MasteringChemistry

School Name University of North Florida, Jacksonville, FL

Course Name General Chemistry

Course Format Face-to-face

Key Results Students in this study who skipped fewer MasteringChemistry assignments tended to do better on the final exam than students who skipped more assignments, and there was a strong positive correlation ($r = 0.61$) between average MasteringChemistry homework scores and final exam scores.

Submitted by
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Course materials
MasteringChemistry and *Chemistry: The Central Science,* Theodore E. Brown, H. Eugene LeMay, Bruce E. Bursten, Catherine Murphy, Patrick Woodward, Matthew E. Stoltzfus

Setting

The University of North Florida is a four-year public university that was established in 1972 and today serves approximately 16,500 students. Between fall 2008 and fall 2012, first-year retention rates ranged from 81 percent to 84 percent for those starting at the school. Graduation rates for the same period ranged from 46 percent to 49 percent.[1] From 2010 to 2012, at the undergraduate level, 32 percent of the degrees awarded were in areas of strategic importance to the local economy, including degrees in health sciences and STEM.[2]

Associate Professor Michael Lufaso has been teaching General Chemistry I since he started at the school in 2006. He has taught General Chemistry II since 2009.

General Chemistry II is a three-credit course, and the second course in a two-semester sequence taken primarily by biology and chemistry majors. The course covers the chemistry of gases, liquid, solids, thermodynamics, electrochemistry, aqueous equilibria, and reaction rates. The one-credit lab is a separate course, which most students take concurrently with lecture. It is suggested, but not required, that students take the lab as a corequisite.

General Chemistry II is taught only as a face-to-face lecture. Approximately 175 students take the course per semester during the academic year, and an additional 100 students take the course during the summer semester. The majority of students who take the course are required to do so for their program, so successful completion is important. The biology program is limited access, so students must successfully complete this course to be admitted to that major. Other majors that take this course include nursing, nutrition, and premedical. This study includes data from Lufaso's sections only.

Lufaso incorporates the following learning objectives.

- Know the world.
- Demonstrate knowledge of the natural sciences.
- Apply knowledge to real-world situations.
- Recognize the inevitable limits of your own perception and understanding. Think critically.
- Read, analyze, and understand complex texts or quantitative information.
- Solve problems.
- Locate, evaluate, and/or use research sources.
- Formulate and/or apply models to evaluate problems and draw conclusions.

Challenges and Goals

Students who take this course tend to have a diverse set of skills and bring a variety of backgrounds; some have gaps of time between General Chemistry I and II. Since chemistry is a cumulative subject, new material builds upon a series of linked concepts, Lufaso believes that concept repetition and practice is critical for student achievement. Because many students must complete this course to move forward in their program, Lufaso sought a way to both identify areas of weakness and misconceptions and provide resources that would enable students to fill

[1] http://www.unf.edu/acadaffairs/accreditation/Student_Achievement.aspx.

[2] http://www.unf.edu/uploadedFiles/aa/acadaffairs/accreditation/SACS/2015_Fifth-Year_Review/4.1-1e%20President%27s%20Self-Report%202012-13%20%28pp%208-10%29.pdf.

Lufaso's [MasteringChemistry] implementation has changed as new features were added to the program and he became more familiar with its resources.

knowledge gaps and provide needed practice to succeed. He adopted MasteringChemistry in 2007 to address those needs.

As a result, Lufaso engaged in this study to begin to test and measure the relationship between 1) engagement in ongoing repetition and practice to fill knowledge gaps, and 2) performance. To begin to measure the ways his students engaged in this type of prelecture and postlecture practice, Lufaso collected data related to MasteringChemistry assignments that he believed would be helpful for and aligned to the learning outcomes of the course.

Implementation

Since first adopting MasteringChemistry in 2007, Lufaso's implementation has changed as new features were added to the program and he became more familiar with the resources. He believes that the primary roles of homework are to provide an opportunity for students to review and remediate the concepts covered in the lecture and textbook, and to give students a chance to practice and test their understanding in preparation for exams. He also uses the diagnostic feedback to monitor the questions missed most frequently, so he can address them in-depth during class.

During the first few years of MasteringChemistry use, Lufaso only assigned postlecture chapter homework. Table 1 shows the implementation changes through fall 2014, including the addition of prelecture, optional Knewton Adaptive Follow-Up (AFU), and optional practice assignments.

For the fall 2014 semester, MasteringChemistry assignments included the following:

Prerequisite knowledge assignment. The first required assignment of the semester covered concepts from General Chemistry I. An optional Knewton Adaptive Follow-Up assignment was available so students could remediate any missed prerequisite concepts.

Prelecture assignments. These required assignments were designed to encourage reading before lecture. They included a few short questions, usually for extra credit, and generally comprised reading questions. They were not timed, were due before lecture, and multiple attempts were allowed. For multiple choice, the standard deduction applied (100%/[# of answer options – 1]) to discourage students from guessing. All other questions were typically a deduction of 8 percent per incorrect answer.

