

# MasteringBiology

School Name University of Vermont, Burlington, VT  
Course Name Principles of Biology I and II  
Course Format Lecture and lab

**Key Results** Controlling for variables that influence a student's exam score, results show that students who attempted more MasteringBiology assignments showed a significant trend towards higher exam scores.

## Submitted by

Laura Almstead, Lecturer, and Becky Miller, Lecturer, University of Vermont; Statistical Analysis by Shellene Foster, Collin College

## Course materials

*Campbell Biology: Concepts and Connections*, Reece, Taylor, Simon, Dickey, and Hogan

## Background

The University of Vermont, a public research university and one of the oldest universities in the United States, enrolls more than 11,000 students a year. Approximately 420 students take Principles of Biology I each fall, and the same number of students take Principles of Biology II each spring.

Principles of Biology I focuses on cellular biology, and includes topics such as the nature of scientific inquiry, cellular processes, genetics, and microevolution. Principles of Biology II focuses on the function of organisms, and also emphasizes the nature of scientific inquiry. Topics include evolution and speciation, evolutionary relationships (evolutionary trees), plant and animal homeostasis, animal behavior, population ecology, and community ecology.

Both courses are designed for mixed majors (nonbiology majors), and neither have prerequisites. They are separate courses, and need not be taken sequentially. Some majors (e.g., psychology) are required to take both courses. In addition, Principles of Biology I and II are primary introductory courses taken by postbaccalaureate premedical students. Both courses include a lab component.

## Challenges and Goals

Lecturers Laura Almstead and Becky Miller believe that students need to practice applying concepts in order to develop a more thorough and lasting understanding of course content, and to do well in the course. Due to the high enrollment in these courses, timely grading of homework is a significant challenge. Their goal in adopting MasteringBiology was to administer frequent, required, graded homework that would provide students with immediate feedback.

## Implementation

MasteringBiology is a required component of both Principles of Biology I and II. MasteringBiology assignments cover the topics discussed in lecture the previous week. They are posted weekly and due on Sunday evenings. Assignments include a mix of question types, including multiple choice, activities, and questions they wrote and added to MasteringBiology.

## Assessments

56 percent	Exams (four)
25 percent	Lab
14 percent	MasteringBiology homework
5 percent	In-class concept tests (iClicker questions)

## Results and Data

The analysis began with a grouping of students based on their level of MasteringBiology homework participation. For this investigation, a MasteringBiology homework with a score of 0 was considered skipped.

Following are results for the fall 2012 Principles of Biology I:

- A total of 386 out of 389 students completed all four exams.
- Sixty-four percent of the students who completed all exams also attempted all 12 MasteringBiology homework assignments.
- The average number of assignments skipped for students who skipped one or more assignments was 1.74.

The same analysis was conducted for the spring 2013 Principles of Biology II, with similar results:

- A total of 396 students out of 399 completed all four semester exams.
- Sixty-two percent of the students who completed all exams also attempted all 13 MasteringBiology homework assignments.
- The average number of assignments skipped for students who skipped one or more assignments was 2.05.

The homework participation analysis did not account for characteristics, other than attempts at homework assignments, that influence student exam performance. These variables, such as effectiveness of study skills, can confound the results.

To control for these variables, a mixed linear model was used to relate exam scores to number of MasteringBiology assignments skipped. The lme4<sup>1</sup> package in R<sup>2</sup> was used for statistical analysis. The fixed effect was the *number of Mastering Biology assignments skipped*, and random effects were *student* and *exam number* (exams 1–4). For the by-student and by-exam analyses, random slopes were used to determine an effect of the number of MasteringBiology assignments skipped. Residual plots were inspected and did not indicate any departures from homoscedasticity or normality. The *p*-value for the model was obtained using the likelihood test ratio of the model with the number of MasteringBiology assignments skipped versus without.<sup>3</sup>

## Principles of Biology I, fall 2012

Results indicate that the number of MasteringBiology assignments skipped significantly affected exam scores ( $\chi^2(1) = 5.0287$ ,  $p = .0249$ ) as shown in Figure 1. For each assignment skipped, we expect a reduction in average exam grade percent of  $-2.172 \pm 0.776$  (standard errors). Table 1 shows the slope coefficients by exam for the analysis of Principles of Biology I, fall 2012.

