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ARTICLE · JANUARY 2009

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Incorporating Primary Literature Summary Projects into a First-Year Chemistry Curriculum

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Improving students' research and writing skills in chemistry curricula has attracted increasing attention in the past two decades *(1–5)*. While writing exercises and reading the primary literature are commonly assigned in upper-level courses *(6–11)*, these tasks are much less commonly part of introductory courses *(2, 12)*, except in nonmajors' courses *(13, 14)*. An important factor limiting inclusion of these assignments in introductory courses is the perceived increase of the workload for students and instructors, particularly in large classes. In addition to large class sizes, other constraints hamper introducing students to the primary literature earlier, including time restrictions of content-rich curricula, and pedagogical issues involved in reading and analyzing scientific literature.

Many students are not exposed to primary literature until the final two years of their undergraduate education, yet the peer-reviewed literature represents the foundations of scientific communication. Reading and writing scientific literature are key skills students of scientific disciplines need to master. Getting students interested in chemistry, and science in general, by engaging them in reading this literature at an introductory stage of their education was the primary goal of the assignment we present here. Working on this assignment, students see that the diverse topics they learn about in first-year chemistry are central to the science occurring in research laboratories; they discover how much of science is interconnected in today's collaborative, multi- and interdisciplinary research; and students witness how fundamental and applied chemical research works to improve our global society.

As educators, we are responsible for teaching students material that is often viewed as necessary to "pass the exam" or to prepare students for subsequent courses. Indeed, we tend to focus almost exclusively on course content material and neglect the development of other essential skills such as reading, writing, and critical thinking *(15, 16)*. The assignment described here attempts to address this issue, while at the same time showing that a well-designed assignment does not need to be a time burden either to students or instructors, allowing it to be implemented in large classes. The purpose of the assignment is twofold: (i) to introduce students at an early stage of their postsecondary education to the primary scientific literature, including the ability to search and access both printed and electronic resources and (ii) to engage students in contemplating the theory covered in lectures within a broader context through the lens of a topic applied in an interesting area of real science.

Methodology

Students are required to submit two summaries of current primary literature as part of their overall assessment during the final semester of a two-semester first-year chemistry course. The students are given a handout describing the assignment and assessment (see the online material). Expectations are further discussed in class, and a session with the campus librarian introduces the research tools available for locating and accessing relevant articles.

The handout provides a context for the assignment, in addition to details, example topics, learning outcomes, and assessment criteria. It contains a brief rationale, including introducing the concept of the peer-review process and how scientific experimentation is presented to colleagues and the scientific

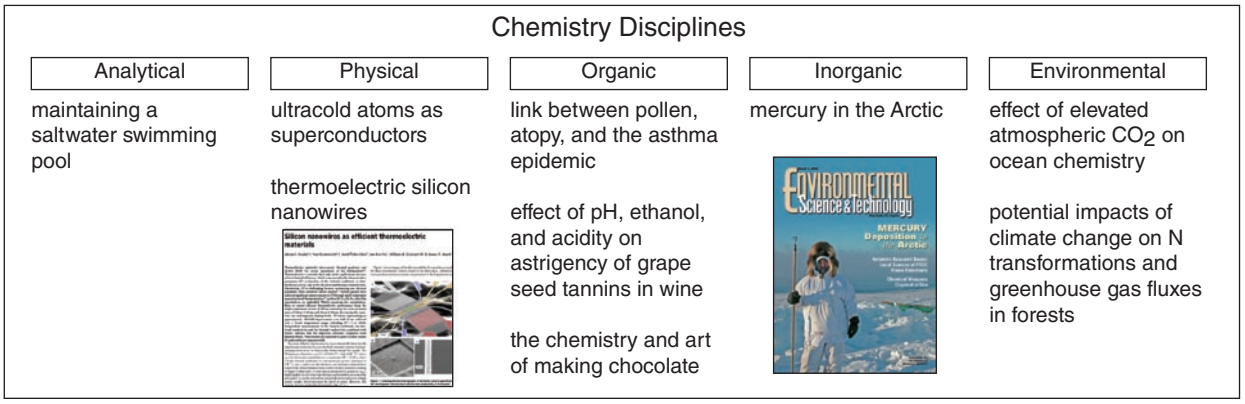

Figure 1. Example topics chosen for the primary literature summary assignment. The left image is reprinted with permission of Macmillan Publishers Ltd.: *Nature* **2008**, *451*, 168. The right cover image is reprinted with permission from *Environ. Sci. Technol.* **2008**, *42*; © American Chemical Society.

