JOURNAL OF CHEMICAL EDUCATION

Article

pubs.acs.org/jchemeduc

Combining Chemical Information Literacy, Communication Skills, Career Preparation, Ethics, and Peer Review in a Team-Taught Chemistry Course

Mary Lou Baker Jones*

University Libraries, Wright State University, Dayton, Ohio 45435, United States

Paul G. Seybold

Chemistry Department, Wright State University, Dayton, Ohio 45435, United States

Supporting Information

ABSTRACT: The widely acknowledged need to include chemical information competencies and communication skills in the undergraduate chemistry curriculum can be accommodated in a variety of ways. We describe a team-taught, semester-length course at Wright State University which combines chemical information literacy, written and oral communication skills, professional ethics, and career preparation. The chemical literature instruction includes evaluation of sources, practice with scientific databases, and an introduction to reference management. Written communication skills are addressed in a term paper assignment which includes a peer review exercise to provide students with exposure to an author's and a reviewer's perspective. Students' oral communication skills are honed through training in presentation techniques and the completion of several speaking assignments. Resumé-writing, professional ethics discussions, and presentations by alumni who are employed in a variety of chemistry-related positions contribute to the course's career preparation goals.

KEYWORDS: *Upper-Division Undergraduate, Chemoinformatics, Communication/Writing, Applications of Chemistry, Student/Career Counseling*

INTRODUCTION

There is increasing awareness of the need to train today's chemistry students in the rapidly developing area of chemical information.[1−6] For a number of years, we have offered a one-quarter, and more recently a one-semester, course for second, third, and fourth year chemistry majors dealing with aspects of literature searching and evaluation, written and oral presentation techniques, and career opportunities. The course has changed and evolved considerably over the past decade, in part driven by technological developments and the widespread expansion of electronic data sources. The course is limited to 24 students and is mandatory for the American Chemical Society Certified Bachelor of Science degree at Wright State University. Although Chemistry Department guidelines recommend that students take this course in their third year, it is not unusual for second and fourth year students to be enrolled in the course. In its present form, the course has three principal aims: (1) to help students gain proficiency in the use of chemical information resources, (2) to improve the written and oral communication skills of our students, and (3) to alert students to the great variety of possible career opportunities open to them and aid them in their career preparations.

Three signature attributes of this undergraduate course are that (1) it is team-taught by the university's chemistry librarian and a Chemistry Department faculty member;[7] (2) it encompasses a diverse set of topics, ranging from chemical information searching to communication skills and career preparation;[8] and (3) it incorporates a peer-review process developed in collaboration with the university's Writing Across the Curriculum (WAC) program. A number of earlier articles in this journal have addressed specific aspects of this course but we are unaware of any courses that combine these three attributes. (See Supporting Information for a more extensive bibliography of related *Journal of Chemical Education* articles.)

CHEMICAL INFORMATION RESOURCES INSTRUCTION

In this section, we will discuss the library-focused learning objectives. We expect that the students who successfully complete the course will:

Special Issue: Chemical Information

DOI: 10.1021/acs.jchemed.5b00416
J. Chem. Educ. XXXX, XXX, XXX−XXX

- recognize peer-reviewed journal literature and understand how it is produced
- efficiently use library-purchased databases, such as SciFinder and Science Citation Index Expanded, to identify appropriate information sources for their chemistry research
- use Google Scholar successfully to locate and access scholarly literature
- competently apply source evaluation criteria to the available information sources
- demonstrate an awareness of potential ethical problems in scientific information use

In our recent experience, students are entering this course with even less proficiency in the use of chemical information sources than the students of five to ten years ago. For many years, we have given a simple pre- and post-test to gauge students' chemical information skills, and although the class scores have always improved between pre- and post-tests, in recent years the pretest scores are among the lowest we have ever recorded. (See Table 1.) Chemical information instructors at Purdue University have reported similarly that today's students appear to be having a more difficult time finding and using chemical information than students of 20 or 30 years ago.[4]