Exam Number	Slope Coefficient (percent)
1	-3.536812
2	-2.382590
3	-1.580921
4	-1.185699

Table 1. Slope Coefficients by Exam in the Analysis of Principles of Biology I, Fall 2012 (Exam 1: attempted all,  $n = 353$ ; skipped 1 or more,  $n = 33$ ; Exam 2: attempted all,  $n = 341$ ; skipped 1 or more,  $n = 45$ ; Exam 3: attempted all,  $n = 312$ ; skipped 1 or more,  $n = 74$ ; Exam 4: attempted all,  $n = 332$ ; skipped 1 or more,  $n = 54$ ; Total exam average: attempted all,  $n = 248$ ; skipped 1 or more,  $n = 138$ )

## Principles of Biology II, spring 2013

The results indicate that the number of MasteringBiology assignments skipped significantly affected Exam Grade ( $\chi^2(1) = 5.6749$ ,  $p = .01721$ ) as shown in Figure 2. For each assignment skipped, we expect a reduction in average exam grade percent of  $-2.165 \pm 0.610$  (standard errors). Table 2 shows the slope coefficients by exam for the analysis of Principles of Biology II, spring 2013.

Exam Number	Slope Coefficient (percent)
1	-1.717454
2	-2.101015
3	-2.196533
4	-2.64383

Table 2. Slope Coefficients by Exam in the Analysis of Principles of Biology II, Spring 2013 (Exam 1: attempted all,  $n = 354$ ; skipped 1 or more,  $n = 42$ ; Exam 2: attempted all,  $n = 306$ ; skipped 1 or more,  $n = 90$ ; Exam 3: attempted all,  $n = 328$ ; skipped 1 or more,  $n = 68$ ; Exam 4: attempted all,  $n = 344$ ; skipped 1 or more,  $n = 52$ ; Total exam average: attempted all,  $n = 245$ ; skipped 1 or more,  $n = 151$ )

<sup>1</sup>Douglas Bates, Martin Maechler, and Ben Bolker (2011). lme4: Linear mixed-effects models using Eigen and S4 classes. R package version 0.999375-39, <http://CRAN.R-project.org/package=lme4>.

<sup>2</sup>R Development Core Team (2010). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, <http://www.R-project.org>

<sup>3</sup>Winter, B. (2013). Linear models and linear mixed effects models in R with linguistic application. arXiv:1308.5499, <http://arxiv.org/pdf/1308.5499.pdf>.

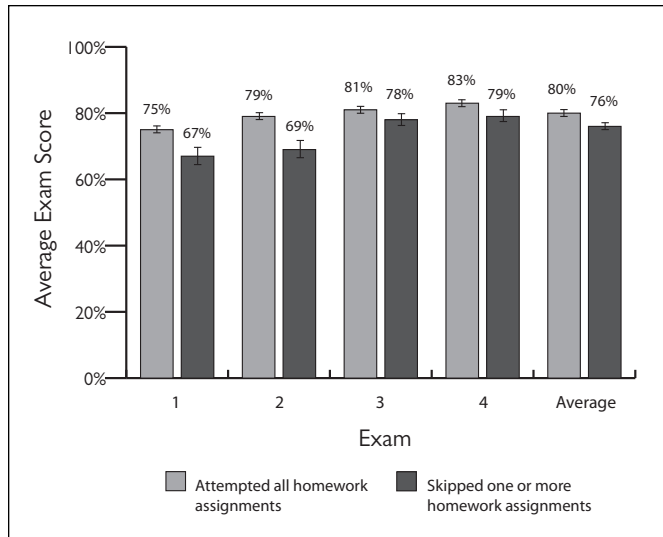


Figure 1. Exam Score Based on MasteringBiology Homework Participation, Principles of Biology I, Fall 2012 (Exam 1: attempted all,  $n = 353$ ; skipped 1 or more,  $n = 33$ ; Exam 2: attempted all,  $n = 341$ ; skipped 1 or more,  $n = 45$ ; Exam 3: attempted all,  $n = 312$ ; skipped 1 or more,  $n = 74$ ; Exam 4: attempted all,  $n = 332$ ; skipped 1 or more,  $n = 54$ ; Total exam average: attempted all,  $n = 248$ ; skipped 1 or more,  $n = 138$ )

