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Everyday Chemical Reactions: A Writing Assignment to Promote Synthesis of Concepts and Relevance in Chemistry

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Writing has long been promoted as one of the most important skills for members of the chemical profession or indeed, almost any profession. An effusive description of the importance of writing skills in the chemical profession appeared in this *Journal* in 1943 (1). Readers interested in other writing assignments developed for chemistry courses should refer to the annotated bibliography published in this *Journal* by Shires in 1991 (2).

This writing assignment allows students to select reactions relevant to their lives outside the chemistry classroom ("everyday" reactions) as topics for a critical analysis paper. The reaction must be classified by reaction type, and the structures of the starting materials must be analyzed in order to explain their reactivity. Student response to this assignment has been favorable.

Course Description

The course for which this writing assignment was developed is a one-semester survey course in organic chemistry offered during fall, spring, and summer semesters at Michigan State University. Students from a wide variety of majors including agriculture, nutrition, and packaging are required to complete this course. General chemistry is a prerequisite, although many students separate these courses by several years. Many students enter this course with a set of negative conceptions about chemistry and its relevance.

The writing assignment developed for the organic survey course is used in lieu of a comprehensive final examination and requires a great deal of concept synthesis and application. Replacement of the final examination with a writing assignment was done to promote the application of chemical concepts learned in the course to unfamiliar situations and reduce the use of memorization and regurgitation of facts. The synthesis required by the assignment was intended to demonstrate the interconnected nature of chemical concepts and use of chemistry as a way of looking at the world. This assignment has since been applied at the University of Memphis to replace the last in-class examination prior to the final examination for second-semester organic chemistry.

Assignment Description

The everyday-reaction writing assignment requires students to select an everyday organic reaction. "Everyday" in this context refers to reactions that students come into contact with during their lives outside the chemistry classroom. Some substitution was allowed if students wished to select a reaction important to their major. It was hoped that student-selected everyday reactions would emphasize the relevance and im-

portance of chemistry while being more interesting to the students than an assigned topic. Students were provided the following written instructions about writing their papers.

- Select an **organic** reaction that impacts you in daily life or has application in your major—if you are interested in a complex process such as fermentation or respiration you will need to include not only the net reaction, but will need a specific conversion of one intermediate to the next. Seek help if necessary.
- Classify the reaction as belonging to one of the classes from the categorization exercises (other categories may apply as well, such as polymerization or hydrolysis, and these may be included as extras).
- Analyze the structures of the starting materials to indicate why they are capable of undergoing this type of reaction.
- Type a 1–2-page (double-spaced) paper that includes the following:

A brief introduction to the reaction (why did you choose it, how does it impact you?)

A representation of the chemical reaction—either 2-dimensional structures from ChemDraw may be copied and pasted into a Microsoft Word document or you may **very neatly** add this by hand.

Identification of the reaction type (acid–base, nucleophile–electrophile, oxidation–reduction, or free radical) with explanation of why you classified the reaction that way.

An analysis of the structure of the starting materials indicating why they react this way—consider suggesting other chemicals that might also be suitable for this reaction.

A wide variety of topics derived from student experiences at the beauty salon, in the kitchen, and on the drive to school have been used in this writing assignment. Several example topics are given in the following list.

Application of Acrylic Nail Overlays
Chemistry of Permanent Waves
The Function of Catalytic Converters
Smog Production
Fruit Browning
Prevention of Fruit Browning by Lemon Juice

Grading Criteria

The following set of grading criteria was distributed to students with the assignment description above.

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Key Elements

Provides a detailed (and correct) explanation of the reaction type.
Explains *why* the reaction is classified that way.
Correctly identifies structural characteristics that confer this reactivity.
Explains *why* these structural characteristics confer this reactivity.

Secondary Elements

Gives an introduction indicating the everyday importance of reaction.
Reaction is organic.
Focuses on a single reaction rather than a net reaction.
Includes correct representation of the reaction.
Reads clearly (minor errors OK if they do not distract from content).

Characteristics of a 4.0 Paper

Contains all key and secondary elements.

Characteristics of a 3.5 Paper

Key and secondary elements present, minor detail lacking in explanation of one element.

Characteristics of a 3.0 Paper

Missing secondary element AND/OR
Intermediate detail lacking in explanation of one key element, but analysis still correct.