Prior to lectures, Lufaso reviewed the diagnostics from the completed prelecture assignments in order to better understand what concepts students struggled with and to focus on those during class time. He also used diagnostic information to improve lecture notes and to plan in-class activities that enhanced understanding of challenging concepts. These activities helped students understand misconceptions prior to attempting postlecture chapter assignments.

Postlecture chapter assignments. These required assignments were due one week after chapter content was addressed in lecture. Assignments included tutorial and activity questions, along with other question types. Typically, a tutorial question was followed by an end-of-chapter question. The maximum number of allowed attempts was six, and they were not timed.

Time Period	# of MC Postlecture HW	# of MC Prelecture HW	# of MC Practice Assignments (Optional)	# of MC Knewton Adaptive Follow-Up Assignments
2007–11	~10	0	0	0
2012	10	7	11	0
2013	10	19	11	5
2014	10	~19	~11	9

Table 1. MasteringChemistry Implementation, Fall 2007–Fall 2014

Knewton Adaptive Follow-Up assignments. Optional Adaptive Follow-Up assignments were intended to address knowledge gaps. They were generated by MasteringChemistry based on each student's performance on postlecture chapter homework. Assignments were due two days after the chapter assignment for extra credit. Students who earned a 95 percent or higher on the MasteringChemistry chapter assignment tested out of the optional assignment and automatically earned full extra credit.

Practice assignments. Optional chapter problems were available for additional practice.

Three exams and a comprehensive final were administered. The exam format typically consisted of multiple-choice conceptual questions and problems, multiple-part problems (multiple-choice format), matching, fill-in-the-blank, drawing/sketching/graphing, and short-answer problems.

Exam questions comprised a combination of Pearson test bank and instructor-written questions. Term exams were 75 minutes, and the final exam was 110 minutes. Exam questions were similar to MasteringChemistry homework questions. When providing answer keys after exams, Lufaso noted which questions were similar to specific MasteringChemistry problems.

Assessments

450 points	Term exams (three)
275 points	Final exam
250 points	MasteringChemistry homework
25 points	MasteringChemistry prerequisite knowledge assignment

Results and Data

Fall 2014 data was analyzed to understand the relationship between use of MasteringChemistry and learning and course outcomes. Seventy-one students were enrolled after the official withdrawal period. Seven students (10 percent) neither completed the course, nor officially withdrew.

Of the seven students who did not complete the course, one did not take any of the four exams, and another student stopped after exam 1. Four other students stopped after exam 2. Another student did not take the final exam. Because these students did not complete the final exam, their data were excluded from the following analyses. For purposes of this analysis, a skipped MasteringChemistry homework is one with a score of zero.

Results show a strong positive correlation between MasteringChemistry scores (including all required and optional assignments), and the final exam score with $r = 0.61$ (Figure 1).

Because Lufaso was interested in investigating the relationship between completion of MasteringChemistry assignments and course performance, an analysis was done using exam 1 as a baseline. Students were divided into two groups based on the exam 1 median score of 74: low exam 1 (LE1) for students scoring less than the median and high exam 1 (HE1) for students scoring higher than the median (Table 2).

MasteringChemistry homework participation was calculated based on the number of skipped assignments out of the 38 total required and optional assignments (prerequisite knowledge, prelecture, chapter, and Knewton Adaptive Follow-Up).

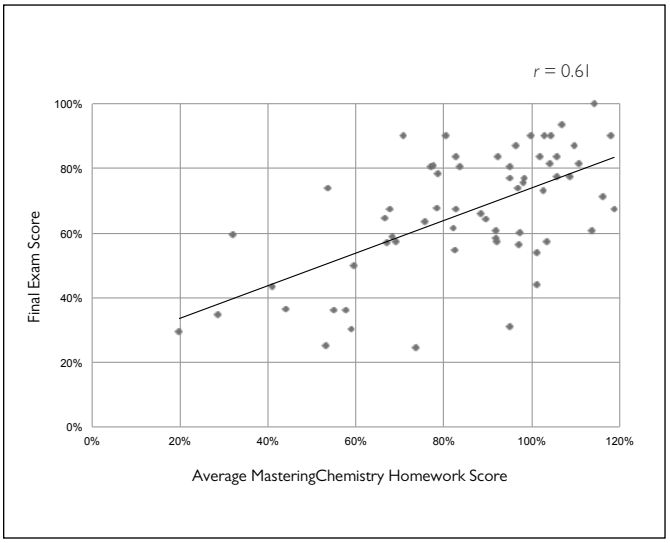

Figure 1. Correlation between Average MasteringChemistry Scores and Average Final Exam Scores, Fall 2014 ($n = 64$)

