

## Mastering Chemistry educator study evaluates learning resources at Miami Dade College

### Key Findings

- The group of students who performed above average on the required Mastering homework had a significantly higher final exam score than the students who performed at or below average.
- The group of students who earned more points on optional Adaptive Follow-Up assignments had a significantly higher final exam average than the students who earned fewer points.
- The group of students who scored 51–100% on the optional Chemistry Primer had a higher final exam average than students who scored 0–50% on the Chemistry Primer.
- On an end-of-semester survey, responding students reported that doing the Dynamic Study Modules before class helped them better understand lecture and that Learning Catalytics was a fun way to learn.

### Study Specifics

**School name:** Miami Dade College, Miami, FL  
**Course name:** General Chemistry and Qualitative Analysis II  
**Course format:** Face to face  
**Course materials:** Modified Mastering Chemistry for *Chemistry: The Central Science* by Brown, Lemay, Bursten, Murphy, Woodward, and Stoltzfus

**Timeframe:** Spring 2018  
**Educator:** Jo Nell Aarons Gillings  
**Results reported by:** Betsy Nixon, Results Manager

### Setting

- Type: State college with eight campuses and twenty-one outreach centers located throughout Miami-Dade County
- Enrollment: 92,085 credit students (2014–2015)
- Enrollment increase: Credit students increased 28% since 2000
- Course success rate: 89% for full-time students; 84% for part-time
- Graduation statistics: 45% of full-time, two-year students graduated after three years; another 25% still enrolled in good standing; 19% left with transferable credits
- Ethnicity: 71% Hispanic; 17% Black non-Hispanic; 12% Other

### About the Course

Instructor Jo Nell Aarons Gillings teaches Introduction to Chemistry, Chemistry for Health Science, and General Chemistry I and II. She is in her second year of teaching at Miami Dade College (MDC). Prior to that, she taught as an adjunct and spent several years teaching in the public school system in Florida.

General Chemistry and Qualitative Analysis II (Gen Chem II) is the final course of a two-semester general chemistry sequence. It is a three-credit lecture course with a separate required lab taken concurrently. Students who generally take this course as a prerequisite to their program include Pharmacy, Pre-med, Occupational Therapy, Physician Assistants, Pre-Dental, and some Engineering majors. Topics covered include oxidation-reduction, chemical and acid-base equilibrium, kinetics, electrochemistry, coordination chemistry, thermodynamics, nuclear chemistry, an introduction to organic chemistry, and highlights of descriptive chemistry of metals. The general education outcomes addressed in the course include:

- Use quantitative analytical skills to evaluate and process numerical data
- Solve problems using critical and creative thinking and scientific reasoning
- Formulate strategies to locate, evaluate, and apply information
- Describe how natural systems function and recognize the impact of humans on the environment

## Challenges and Goals

Aarons Gillings says that general chemistry is a difficult course for students, and it takes a lot of hard work on their part to succeed. She finds that many students don't fully understand what they need to do and when to do it to be successful in the course, because many confuse studying with learning. She feels she must help students understand the importance of the class to their goals and help them develop study skills to enhance success in the course. To achieve these goals, she has tried to create structure in her course through the activities and homework. On her syllabus, she tells students the following:

- To prepare for an exam, you will need to study three to four hours for every hour of lecture, totaling about nine hours each week.
- Each chapter in chemistry builds on the knowledge of the previous chapters, so it's important to understand and retain the content and not get behind in the beginning.
- The course is not a "listen and learn" type of course. Most of the learning will happen later, while reviewing notes, reading the textbook, and most importantly, while solving problems.
- You will need to utilize mathematical skills.
- The textbook is a very important tool. Stay ahead of the material (in the worst case, stay on top of it), and lectures will make more sense to you this way.
- Learning chemistry is a collaborative effort, so interact with your instructor and classmates as often as possible.
- During a lecture, if you have a question, please bring it up (there are no dumb questions; I guarantee there will be several other people with the same question who are too afraid to ask). However, please be respectful and raise your hand, rather than blurting out the question.

In addition, she also shares the following guidelines for studying chemistry on her syllabus:

- Work together in small groups outside of class. This will help you tremendously.
- During my office hours, I am willing to work with you one-on-one, so please feel free to come with any questions you have. It will be more beneficial to you if are prepared and come with questions rather than expect me to explain everything to you. If my office hours do not work for you, email me for an appointment.
- If you have done all the problems at the end of the chapter in your book and feel the need for more practice, come see me, and I will be glad to provide you with extra worksheets.
- Read the chapter and review the PowerPoint presentation before coming to class.
- Ask questions during the lecture if you don't understand.
- Practice problems after each section.