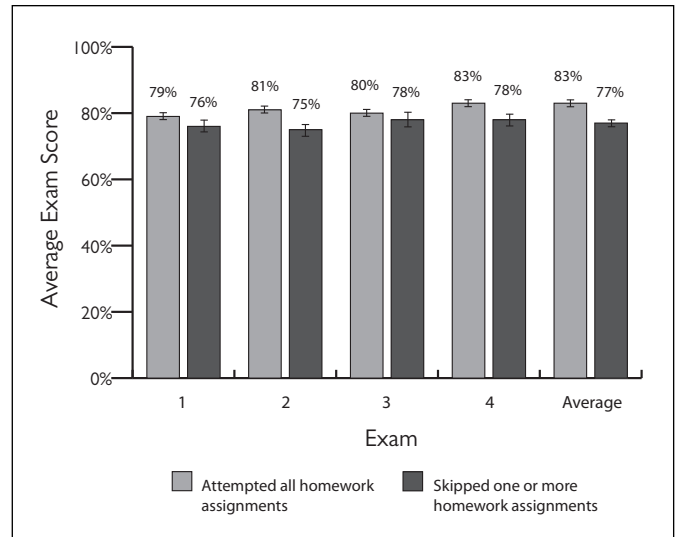


Figure 2. Exam Score Based on MasteringBiology Homework Participation, Principles of Biology II, Spring 2013 (Exam 1: attempted all,  $n = 354$ ; skipped 1 or more,  $n = 42$ ; Exam 2: attempted all,  $n = 306$ ; skipped 1 or more,  $n = 90$ ; Exam 3: attempted all,  $n = 328$ ; skipped 1 or more,  $n = 68$ ; Exam 4: attempted all,  $n = 344$ ; skipped 1 or more,  $n = 52$ ; Total exam average: attempted all,  $n = 245$ ; skipped 1 or more,  $n = 151$ )

For both courses, results indicate that students who attempted all of the MasteringBiology assignments showed a significant trend toward higher exam scores (Figures 1 and 2).

What teaching/learning technique did you find most helpful for understanding the concepts?	Section A	Section B
MasteringBiology homework assignments	21.1%	21.6%
Lecture review questions at the end of each lecture	17.7%	16.8%
Working through problems as a class	17.1%	16.0%
Using iClickers to answer questions during class	13.2%	15.2%
Viewing videos or animations	14.5%	13.6%
Use of figures not found in the course textbook to illustrate concepts during lecture	9.2%	11.2%
Discussing questions posed in class with my classmates	7.2%	5.6%

Table 3. Survey Responses, Principles of Biology I, Fall 2012 (Section A:  $n = 152$ , Section B:  $n = 125$ )

### The Student Experience

In a fall 2012 end-of-semester survey in Principles of Biology I, students were asked what teaching/learning technique they found the most helpful for understanding the concepts. In both sections, students ranked MasteringBiology homework as the highest of available course resources (Table 3).

### Conclusion

MasteringBiology enables Almstead and Miller to assign graded homework, including problem-solving opportunities and immediate feedback, in their large-enrollment courses. From the modest increases in most exam scores after completion of all assignments, they conclude that these assignments help students identify misconceptions prior to exams. By learning which questions and concepts they missed, students receive valuable feedback they can use to focus their study efforts and facilitate targeted learning. In addition, the lecturers use student performance on specific questions to inform their teaching—if a significant number of students miss a particular question, they revisit the concept in class and help clarify the material.