Study 2. MasteringBiology
Introductory Biology, Fall 2008
Monash University, Victoria, Australia

Study design: In 2008 students were assigned weekly MasteringBiology homework consisting of tutorials, multiple-choice questions, and selected readings in preparation for the lecture. A 15-minute open-book quiz was then given in Blackboard® within 36 hours of the lecture. The quiz scores were compared with the year 2007, in which MasteringBiology had not been used in a similar course with the same instructor. Sequence, quiz length, question types and degree of difficulty, and time allowed for a quiz were kept the same in 2008 with MasteringBiology to allow for a fair comparison with 2007 in which MasteringBiology was not used.

The final exams in both years were identical, students repeating the course were not included. Furthermore, entering students did not differ in any substantial way as judged by the university’s entrance rankings (75.0 in 2007 as opposed to 75.0 in 2008). The number of students in the course for each year is on the order of 600.

Results: In all of the 12 weekly quizzes, students who used MasteringBiology in 2008 outperformed those who did not use it in the previous year. The average quiz score gain was 6.4 ± 3.3 (95% confidence interval). Students who used MasteringBiology placed at the 62nd percentile on average in the final exam, which corresponds to an effect size of 0.3.

Summary
The consistency in score gains for students who used MasteringBiology in comparison to those who did not—across all of the quizzes and hence, across many concept domains in biology—is an educationally significant result. (For more details, see G. Rayner, Evaluation and student perception of MasteringBiology as a learning and formative assessment tool in a first year Biology subject, Proceedings of the 2008 Australian Technology Network Assessment Conference.)

Score Gains
Score improvements in the formative and the summative assessment stages represent an important indicator of the effects of an educational intervention. The assignment of Mastering homework shows that students were positively affected by its use in improved quiz and final exam scores.1

Study 1. MasteringChemistry
General Chemistry, Fall 2008
University at Buffalo, State University of New York

Study design: In the years 2004–07 online homework was not used in General Chemistry courses. In fall 2008 MasteringChemistry was introduced for credit for online homework in the course. Historical comparisons were feasible since the course coverage and instructional components were comparable over the years. Fall-semester final exam scores for the years 2004, 2005, 2006 (without MasteringChemistry), and 2008 (with MasteringChemistry) were compared for students who completed the course within a given semester.2 The number of students in the course in a given year ranged from 912 to 1,125.

Results: Students who used MasteringChemistry in fall 2008 showed an improvement of 0.5 in effect size in the final exam in comparison to the years 2004, 2005, and 2007, in which MasteringChemistry was not used. In other words, the average student who used MasteringChemistry in 2008 is at the 69th percentile. Hence, in terms of percentile points, there is a 19-percentile-point improvement in the final exam score, on average, when students were assigned homework in MasteringChemistry.3

More importantly, students at each of the score quartiles (25th, 50th, and 75th percentiles) were positively affected by the use of MasteringChemistry in fall 2008 relative to the previous years. In particular, the probability that a student at the 25th percentile of the class would obtain a final exam score of 50 or above is 81%. That probability is less than 50% in the previous years (42% in 2004, 26% in 2005, and 17% in 2007) in which MasteringChemistry was not used.

1The studies documented are observational in nature as opposed to randomized controlled experiments, and thus attention has been paid to possible confounding factors in drawing conclusions.

2The difficulty levels of the final exams across the years were assumed to be comparable. This is a reasonable assumption through it cannot be rigorously proven. The fall 2006 final exam scores were lower by about 0.6 standard deviations compared with the other non-MasteringChemistry years 2004, 2005, and 2007, and hence are not included in the analysis. According to the instructor, this may be due to an ice storm that hit the campus area on the day of the final exam, which led to its cancellation. This also deprived students from study for about two weeks. Though the ice storm did not occur during the final exam, it may have had a significant effect as reflected in the low final exam scores. The lower scores in 2006 may further support the argument that the final exams had comparable difficulties, since an easier exam to “compensate” for the ice storm would not have resulted in such a decrease.2

3It is difficult to adjust the observed effect size (0.5) for individual teacher influences in 2008 over and above teacher effects for the years 2004, 2006, and 2007. According to some research findings an effect size of about 0.2 is attributable to the teacher in a traditional classroom setting, whereas various other teacher influences such as reinforcement, peer tutoring, class environment, and questioning would result in an average effect size of about 0.4 (Hattie, In search of effects: 0.7 is not a magic number, 1988). If the effect size attributable to MasteringChemistry was assumed to be 0.3, then the total effect size attributable to MasteringChemistry would then be about 0.8, which would place the average student at the 62nd percentile.

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Figure 5. The weekly average quiz score comparison for students who did (orange) and did not (gray) use MasteringBiology in the years 2008 and 2007, respectively.
Figure 1. The final exam score (historical) comparisons of students who did not use MasteringChemistry in the years 2004, 2005, and 2007 to students who used MasteringChemistry in 2008. Students who used MasteringChemistry showed a 0.5 improvement in effect size, which placed the average student at the 69th percentile. The errors shown are the 95% confidence interval of the standard error of the mean. The final exam scores are scaled to a maximum of 100%.

Figure 2. The final exam score (probability) distributions for a student at the 25th percentile. The probability that a student at the 25th percentile of the MasteringChemistry class in 2008 would obtain a score of 50 or above is 81%. That probability is less than 50% in the previous years (42% in 2004, 26% in 2005, and 17% in 2007) in which MasteringChemistry was not used. Graph legend: Green (2004), Blue (2005), Black (2007), Red (2008, with MasteringChemistry).

Figure 3. The final exam score (probability) distributions for a student at the 50th percentile. The probability that a student at the 50th percentile of the MasteringChemistry class in 2008 would obtain a score of 70 or above is 23%. That probability is less than 10% in the previous years (3% in 2004, 2% in 2005, and 2% in 2007) in which MasteringChemistry was not used. Graph legend: Green (2004), Blue (2005), Black (2007), Red (2008, with MasteringChemistry).

Figure 4. The final exam score (probability) distributions for a student at the 75th percentile. The probability that a student at the 75th percentile of the MasteringChemistry class in 2008 would obtain a score of 85 or above is 3%. That probability is three times as less in the previous years (1% in 2004, 0.5% in 2005, and 1% in 2007) in which MasteringChemistry was not used. Graph legend: Green (2004), Blue (2005), Black (2007), Red (2008, with MasteringChemistry).

Summary
The use of MasteringChemistry in the General Chemistry course in fall 2008 resulted in 0.5 effect size score gains in the final exam. Thus, the average student who used MasteringChemistry can be placed at the 69th percentile in relation to the previous years’ score distributions in which MasteringChemistry was not used. Though an observational study, the attribution of score improvements to MasteringChemistry is supported by the observation that the final exam score distributions (mean and variances) remained stable in the years 2004, 2005, and 2007 in which MasteringChemistry was not used. Students at each score point were positively affected by the use of MasteringChemistry. For example, the probability that a student at the 25th percentile of the class would earn a final exam score of 50 or above is 81%. That probability is less than 50% in the previous years in which MasteringChemistry was not used. Thus, students who were less skillful or were at risk of failing the course were positively affected by the use of MasteringChemistry. Similarly, a student at the 75th percentile who has used MasteringChemistry has three times as much chance of scoring above 85 than a student at the same percentile level who did not use MasteringChemistry.