Incorporating Information Literacy Skills into Analytical Chemistry: An Evolutionary Step

ARTICLE *in* JOURNAL OF CHEMICAL EDUCATION · JULY 2007

Impact Factor: 1.11 · DOI: 10.1021/ed084p1385

2 AUTHORS, INCLUDING:

Paul Timothy Jackson
St. Olaf College

14 PUBLICATIONS **268** CITATIONS

SEE PROFILE

Chemical Information Instructor

edited by
Andrea Twiss-Brooks
John Crerar Library
University of Chicago
Chicago, IL 60637

Incorporating Information Literacy Skills into Analytical Chemistry: An Evolutionary Step

Mary M. Walczak* and Paul T. Jackson
Department of Chemistry, St. Olaf College, 1520 St. Olaf Avenue, Northfield, MN 55057; *walczak@stolaf.edu

The current Committee on Professional Training (CPT) guidelines *(1)* from the American Chemical Society emphasize the importance of teaching literature and information retrieval skills to chemistry students as the volume of literature expands rapidly and the tools available for searching become more complex. The proposed revised guidelines continue to expect chemistry curricula to incorporate instruction in accessing and using scientific information *(2)*.

Chemistry departments have taken various approaches to address this component of the curriculum. Several reports of chemical information courses have been reported in this *Journal (3–7)*. Some of these courses focus entirely on literature searching *(4, 6)*, while other courses also incorporate oral or written communication *(3, 5, 6)*. Most of these courses are intended for intermediate undergraduate students in their second or third year of study, although one course targets beginning graduate students *(7)*. Other departments have adopted an integrated approach, incorporating the necessary chemical information skills into courses *(8–11)*. Several reports of such approaches in organic chemistry have appeared *(8–10)*. Somerville and Cardinal *(11)* describe an integrated chemical information instruction program at the University of Rochester that includes instruction at all levels of the curriculum.

The St. Olaf College Chemistry Department[1] also has adopted an integrated approach of incorporating information literacy skills throughout its curriculum. As a starting point to formalizing the integrated approach, the chemistry faculty developed a list of information literacy skills students should acquire prior to graduation. Four broad categories frame the skill set:

1. Finding and retrieving information
2. Cataloging and analyzing information
3. Information transfer
4. Skill development

The details found in Lists 1–4 represent an ideal scenario; depending on the array of courses taken, a student may not experience all of the items on the list (e.g., most students will not have opportunities through their courses to present a 45-minute seminar). The items presented in italicized text are skills that the chemistry faculty consider essential for all the graduates of our program. Once this planning framework was established the department mapped the list of skills onto the different courses in the curriculum. Finally, faculty contributed specific assignments in different courses that met the department's information literacy goals.

List 1. Skills for Finding and Retrieving Information

A. Tools for exploring and managing the primary literature
- 1. Understanding and applying different search modes
- 2. Using databases to retrieve information
  - a. Web of Science
  - b. Scifinder Scholar
- 3. EndNote
- 4. Obtaining papers
  - a. Online journals
  - b. Journals on the library shelf
  - c. Requests from other libraries
  - d. Requests for copies from other sources

B. Alternative information sources
- *1. World Wide Web*
- *2. Reference books*
- *3. CRC Handbook and other handbooks*
- *4. Safety/MSDS*
- 5. Company catalogs
- 6. Online database tools (e.g., Protein Data Bank)
- *7. Books, monographs*

List 2. Skills for Cataloging and Analyzing Information

C. Source reliability
- 1. Peer review
- 2. World Wide Web

D. Critique and evaluate work (peers' and others)
- 1. Ascertain its quality
- 2. Ascertain its relevance
- 3. Formulate questions from the work
- 4. Accept and give constructive criticism

E. Use published work to
- *1. Inform interpretation of lab results*
- 2. Propose experiments
- 3. Design experiments
- 4. Introduce applications or context of course material

In the analytical chemistry course, we include opportunities for students to practice many of the essential elements in Lists 1–4 (italicized items). To describe all the information literacy components in the course is beyond the scope of this paper. Our intentions here are to describe the assignments in analytical chemistry that meet a suite of information literacy goals. In particular, we want our analytical students to demonstrate how to locate and effectively use Internet-based science resources, create and manage electronic information, evaluate the content and source of the information, and gain proficiency with an array of professional software tools related to the above processes. Many of these topics overlap the categories in Lists 1–4 as well as build on foundations established in the first two years of the chemistry curriculum.

List 3. Skills for Information Transfer

F. Oral presentations and seminar presentations
   1. Identify components of a professional oral presentation
   2. Types of oral presentations
      a. 5-minute talk
      b. 15–20-minute talk
      c. 45-minute seminar talk
      d. Group discussion of published/unpublished work
   3. Creating a story using a set of professional graphics
   4. Opportunities for practice

G. Poster presentations
   1. Identify professional poster presentation components
   2. Discuss the format and venues for presentations
   3. Create a story using a set of professional graphics
   4. Accept and give constructive criticism

H. Structured technical writing
   1. Laboratory notebook
   2. Literature review
   3. Journal article-style report

I. Creative technical writing
   1. Research proposal
   2. Book/article review
   3. Report to customer
   4. Resumes, job application
   5. Instructional material
   6. Popular science writing for general public
   7. Memorandum to colleague or supervisor