community in written form. Students are encouraged to choose a topic of interest to them and that is broadly related to a concept covered in either semester of the full-year course. They are given a number of example topics, and are also directed to their textbooks *(17, 18)* (which contain "applications of chemistry" sections) and to science magazines (both online and in print) as sources of ideas. Given the breadth of topics covered in a full-year chemistry curriculum, topics chosen by students have been equally broad. (See Figure 1 for examples.)

Students are encouraged to spend time thinking about a topic and searching for an article to review. In particular, they are instructed to choose an article that is not too complicated for them to understand, that communicates the results of a scientific experiment, and belongs to the peer-reviewed primary literature. If they are unsuccessful in finding an appropriate resource, students are asked to seek assistance either from peers, their instructor, or the librarian. Students can also inquire whether an article they have chosen is suitable for the assignment.

The two literature reviews constituted 2.5% of the course's total term mark. Discussions with colleagues affirmed that the time and effort that students put into the literature search and the pedagogical benefits of the assignment merit what might seem a high proportion of the course's assessment criteria. Half of the points for each assignment were used to evaluate the search and selection of an appropriate article; the remaining points were awarded based on the quality of the written summary. For this we evaluated correct usage of standard English, spelling, grammar, and organization of the text. We also required students to provide written personal comments on their experiences with the assignment.

During the three years we have used this assignment, two different techniques have been used to introduce students to searching library resources for literature. In the first two years, we determined that all students had been exposed to a library orientation session within a few weeks of the start of classes in the fall as part of their first-year English course. In addition, a large majority of students had also been given a more specific orientation to finding scientific literature in the context of a biology research project. To ensure all chemistry students received equal instruction in a scientific context, campus librarians were engaged early in the fall semester to provide a half-hour session on searching library resources across scientific disciplines. After this session, students completed a short assignment (not discipline-specific) requiring them to locate relevant in-library resources as well as online materials, such as books, reference resources, and journal articles. Before beginning the literature summary assignment in the second semester, librarians provided a second, half-hour session on searching scientific databases for topics and articles of typical first-year courses in chemistry, biology, physics, mathematics, geology, and geography. The librarians also helped students with individual searches for a paper.

In the third year, the initial session in the fall semester and subsequent library resource assignment was repeated. However, the second session on searching scientific databases was conducted by one of the authors (KF) rather than by the librarians. The differences in student response to this approach and assignment outcome are discussed below.

Discussion

What challenges us in teaching is to not only teach students the required material, but to keep the subject of chemistry interesting, timely, and relevant to the personal and educational goals of students. The primary literature summary assignment was designed as a way of encouraging students to think more broadly about what they were learning in lecture and to explore an area of interest to them, rather than to test their learning in a more traditional sense.

Students are often more engaged when an assignment allows them to investigate a topic of personal interest: some of our students have even identified subsequent educational goals as a result of their work on this assignment. In reading and summarizing primary literature of their choice, students explore topics of interest while developing cognitive skills—reading, writing, and critical thinking—that are often not taught or developed in content-rich, first-year curricula.