Table 1. Student Pre- and Post-Test Score Averages Where 12 Is a Perfect Score

Year	Pre-Test Average	Post-Test Average	% Improvement
2014	5.5	7.9	44%
2013	6.85	10.9	59%
2012	5.4	8.1	50%
2011	5	7.6	52%
2010	7.54	9	19%
2009	7.5	10.1	35%
2008	7.2	9.8	36%
2007	7.7	10.7	39%
2006	7	10	43%

Additionally, a recent study by Project Information Literacy points out that students entering college today are likely to have had very little precollege experience with any kind of information research.[9] We are seeing this lack of competency persisting in the second, third, and fourth year students who enroll in our course, and because of this, we see the course as an important part of the undergraduate chemistry curriculum and we believe that it is useful for the course to be team-taught by a scientific instructor and a librarian.

Librarian-taught sessions include the following:

- An interactive session on journals that includes hands-on experience with print peer-reviewed and non-peer-reviewed science periodicals, practice with interpreting journal article references for source types, use of CASSI (Chemical Abstract Service Source Index) and library catalogs for journal title abbreviation deciphering, and an introduction to Ulrichsweb as a source for journal background information.
- Several sessions and assignments on using the Web of Science's Science Citation Index Expanded, Chemical Abstract Service's (CAS) SciFinder, and major patent databases. These sessions take place in the library computer lab so that all students have hands-on searching experience. The assignments encourage students to find literature related to either their research term paper topic for the present course or their undergraduate research.
- A session on using Google and Google Scholar and on evaluating online resources using the CRAAP criteria.[10] (CRAAP is an acronym for "Currency, Relevance, Authority, Accuracy, and Purpose".) This session becomes the basis for the students' 3 min oral presentations in which they describe the audience, potential use, and credibility of a Web site of their choice.
- A session on using RefWorks, the library-provided bibliographic management system. Although some of the students in this course are not yet motivated to use a bibliographic management system, those who are ready for it benefit greatly.

WRITTEN AND ORAL COMMUNICATION SKILLS

Term Paper

A central feature of the course is the development and presentation of a term paper and an associated oral presentation on the same topic at the end of the semester. One of the greatest perceived weaknesses (arguably *the* greatest weakness) in our students lies in the area of effective writing skills. We attribute this to limited exposure to and experience in writing[11] and limited reading by students in an age dominated by television and other electronic media.[12]

Accordingly, students in the course are required to research and prepare a term paper on a scientific or technological topic of particular interest to them. They are advised that the topic should be well focused: not, for example, a broad subject like "analytical chemistry" or "carbon compounds", but rather a topic narrow enough to be of particular interest to the individual student but sufficiently developed so that appropriate scientific references can be located using the literature searching skills developed earlier in the course. Otherwise, the choice of topic, which must be approved by the scientific course instructor, is quite open and need not be in chemistry. Actual topics chosen have covered a wide range, including "Black Holes", "Freeze Tolerance in Amphibians and Insects", "The Chemistry of Brewing", "Environmental Consequences of Plastic Bottles", and "Cognitive Effects of Bilingualism". Some students have chosen topics related to the diagnosis or treatment of particular diseases, often motivated by personal or family experience. Still others have chosen topics related to their undergraduate research projects, with the warning that the words and search efforts produced must be their own and not those of their research advisor.

Following a lecture on the nature of scientific publications, covering research journals, reviews, and more general background publications (e.g., *American Scientist*, *Scientific American*, etc.), students are asked to choose an appropriate journal (and hence format) for their own essay. The final report is to be written largely in that format, limited to four pages of text plus a page for references and one or two pages for tables and figures. This limitation is highly intentional and aimed at forcing students to prioritize their topics, the aim being "strength, not length". Students are reminded of the journalist's classic excuse, "I didn't have time to write it short", and warned against it. Unless exempted by the scientific instructor, every term paper must include at least one table and one figure. The paper must include at least six references, at least four being scholarly

DOI: 10.1021/acs.jchemed.5b00416
J. Chem. Educ. XXXX, XXX, XXX−XXX

journal articles or books, and these references must be presented in a style appropriate to the chosen model journal. Students writing in a research journal format should include the appropriate sections (Title, Author (the student), Abstract, etc.), whereas those writing for a more general audience will normally include a "teaser line" consisting of a few sentences intended to draw in the reader in place of an abstract.

