

Principles of Chemistry I (CHEM 1211) Course Redesign at Valdosta State University

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It is critical that students taking chemistry courses acquire basic skills in the introductory course. Chemistry faculty at Valdosta State University realized that students who took the Principles of Chemistry I course were not mastering the skills related to chemical reactions concepts. To address this issue, course innovations consisting of a practice assignment and review session were implemented. Findings suggest that these activities were effective in reducing the percentage of students who failed to meet course learning outcomes related to chemical reactions topics. Thus, instructors are encouraged to use similar strategies in other topics and chemistry courses.

STATEMENT OF THE PROBLEM

The Principles of Chemistry I (CHEM1211) lecture course taught at Valdosta State University covers material expected by the American Chemical Society for an introductory chemistry course for students in this major (Holme & Murphy, 2012). At our institution, the majority of students enrolled in the course are Biology students, followed by Chemistry, and other majors. One of the important threshold concepts in the CHEM 1211 course is the understanding of chemical reactions (Nakhleh, 1992; Talanquer, 2015). The interpretation of chemical reactions is a foundational learning outcome needed for successful progression in the chemistry course sequence. Learning objectives include skills such as classifying reaction types and predicting the products when given the reagents. These learning objectives are communicated to students in the CHEM 1211 course syllabus and lectures, and to make the objectives more transparent, they could be included in the description of specific assignments (Winkelmess et al., 2016). The topic on chemical reactions is identified as one of the highest 'fails to meet expectations' based on our course assessment data. Given the impact that knowledge and student confidence in chemical reactions can have on other areas of the course, from stoichiometry to thermochemistry, a just-in-time review is included in the class during the last two weeks of the course and before the final exam. A practice assignment with several types of questions on chemical reactions is made available for all students. Along with this interactive activity for the lecture course, the laboratory manual for the Principles of Chemistry I Laboratory (CHEM 1211L) course was revised to include more practice questions on classification of chemical reactions. All students in the lecture course are required to take the laboratory course CHEM 1211L and submit hand-written laboratory reports to practice topics covered in lecture.

METHODS

Implementation of an assignment with a review session near the end of the course is described. The activity developed by a group of faculty who regularly teach CHEM 1211 includes practice questions for identifying types of reactions and predicting chemical products. Two lecture sections of CHEM 1211 were offered in Fall 2019; one included the review session, labeled here as the modified section, and the other section remained unmodified. Concepts in chemical reactions are covered during the first half of the course and given its importance in the course, a review was offered during one of the class sessions for the modified course. The class met for an activity in which students compared their answers and had the opportunity to ask questions to the instructor and the supplemental instructor. The instructor addressed questions during the session and later released the answers to

the assignment in the learning management system. A revised laboratory manual with new practice questions on identifying types of reactions and writing chemical reactions was available for all CHEM 1211L sections including students in modified and unmodified lecture sections. Data from the final exam analyzed by topic for each section was compared to data collected from the previous academic year with the Nomenclature topic used as reference. The overall assessment included 20 questions, the Nomenclature and the Reactions topics included three questions each. The scores used for assessment were 75% and higher as Exceeds Expectations (Exceeds), 50-74% as Meets Expectations (Meets), and below 50% as Fails to Meet Expectations (Fails).