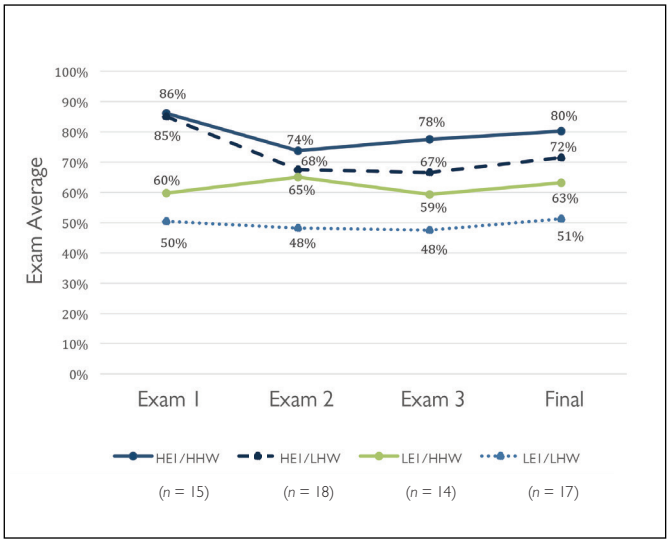

Figure 2. Comparison of Average Exam Scores based on MasteringChemistry Participation, Fall 2014 ($n = 64$)

The average number of skipped homework assignments was 8.5. Students were assigned to groups based on whether they skipped fewer (high homework, HHW) or more (low homework, LHW) than the average of 8.5 skipped.

HE1/HHW	High exam 1/high homework participation
HE1/LHW	High exam 1/low homework participation
LE1/HHW	Low exam 1/high homework participation
LE1/LHW	Low exam 1/low homework participation

Table 2. Exam Performance/Homework Participation Groups

Figure 2 shows the exam averages by homework participation groups. Data indicated the following:

- HE1/HHW and HE1/LHW exam 1 scores were statistically equivalent. HE1/HHW (M = 86%; SD = 8%; *N* = 15) and HE1/LHW (M = 85%; SD = 7%; *N* = 18).
- By the final exam, HE1/HHW scores were 8 percentage points higher than the scores for HE1/LHW, a statistically significant difference ($p < .05$). HE1/HHW (M = 80%; SD = 14%; *N* = 15) and HE1/LHW (M = 72%; SD = 14%; *N* = 18).
- LE1/HHW exam 1 scores were 10 percentage points higher than LE1/LHW scores, a statistically significant difference ($p < .05$). LE1/HHW (M = 60%; SD = 11%; *N* = 14) and LE1/LHW (M = 50%; SD = 15; *N* = 17).
- LE1/HHW final exam scores were 12 percentage points higher than LE1/LHW scores, a statistically significant difference ($p < .05$). LE1/HHW (M = 63%; SD = 17%; *N* = 14) and LE1/LHW (M = 51%; SD = 19%; *N* = 17).
- The difference between HE1/LHW and LE1/HHW was 25 percentage points on exam 1. It decreased to two percentage points on exam 2, and the gap was 9 percentage points on the final exam.

Study findings do not include the unmeasured influence of variables that can impact student performance, such as motivation. However, based on the performance of Lufaso's students, the students in each group who attempted more MasteringChemistry homework performed better on the comprehensive final exam than students in the same group who attempted fewer assignments. In addition, students in the LEI group, who attempted more MasteringChemistry homework, narrowed the gap with those in the HEI group, who attempted less homework, on each subsequent exam. Further research is needed to test what the initial data seems to suggest is a relationship between 1) attempting MasteringChemistry assignments and engaging in optional resources, and 2) course performance.

The Student Experience

Students report that they like MasteringChemistry and the opportunity to do its different types of activities. On the course evaluation, one student wrote, "The MasteringChemistry homework online really did help me improve my work. Making it mandatory for students to do is a good decision. This way they are forced to learn what they wouldn't do on their own leisure time."

Conclusion

Since adopting MasteringChemistry in 2006, Lufaso has continually redesigned his implementation with additional activities and assignments designed to address individual student needs and diverse skills and knowledge levels. "MasteringChemistry has impacted my teaching in a positive way," he says. "It enables me to obtain information about student learning more readily. I use that information to make changes to my lecture, in-class activities, notes, homework assignments, and exams."

By better understanding student performance during the course, he is able to address issues as they arise, and then use the data to make informed decisions for future semesters.

Lufaso recommends that instructors who are starting to use MasteringChemistry take advantage of the educator support to get trained, and use the implementation guide as a resource to plan the course around the instructor's specific issues and goals. He explains that by designing the MasteringChemistry course wisely and following best practices, the program can help instructors achieve the best results. Finally, he advises instructors to not immediately use every available feature, but to start with those that best address course goals. Evidence from Lufaso and his students suggests that thoughtful implementation of MasteringChemistry has helped create a positive course experience for himself and his students.

Implementation and results case studies share actual implementation practices and evaluate possible relationships between program implementation and student performance. The findings are not meant to imply causality or generalizability within or beyond these instances. Rather, they can begin to provide informed considerations for implementation and adaptation decisions in other user contexts. For this case study, mixed-methods designs were applied, and the data collected included qualitative data from interviews, quantitative program usage analytics, and performance data. Open-ended interviews were used to guide data collection.