The term paper itself is approached with a graduated set of writing assignments and a peer-review process. The level of complexity of the assignments moves from choosing an appropriate topic and model journal, to writing a short critique on a scientific research article chosen by the student, to preparing a fairly detailed outline for the paper, to writing a mature draft to be presented for peer review. The students' submission of their topics, outlines, and first drafts are paced through the first two-thirds of the term. In the last third of the term, students rewrite their papers after participating in a peer review assignment.

Peer Review

We introduced peer review into the course several years ago with the assistance of our campus WAC program instructors. The peer review module was our response to the poor quality of so many of the term paper first and second drafts submitted by students. We felt that a writing process that more closely reflected an author's scientific publishing experience might produce better quality final papers.[13,14]

To start, a WAC instructor leads a class discussion on the expectations and procedures of the peer review process and in applying peer review guidelines to sample student term papers. Students are then assigned to groups of three. Each student reviews and comments on the drafts of the other two students and in turn receives two reviews on his or her term paper draft. This rubric-based student peer review process is focused on the students' writing and organizational skills, and we believe that the exercise has several benefits for the students; in this process, the students experience the roles of reviewer and author, the application of a rubric, and the importance of audience. In addition to these student reviews, the course instructors separately review and grade a number of technical features of the draft term papers, such as proper length, inclusion of a proper abstract or teaser line, correct reference style, and so forth. The instructor reviews do not deal with the writing aspects of the drafts such as organization, grammar, spelling, and clarity of expression.

Students revise their first drafts in response to their peers' reviews and the instructors' feedback. We provide them with access to their originality reports in Turnitin so that they can use this tool to not only check their own work for plagiarism but also compare their two drafts against each other. The final draft is graded by both instructors with regard to writing style, content, and compliance with the technical rubric.

Oral Presentation

Most of our students seem to be more comfortable with oral communication than with formal writing, but our approach to oral communication is graduated also. One class session during the term is devoted to an activity-based workshop on presentation skills, led by an expert on the subject from the University Libraries staff. The workshop focuses on the physical aspects of public speaking such as posture, dress, facial expression, and eye contact. Usually, students are expected to speak publicly, with some preparation, three times in the course. First, they are expected to explain their written critique of a scientific research article in a discussion forum. Second, they offer a 3 min oral presentation from a podium on a scientific Web site of their choosing. For this assignment, students are given the grading rubric in advance and apply it to a sample presentation given by the librarian. Lastly, students present their research reports in 12−15 min Microsoft PowerPoint presentations, followed by short periods for questions. The grading rubric for this oral presentation is also given to the students as a preparation guide.

Since we stress in this course that the students are preparing themselves to participate in scholarly communication, we take the opportunity of their oral presentations to introduce the concept of audience. We expect them as speakers to recognize the level of their audience and to address them appropriately and, as audience members, to listen attentively and to formulate good questions for their peers. They submit written questions at the end of each peer presentation session and this requirement has improved the quality and quantity of the students' oral questions and created a more professional presentation experience.

CAREER DEVELOPMENT

Professional Employment Preparation

Whereas considerable focus in the undergraduate curriculum is directed toward teaching the basic scientific skills of the subject, it is clear that many students have only rather vague ideas about what it is like to actually work as a professional chemist.[15] This aspect of the course is initiated with a presentation from a representative of the university's Career Center. This presentation normally includes, among other topics, information on how to apply for jobs and interviews using the university's electronic application system, advice on interviewing skills, and résumé preparation. The importance of interview preparation, including research about prospective employers, is stressed. The Career Center staff offers practice sessions on interviewing skills.

On the basis of this information, students are asked to prepare and submit appropriate personal résumés, which are graded. Students are required to include "Career Objectives", with the recognition that an individual may have more than one résumé, each stressing different goals, depending on the specific position applied for.