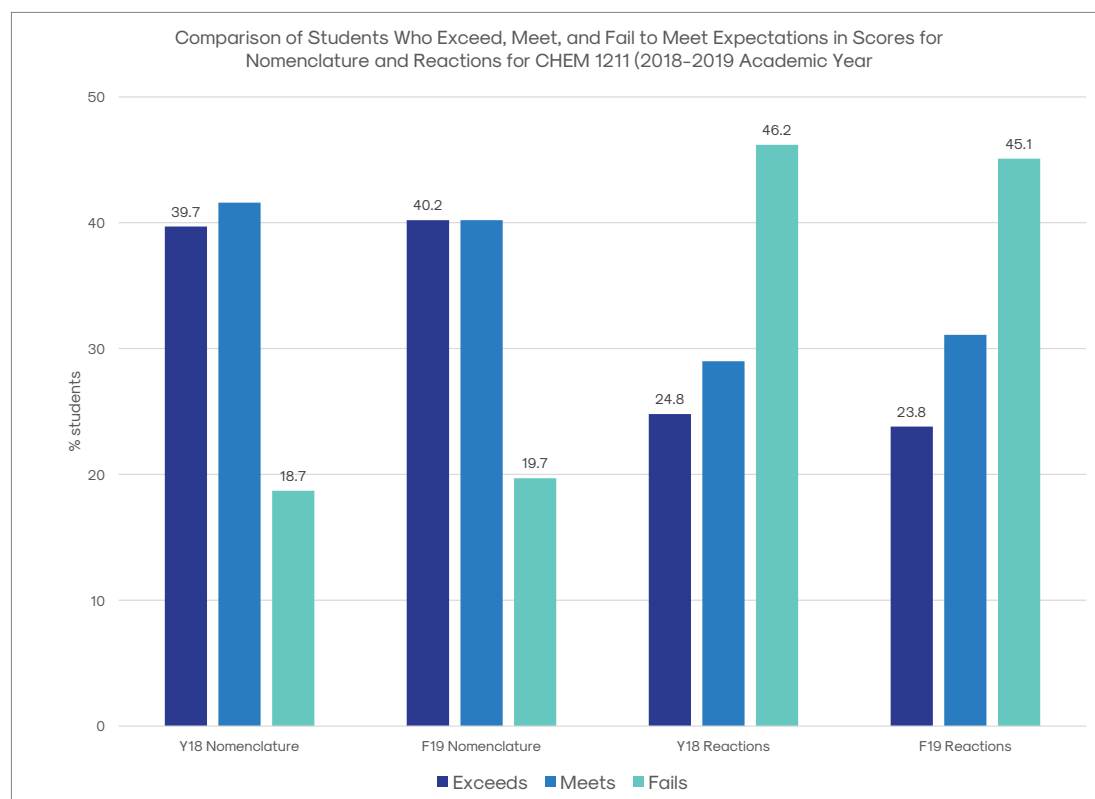
OUTCOMES

Assessment data from academic year 2018-2019 (n=262) and combined sections Fall 2019 (n=122) for the CHEM 1211 lecture course are shown in Figure 1. Data shows 39.7% Exceeds, 41.6% Meets, and 18.7% Fails for the Nomenclature topic for data collected during the 2018-2019 academic year (fall, spring, and summer). Data shows 24.8% Exceeds, 29.0% Meets, and 46.2% Fails for the Reactions topic for data collected during the same academic year. Decreasing the large number of students in 'fails to meet expectations' scores for the topic of Reactions was the goal of the Chemistry Department faculty, which focused efforts on improving the teaching and learning of the related topics. Assessment data from combined Fall 2019 sections shows 40.2% Exceeds, 40.2% Meets, and 19.7% Fails for the Nomenclature topic. These numbers are similar to those of the previous academic year, as is the data from combined Fall 2019 sections for Reactions with 23.8% Exceeds, 31.1% Meets, and 45.1% Fails. No other data was collected for the 2019-2020 academic year (for Spring 2020 or Summer 2020) as courses moved online due to the COVID pandemic.

Figure 1

Comparison of Students Who Exceed, Meet, and Fail to Meet Expectations in Scores for Nomenclature and Reactions for CHEM 1211 (2018-2019) Academic Year