To provide resources for practice and learning, Aarons Gillings piloted Mastering™ Chemistry (MC) in her Summer 2017 session and began using it as part of the course in Fall 2017.

## Implementation

The course included the following components in Spring 2018:

**Exams:** Students were given four paper-and-pencil exams, each with a mix of multiple-choice questions and problems. If it benefitted the student, the final exam score could replace the lowest exam grade.

**Final exam:** A paper-and-pencil cumulative final exam was administered in class. The exam was comprised of 30% multiple-choice questions and 70% problems.

### Mastering Chemistry:

- **Dynamic Study Modules (DSMs)** were assigned as required pre-lecture homework. With the DSMs, students answer questions until they feel confident with the answers; if they don't understand the concept, they get an immediate explanation. There were approximately two DSM assignments per chapter, and the goal was for students to understand what they needed to focus on and to work on the concepts until they understood them. For Fall 2017, DSMs were optional, but Aaron Gillings realized how helpful they were to students and decided to require them in Spring 2018.
- **Chapter homework** was required and included chapter problems and tutorials with hints. There was approximately one post-lecture assignment per chapter. Students were able to use hints with no deductions, and the assignments were not timed. Five attempts were available, but students lost 5% for each wrong answer.
- **Adaptive Follow-Up assignments (AFUs)** followed the chapter homework and were optional. If students earned 95% or higher on the chapter assignment, they tested out of AFUs. All students who tested out of or completed the AFUs within 24 hours of the chapter homework received extra credit.
- **Learning Catalytics (LC)** questions were used for in-class activities one day per week. This became a weekly activity after Aaron Gillings tried LC to overwhelmingly positive student response. Students completed LC questions both individually and with classmates, and LC questions were answered using a cell phone, tablet, or laptop. Students could not make up the LC questions if they were absent from class. Responses were recorded in Mastering, and Aaron Gillings was able to address any misconceptions at that point in time.
- **Chemistry Primer** is a tutorial series designed to help students remediate if they struggle with the math and chemistry skills needed to succeed in their first college chemistry course. The primer was required for students to complete in Gen Chem I, but available and recommended for remediation in Gen Chem II as well.

## Assessments

- 45% Exams (4; lowest exam dropped)
- 30% Final exam (cumulative)
- 25% Mastering Chemistry homework

## Results and Data

Three Gen Chem II sections were taught by Aaron Gillings in Spring 2018 with a total of 68 students, and three were taught in Fall 2017 with a total of 71. Because of weather-related issues in Fall 2017 that caused the cancellation of classes and one missed exam, the Spring 2018 results are the only ones reported in this study. The Spring 2018 results were combined since the sections were taught in an identical manner. Students who did not take the final exam were removed from the analysis, which included five students.

Students were placed into two groups based on the average MC score of 83%; the average score included both required Mastering assignments (chapter homework and DSMs). Students who scored at or above the average had a significantly ( $p < .05$ ) higher final exam average compared to the group of students who earned below average on MC homework (figure 1).