Perhaps the most popular part of the course has been a set of class presentations given by returning Chemistry Department alumni and alumnae describing their postgraduation employment experiences. These talks, sometimes by persons who had previously taken the course, have proven especially helpful in placing the requirements of the workplace and career choices into a perspective to which students can relate. In a typical recent course offering, three returning alumnae presented talks. In the first, an alumna working for the Ohio Bureau of Criminal Investigation (the state's official crime laboratory) described the great variety of activities taking place in this type of forensic center. She also explained the differences between efforts in real-world forensics and the activities of crime fighters presented on television shows such as CSI. In the second presentation, a group leader from CAS in Columbus, Ohio gave both a general overview of the activities of the American Chemical Society and a more focused discussion of the activities taking place at CAS. In the latter category, she described the many steps and skill sets needed to transform a

DOI: 10.1021/acs.jchemed.5b00416
J. Chem. Educ. XXXX, XXX, XXX−XXX

manuscript accepted for publication by a scientific journal into a finished paper published by that journal.

The third talk was given by an alumna working in product development at Procter & Gamble Co. in Cincinnati, where many of our graduates find employment. She described the elaborate steps needed to transform an idea from the laboratory or elsewhere into a successful commercial product, including patent establishment, cost and safety considerations, product branding, and eventual marketing. Many of these aspects are facets of the trade to which students following the usual academic course of instruction are rarely exposed. In addition to these in-class presentations, students were also encouraged to attend a related departmental seminar presented by an alumnus who is a top official in the Food and Drug Administration. He described the workings of that agency, including the decision-making process for new drugs. Among other things, he emphasized the importance of developing good communication skills.

Professional Scientific Ethics

Professional ethical conduct is addressed in two of the 27 sessions of the course. Students work in groups during a librarian-led session to examine and discuss reported cases of unethical scientific publishing behavior. The student groups in this session are charged with constructing a rule that should have guided the scientist's behavior and then their rules are viewed within the context of the American Chemical Society's *Ethical Guidelines to Publication of Chemical Research*.[16] In a second session led by the scientific instructor on the broader topic of "Good Science", greater attention is given to topics such as the morality of scientific endeavors, scientific fraud, treatment of co-workers and rivals, creativity, and attention to details.[17−20]

■ ASSESSMENT

Several assessment tools are used for this course. One of the most useful is a form which asks students to evaluate each specific session. This form has been especially helpful in determining the future evolution of the course. For example, a session on laboratory safety was eliminated after the students responded that they had received this training in several of their other courses.

To assess the peer review exercise, we have used both graded, printed feedback forms and anonymous surveys. Both methods have shown over the years that a majority of students (e.g., 80% in 2012) rate the exercise itself as useful or very useful and that a minority of students (e.g., 13% in 2012) express frustration when their peer review partners do not give them useful reviews. In response to the students' negative feedback, we have worked with WAC to develop techniques for creating balanced peer review groups and for motivating students for this activity.

We have many years of data from another assessment tool, a pre- and post-test of the students' chemical information literacy. This quiz-length test tries to gauge the students' skills at interpreting citations, evaluating information sources, and recognizing scientific databases. It gives us an annual snapshot of both our incoming students' competency and our students' progress in the course. The post-test scores show that almost all students are gaining significantly in their chemical information literacy skill levels during this course. For example, in Table 1 student scores averaged a 44% improvement in 2014.

■ CONCLUSIONS

Both the formal assessment and the positive feedback from graduates of the program give us confidence that this course is an important and successful component of Wright State University's undergraduate Chemistry Program. We believe that it addresses students' needs to improve their chemical information literacy skills, gives them an awareness of professional ethics, encourages them to think seriously and broadly about their career preparation and choices, and gives them opportunities to practice and improve their very necessary scientific communication skills.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

The Supporting Information is available on the ACS Publications website at DOI: 10.1021/acs.jchemed.5b00416.

Student handouts on course assignments, term paper advice, peer review guidelines, Web site presentation grading rubric, and oral presentation guidelines plus a bibliography of related *Journal of Chemical Education* articles and the Pre/Post-Test (PDF)

■ AUTHOR INFORMATION

Corresponding Author

*E-mail: marylou.jones@wright.edu.

Notes

The authors declare no competing financial interest.

■ REFERENCES

(1) Currano, J. N. Teaching Chemical Information for the Future: The More Things Change, the More They Stay the Same. In *The Future of the History of Chemical Information*; McEwen, L., Buntrock, R. E., Eds.; ACS Symposium Series 1164; American Chemical Society: Washington, DC, 2014; pp 169−196.