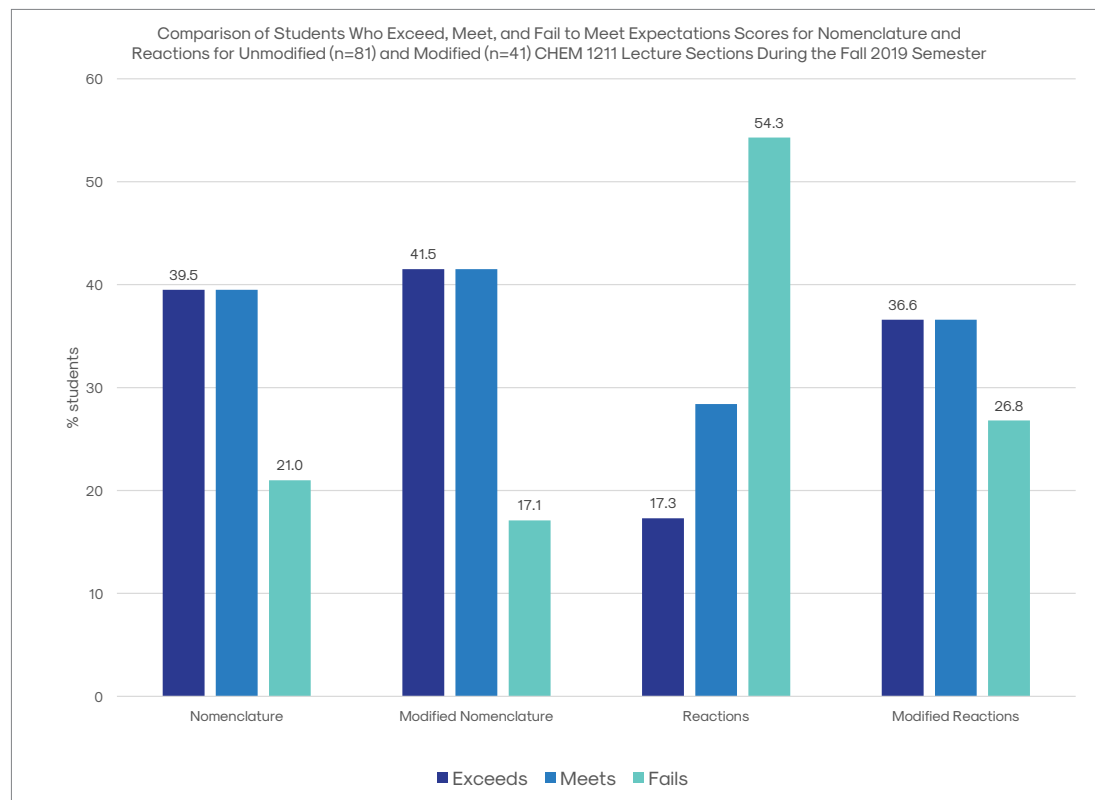
Separating the data for the two sections in Fall 2019 semester, we observed the results shown in Figure 2. There are no significant differences in the Nomenclature topic between the two Fall 2019 CHEM 1211 lecture sections. In contrast, there is a significant improvement in the Reactions topic for the modified section. The unmodified section showed 17.3% Exceeds, 28.4% Meets, and 54.3% Fails while the modified section the scores were 36.6% Exceeds,



36.6% Meets, and 26.8% Fails. The data for the unmodified section is similar to that of the 2018-2019 academic year but for the modified section, the data for Reactions has a similar distribution to that of Nomenclature topic and the percent of failing scores was significantly lower.