### Average final exam scores based on Mastering Chemistry quiz score and number of AFU extra credit points earned

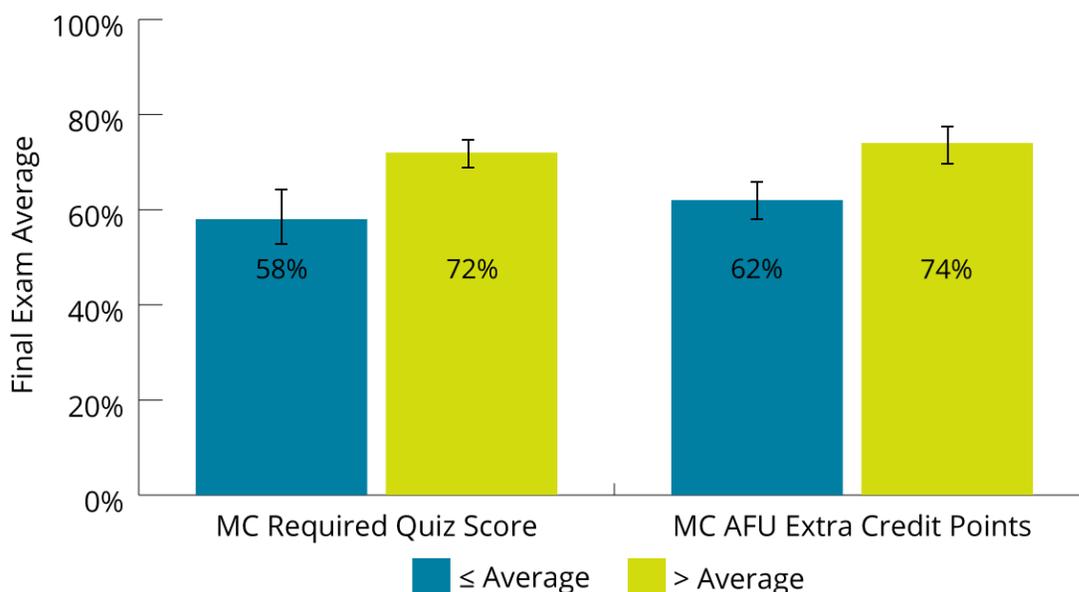


Figure 1. MC  $\leq 83\%$  ( $n=23$ ); MC  $> 83\%$  ( $n=40$ ); AFU Extra Credit Points  $\leq 6$  ( $n=35$ ); AFU Extra Credit Points  $> 6$  ( $n=28$ ); Spring 2018

AFU assignments were optional. The same analysis was done looking at participation on AFU assignments. The average number of extra credit points earned for AFUs was six. Students who earned more AFU points than average had a significantly higher final exam average (74%) than the group of students who earned at or below average AFU points (62% final exam average). Since AFUs were optional, these results may be impacted by other factors that are difficult to measure, such as student motivation and study skills.

Aarons Gillings required the Chemistry Primer in Gen Chem I. She estimates that approximately 80% of the students in her Spring 2018 Gen Chem II course had her Gen Chem I course in Fall 2017 and would have completed the Primer. However, for Gen Chem II, it was optional and available for students to use, and a majority of students worked on the primer earning a score higher than 50% (table 1). While eight students had a score of zero on the Primer, this may be an indication that they felt they did not need any further remediation, since three of those students earned over 80% on the final exam.

Chemistry Primer score	Final exam average	n-count
0–50%	57%	15
51–100%	70%	48

Table 1. Final Exam Average Based on MC Primer Performance, Spring 2018

## The Student Experience

*“What I liked about Mastering was the relevance it had toward the material we experienced on the exams and in class.”*

—Student, Miami Dade College

At the end of the Spring 2018 semester, a survey was administered, and 28% of students (19 of 68) participated. While a majority did not participate, Aarons Gillings reports she has received positive feedback from students about Mastering. In particular, students state they love the Dynamic Study Modules and have requested using Learning Catalytics in class more often to do activities. A majority of those responding answered strongly agree or agree to the statements about Mastering in table 2.

Survey statement	Percent answering strongly agree/ agree
Doing the Mastering assignments helped me understand what I know and what I need to study.	100%
Working on Learning Catalytics questions in class was a fun way to learn.	100%
I would recommend Mastering to another student as a good resource for the course.	89%
Doing the Dynamic Study Modules before class helped me understand more during lecture.	84%

Table 2. Percent of Students Answering Strongly Agree or Agree on Spring 2018 Student Survey (n=19)

When asked what they liked about Mastering, respondents gave the following answers:

- *“What I liked about Mastering was the relevance it had toward the material we experienced on the exams and in class.”*
- *“I liked the feedback on problems.”*
- *“It was very interactive, very clear, and easy to understand.”*
- *“I like that it takes you step-by-step through how to solve a problem.”*
- *“It tells you hints throughout & the study module helped me work out problems when I didn’t know.”*

## Conclusion

For Fall 2018, Aarons Gillings is planning to make some additional changes to her Mastering implementation. She is planning to modify the homework to create smaller, more frequent assignments and is considering adding a weekly quiz to help students better assess their understanding. From her experience, she recommends the following for other instructors starting out with Mastering:

- If you plan to assign only one type of homework, start with the Dynamic Study Modules. She has found that students loved them, and she believes they should be required because they help students understand what they don’t know and provide information about the concept as they are working through the questions.
- Try Learning Catalytics during a class session and get feedback from students. Once Aarons Gillings started using it, she found students asked her to use LC more frequently.

Aarons Gillings finds that students often struggle with Gen Chem II. She adopted Mastering Chemistry in 2017 to use for homework and to provide diverse resources that would help students with their learning. She has used different resources from MC as both for-credit assignments and optional remediation. Student feedback about the experience using Mastering has been positive, and course results from Spring 2018 show that, in general, students who did better on the MC homework and used the optional resources did better on the final exam.