(2) Kerr, W. J.; Murray, R. E. G.; Moore, B. D.; Nonhebel, D. C. An Integrated Communication Skills Package for Undergraduate Chemists. *J. Chem. Educ.* **2000**, *77*, 191−194.

(3) Somerville, A. N.; Cardinal, S. K. An Integrated Chemical Information Program. *J. Chem. Educ.* **2003**, *80*, 574−579.

(4) Garritano, J. R.; Culp, F. B.; Twiss-Brooks, A. Chemical Information Instruction in Academe: Who is Leading the Charge? *J. Chem. Educ.* **2010**, *87*, 340−344.

(5) Jensen, D.; Narske, R.; Ghinazzi, C. Beyond Chemical Literature: Developing Skills for Chemical Research Literacy. *J. Chem. Educ.* **2010**, *87*, 700−702.

(6) Gewalt, E. S.; Adams, B. A Chemical Information Literacy Program for First-Year Students. *J. Chem. Educ.* **2011**, *88*, 402−407.

(7) Tucci, V. K. Faculty/Librarian Collaboration: Catalyst for Student Learning and Librarian Growth. *Sci. Technol. Libr.* **2011**, *30*, 292−305.

(8) Ashraf, S. S.; Marzouk, S. A. M.; Shehadi, I. A.; Murphy, B. M. An Integrated Professional and Transferable Skills Course for Undergraduate Chemistry Students. *J. Chem. Educ.* **2011**, *88*, 44−48.

(9) Head, A. J. Learning the ropes: How freshmen conduct course research once they enter college; *Project Information Literacy Research Report*, 2013. http://projectinfolit.org/images/pdfs/pil_2013_freshmenstudy_fullreport.pdf (accessed May 2015).

(10) Meriam Library, *Evaluating Information—Applying the CRAAP Test*; California State University: Chico, CA, 2010. https://www.csuchico.edu/lins/handouts/eval_websites.pdf (accessed May 2015).

(11) Crank, V. From High School to College: Developing Writing Skills in the Disciplines. *WAC J.* **2012**, *23*, 49−63.

DOI: 10.1021/acs.jchemed.5b00416
J. Chem. Educ. XXXX, XXX, XXX−XXX

(12) Mokkhtari, K.; Delello, J.; Reichard, C. Connected Yet Distracted: Multitasking Among College Students. *Journal of College Reading & Learning* **2015**, *45* (2), 164−180.
(13) Gragson, D. E.; Hagen, J. P. Developing Technical Writing Skills in the Physical Chemistry Laboratory: A Progressive Approach Employing Peer Review. *J. Chem. Educ.* **2010**, *87*, 62−65.
(14) Glaser, R. E. Design and Assessment of an Assignment-Based Curriculum to Teach Scientific Writing and Scientific Peer Review. *J. Learn. Des.* **2014**, *7* (2), 85−105.
(15) Tucci, V. K.; O'Connor, A. R.; Bradley, L. M. A Three-Year Chemistry Seminar Program Focusing on Career Development Skills. *J. Chem. Educ.* **2014**, *91*, 2071−2077.
(16) American Chemical Society. *Ethical Guidelines to Publication of Chemical Research*; American Chemical Society: Washington, DC, 2015. http://pubs.acs.org/userimages/ContentEditor/1218054468605/ethics.pdf (accessed May 2015).
(17) Smith, D. H.; Coppola, B. P. A Case for Ethics. *J. Chem. Educ.* **1996**, *73*, 33−34.
(18) Kovac, J. Scientific Ethics in Chemical Education. *J. Chem. Educ.* **1996**, *73*, 926−928.
(19) Kovac, J. *The Ethical Chemist: Professionalism and Ethics in Science*; Pearson: Upper Saddle River, NJ, 2004.
(20) Speight, J. G.; Foote, R. *Ethics in Science and Engineering*; Scrivener: New York, 2011.

DOI: 10.1021/acs.jchemed.5b00416
J. Chem. Educ. XXXX, XXX, XXX−XXX