Characteristics of a 2.5 Paper

Several secondary elements (2–3) not satisfactory OR
Minor errors in a key element.

Characteristics of a 2.0 Paper

Several secondary elements (2–3) not satisfactory with minor detail lacking in a key element AND
Significant error in a key element.

Characteristics of a 1.5 Paper

A key element missing OR
Most (4–5) secondary elements not satisfied OR
Errors in more than one key element.

Characteristics of a 1.0 Paper

A key element missing AND
Most (4–5) secondary elements not satisfied OR
Two missing key elements.

Keys to Improve Student Learning

This assignment has been used in three consecutive semesters (fall, spring and summer). During the first two semesters, the final draft of the paper was submitted to the instructor at the end of the semester. The instructor found that the majority of papers had a significant lack of scientific analysis, although introductions on the relevance and setting of the reaction were usually reasonably good. Some papers even failed to discuss organic reactions; others discussed chemicals or a class of chemicals, rather than a chemical reaction. The few assignments that had strong analysis and good use of concepts from the course were from students who had made repeated visits to office hours to seek help understanding the new reactions.

The shortcomings noted in the first two iterations of this writing assignment were addressed by the use of incremental

deadlines, with feedback from the instructor before the next deadline. During the five-week summer session the deadlines were several days apart (for a class meeting daily); deadlines separated by a week would be more appropriate for a class meeting two or three times per week during the regular semester. The quality of the worst of the final papers was considerably better, although the first draft of each increment was not. For example, many students still initially selected net reactions (such as photosynthesis or glycolysis) but were directed to select a step within the process before completing their papers. These students were much better able to categorize their reaction and analyze the reactivity of the starting materials than were students in prior semesters who wrote their entire paper on a net reaction. A much higher percentage of students discussed their reactions with instructors, and most of this added discussion occurred after they received feedback on an increment. Some of this added discussion may be attributed to the smaller class sizes in summer courses, although a difference in the amount of help sought by students on other assignments relative to regular semesters was not evident.

The average grade earned by the class during semesters with and without incremental feedback showed little difference—87% and 80%, respectively. Likewise, the highest grades earned on the assignment were essentially the same with (100%) and without (96%) incremental feedback. The significant change in grades was at the low end of the grading scale. The low grade on the assignment was 65% when incremental feedback was provided but only 10% when incremental feedback was not used. Note that percentages given for assignments with incremental feedback represent the grade on the revised full paper and do not include scores on the initial increments.

Comparison of the class average scores on the assignment increments shows that students need the most feedback on the structural analysis section (average score was 50% on this increment relative to 75–85% on other increments). This result is not surprising, owing to the higher-order thinking involved.

Student Response

Two specific questions were asked of the most recent group of students during the course evaluation. Feedback was requested on what students had learned the most and least from during the course. The following responses are representative.

Having no tests (papers instead) is a much better learning experience.

I think what has helped me to understand organic chem [sic] more is by doing the final paper and the group project. It is a good and fun way of learning.

Tests force students to learn a whole bunch of information and then afterwards, they quickly forget it. The way this course was, students learned constantly and applied what they learned frequently, which helped us retain information better.

Discussion

The described writing assignment provides students with much-needed coaching in using chemical concepts to analyze

unfamiliar chemical reactions. The relationship between chemical structure and reactivity is strongly emphasized in this assignment. Student performance in analysis of structural features that determine reactivity has considerably improved with the addition of incremental deadlines.

This assignment gives students an opportunity to apply chemical concepts to a phenomenon that they have directly observed and thus discover for themselves that chemistry is a relevant subject to study. Response to this assignment has been positive, as evidenced by students' comments on course evaluations and by personal comments to the instructor.

Writing assignments such as this one have benefits and disadvantages when considered from the instructor's point of view. The biggest disadvantage lies in assigning fair grades in a reasonable period of time in high-enrollment settings. Two specific advantages come to mind that offset this sig-

nificant disadvantage. One of these is in seeing increased student interest in at least one aspect of chemistry. Another is that students' use of chemical concepts is better displayed in this assignment than on an examination.

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2. Shires, N. P. *J. Chem. Educ.* **1991**, *68*, 494–495.