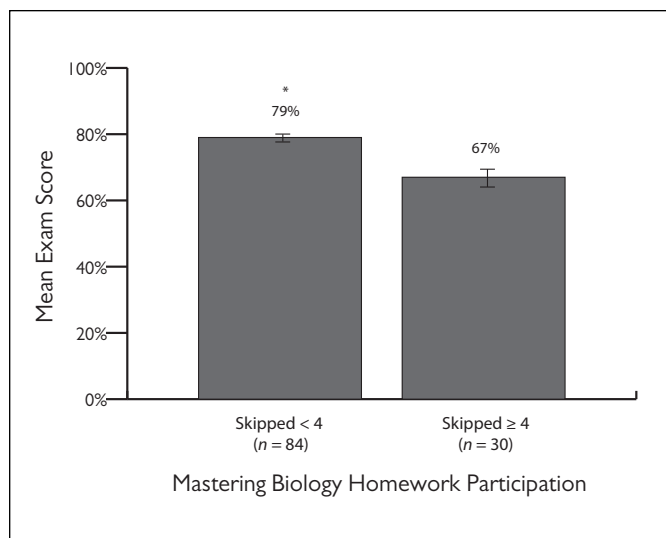


Figure 1. Average Exam Score per Mastering Biology Homework Participation, Fall 2014 (N = 114)

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 Mastering Biology 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 Mastering Biology assignments: Introduction to Mastering, 18 chapter assignments, and 18 Adaptive Follow-Up assignments. For the purposes of this analysis, a skipped homework in Mastering Biology 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 Mastering Biology homework participation by grouping students who skipped fewer than the mean of four skipped Mastering Biology assignments and comparing them to students who skipped four or more. Figure 1 shows that students who skipped fewer Mastering Biology homework assignments (M = 79%; SD = 11%; N = 84) had significantly higher exam averages than did students who skipped more Mastering Biology 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 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 Mastering Biology 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 Adaptive Follow-Up Score Quartile, Fall 2014 (n = 114)

Adaptive Follow-Up assignments are generated based on a student's knowledge as identified by Mastering Biology 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 Mastering Biology 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 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 Mastering Biology.	40%	54%	4%	2%
Mastering Biology 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 Mastering Biology homework, had higher scores on the 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 Mastering Biology assignments and performance in the course.

The Student Experience

Students were surveyed on their homework habits and experiences with Mastering Biology; 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 Mastering Biology and that Mastering Biology 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 Mastering Biology 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 Mastering Biology. Their comments include the following:

About Adaptive Follow-Up

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

About Mastering Biology resources

“Mastering Biology 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 Mastering Biology 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 Mastering Biology assignments. He also observed that because students could test out of 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 Mastering Biology resources to enhance their learning.