Students were asked to evaluate the assignment with an informal, voluntary survey at the end of the semester. The data in Table 1 reveal students' frustration with the exercise and the difficulty they had in locating appropriate articles for review. Given this feedback, we refined the initial instructions to students. We also noted the difficulty many students have in (i) effectively choosing a specific topic and (ii) searching for the requisite information—both of which require time and some independent research. While students were strongly encouraged to read scientific journals or textbook applications of chemistry

Table 1. Assignment Evaluation Responses

Concept Statements	Strongly Agree or Agree (%) (*N* = 114)	Disagree or Strongly Disagree (%) (*N* = 114)
Searching for and locating an appropriate article was a difficult part of this assignment.	85	15
Understanding the article was a difficult part of this assignment.	63	37
Summarizing the article was a difficult part of this assignment.	11	89
The articles I chose increased my appreciation of chemistry.	75	25
The articles I chose increased my enjoyment of chemistry.	65	35
The assignment will likely be of benefit to me in subsequent courses.	89	11
I will continue to read scientific literature through links my instructor makes available.	61	39
The assignment was a useful exercise.	76	24

NOTE: Data from 114 students were collected over the three-year period in which the primary literature project was assigned.

sections as starting points for finding a topic or locating specific article citations, few students took advantage of this method.

Many students identified the most difficult aspect of the assignment as trying to find an appropriate article. On closer inquiry, we discovered that many students were trying to search for an article on a topic that was too broad, or on no specific topic at all (i.e., simply reviewing tables of contents of electronic journals). Given the abundance of literature available and with no context for searching these research journals, students were often unable to decipher a complicated article as appropriate for their assignment. Conversely, several students each year chose articles that were not peer-reviewed and were clearly from newspaper or online magazine sources. This emphasizes the need and value of clearly differentiating between the primary and secondary (or tertiary) literature to first-year science students, and explaining how society advances by generating new knowledge that is reported in the primary scientific literature.

Students spent a great deal of time locating an article because this assignment was the first time many students were asked to search for and locate appropriate scientific literature. We attempted to address this in each subsequent course offering by providing examples of appropriate journals containing articles of a more readable nature (i.e., *Environmental Science and Technology; Nature; Canadian Journal of Fisheries and Aquatic Sciences; Chemistry and Ecology; Planetary and Space Science; The Lancet*). We provided topic examples that were interesting yet could be found in some less technical papers, and, in the most recent year, we personally led the second library database search session. When the database session was tailored to chemistry examples given in the assignment handout using institutionally accessible databases, students were able to readily see how to effectively search databases for appropriate chemical literature. For example, the topic of "biodegradable plastic" was searched using Academic Search Premier. Students were asked to analyze the search results and characterize several of the resulting articles as either peer-reviewed or from a newspaper or magazine, and whether the articles were likely of an appropriate level. This session was found to require less class time because we covered the material directly related to the assignment and offered rapid, tailored responses to student questions. Students reported less difficulty in finding an article in that year compared to previous years, which is likely because of the specific instructions and examples given when the session was conducted by the instructor.

One benefit of this assignment is its smaller scope, which differs from other projects described in the literature. Many similar assignments previously reported are broader in their extent, requiring poster presentations, calibrated peer review, additional background research, or in-class discussion and preparation *(2, 6, 8, 10, 11)*. The reduced scope of our project minimizes class time lost during a busy first-year chemistry course. Other than two, half-hour sessions over two semesters and some class discussion of expectations and evaluation, students are largely able to complete the assignment without additional class time or one-on-one instructor assistance. In addition, assessment was minimal, which benefits those with large class sizes. As instructors, we learned from the assignments, too, because many of the chosen papers represented interesting applications of chemistry.

A majority of students (Table 1) indicated that they found the exercise useful. In addition, the responses in Table 1 report that students believe they would likely benefit from this assignment subsequently when more detailed research projects require such skills; that they were able to find an article that increased their appreciation or enjoyment of chemistry; and that they would continue to seek opportunities to learn more about science by accessing links found on the Web site of one of the authors (KF) *(19)*.

This evaluation indicated that the main objectives of the assignment were met: (i) students had an opportunity to be introduced to the peer-reviewed primary literature in their first year of post-secondary education; and (ii) by choosing a topic of interest to them, students were able to connect the fundamental theories they were learning in lecture with actual scientific investigations. The success of this short yet useful exercise and the ease of its assessment make the project readily transferable to an institution with larger numbers of students.

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