Figure 2

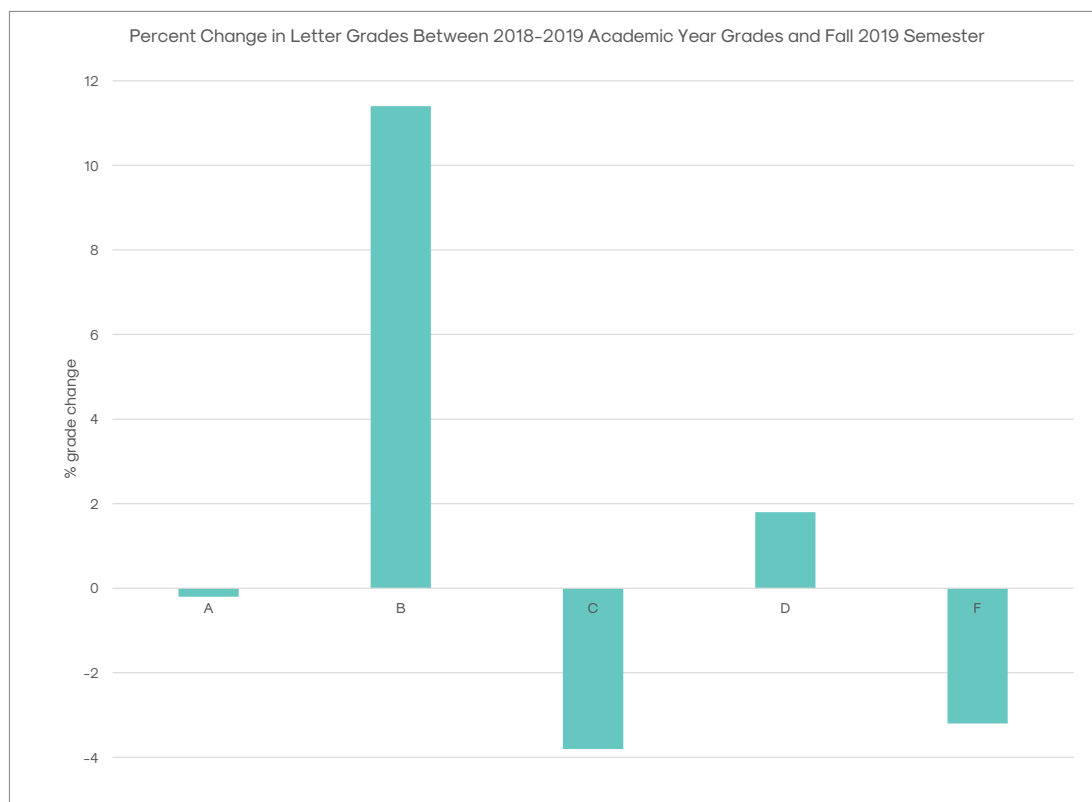
Comparison of Students Who Exceed, Meet, and Fail to Meet Expectations Scores for Nomenclature and Reactions for Unmodified (n=81) and Modified (n=41) CHEM 1211 Lecture Sections During the Fall 2019 Semester



Overall assessment data also showed an improvement between the modified and the unmodified section. The unmodified section had a 28.4% Fails (similar to 29.0% for the 2018-2019 academic year) and the modified section had a 19.5% Fails, a decrease of 8.9%. Overall course success as measured by letter grades showed changes from 2018-2019 to combined Fall 2019 data. The percentage of students with F grades decreased by -3.2%, the percentage of students with D grades increased by +1.8%, the percentage of students with C grades decreased by -3.8%, the percentage of students with B grades increased by +11.4%, and the percentage of students with A grades decreased by -0.4%. The largest change was the increase in B grades which might be significant and overall, a positive signal of student success in the course due to higher exam grades.

Figure 3

Percent Change in Letter Grades Between 2018–2019 Academic Year Grades and Fall 2019 Semester



PLANS FOR CONTINUATION AND EXPANSION

Transparency on assessment and learning are important to center students on the skills needed to succeed in the course. The just-in-time assignments and reviews can emphasize essential skills and threshold concepts in the learning of chemistry topics. Mastery of the skills addressed in the chemical reactions area are expected to impact overall student learning and student confidence in chemistry courses. A group of faculty teaching CHEM 1211 participated in the development of the exercise and are using it in their courses.

It is suggested for faculty teaching lecture courses to implement this and other targeted activities. For instance, at our institution, another area to focus on for this course is Molecular Structure. Also, a detailed analysis of data from the following course, Principles of Chemistry II (CHEM 1212), could identify areas to develop new activities designed to increase student practice of essential skills. It would also be critical to allow enough time during class for students to interact with classmates and instructors to clarify questions about the topics.

LESSONS LEARNED AND POTENTIAL IMPLICATIONS

Given the large amount of material covered in the course, opportunities for review are important in order to revisit and consolidate knowledge. The interaction with classmates and instructors also provides opportunities to clarify misconceptions and plenty of practice to increase student confidence on essential skills for the course. A focused practice assignment, with a just-in-time review that was held in class, lowered the percent of students' scores that failed to meet expectations in the overall assessment by 8.9% when compared to an unmodified section. Findings suggest that these activities were effective in reducing the percentage of students who failed to meet course learning outcomes related to chemical reactions topics. These strategies could be implemented on other topics and courses.

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