List 4. Skills for Communication and Evaluation

J. Gain ability to explain science to audiences of different backgrounds

K. Communicate to increasingly sophisticated audiences over time (both peers and professionals)

L. Increase in ability to evaluate work over time (one's own work and the work of peers)

Analytical Chemistry at St. Olaf College

The analytical chemistry curriculum at St. Olaf College is comprised of two courses, analytical chemistry and instrumental analysis. Analytical chemistry is a blend of the typical "quantitative analysis" and "instrumental analysis" courses in that it focuses on both of these traditional areas of analytical science. The course and its associated laboratory are required for the chemistry major, must be taken concurrently, and are offered in both the fall and spring semesters. Enrolled students meet for two, 85-minute class periods and one, four-hour laboratory each week. Typically students enroll in the analytical chemistry course during their junior year and take instrumental analysis in their senior year. A few ambitious sophomores concurrently enroll in analytical chemistry with the second semester of organic chemistry and it is not uncommon to have a few seniors. Course enrollments have averaged 24 students per semester over the last 10 years. Lab sections have a maximum capacity of 16; consequently, one or two laboratory sections are offered each semester.

The entire class and lab ensemble is taught using the role-playing approach initially developed by our emeritus colleague, John Walters *(12, 13)*. Briefly, the role-playing course is organized around four-person groups, called "companies", that are ultimately supervised by the instructor (Upper Management). Within each company, students take turns playing the roles of Manager, Chemist, Software, and Hardware. The companies and their operation are intended as a reflection of the professional world and the roles played by a working analytical chemist. The roles transcend both the class and lab. During class, Manager is the person who interacts with Upper Management, Chemist provides any needed data from text sources, Hardware operates the company's calculator, and Software operates the company's portable computer (when applicable) or pays attention to how the computer spreadsheets or other programs are manipulated so they can be emulated or modified in the laboratory.

In the laboratory, Manager is responsible for the organization and planning of the experiment, and for the complete outcome of the experiment. To do this well requires that the company communicate outside of class time. Over the years the Managers have used a variety of strategies to assist the company in developing an action plan, including: e-mail, instant messenger, chat rooms, face-to-face meetings, and conference calls. Chemist is responsible for the preparation and delivery of any necessary chemicals or solutions needed to execute the Manager's plan. Hardware is responsible for operating any necessary instrumentation and Software is responsible for the operation of any computers and programs. During the semester the roles rotate every one or two weeks. Each student has the opportunity to play each role twice during the semester. More detailed descriptions of the roles can be found elsewhere *(12)*. Data analysis and

information technology (DAIT) assignments provide a major route for information literacy in the analytical chemistry course. Throughout the term each company is responsible for working together to complete one assignment every 1.5 weeks. Each assignment is included in the course grade, worth approximately 2–3% of the total grade. Some of these assignments develop student's skills with the software programs available for use in our laboratory (Microsoft Office and LabVIEW), while others focus on using Internet resources and searching databases, including SciFinder Scholar. As students rotate through the roles, they learn from the previous person, so skills (including facility with spreadsheets) are passed between company members throughout the semester.

Technology has changed dramatically since the inception of the role-playing laboratory and the course has continually adapted as new technology became available. As pointed out by Ricker and Thompson *(3),* students have become increasingly technologically savvy over the years. For example, in the 1990s the chemistry department spent one of our three-hour introductory (general) laboratory sessions demonstrating and leading students through a series of exercises designed to develop familiarity and expertise with spreadsheet programs. As the familiarity of spreadsheets to our incoming students increased, this exercise shifted to a homework assignment that can be done without assistance, or with tutorial help from the instructor, if needed.

In our analytical chemistry program, facility with spreadsheets is of paramount importance, as all experiments have a data analysis component that is conducted using computational tools. Historically we had spent considerable time teaching students how to use spreadsheet tools in terms of group tutorials and assignments. Based on the changing computer data and file management expertise of our students we have been able to expand the course to bring greater emphasis to information literacy skills and reduce the amount of spreadsheet-related activities.

Science Library Staff and Resources

Our science library has been an integral part of the development and implementation of information literacy. The Glasoe Science Library is staffed seven days a week. In addition to the science librarian, there is a part-time library associate staff member and 12–18 student workers. Although not all science library workers are highly trained in using all online resources, help is readily available on a drop-in basis, by e-mail, or by appointment. Therefore, students and faculty have expertise readily available if questions arise. Not only has the library staff worked with faculty to identify and obtain access to Internet resources and software, we have collaborated on many of the assignments developed or redesigned to utilize online research tools.

We underscore the importance of faculty–librarian collaboration *(11).* The science librarian has developed and provided instruction for participants in our summer research program *(14),* and for faculty and students in the chemistry, biology, and mathematics, statistics, and computer science departments, including a fall semester project for 240–280 introductory biology students. In the analytical chemistry course, research and information management tools are introduced by either the instructor or science librarian at a point in the course when they are needed. Instruction occurs in a computer lab or with a set of wireless laptop PCs; consequently, an important piece of the introduction is hands-on computer access for individual students or student pairs. The science librarian also monitors usage of the available online tools.

The Glasoe Science Library has made a conscientious effort to keep our electronic resources up to date within an array of budgetary restrictions. In 1999, the College subscribed to Web of Science and within two years augmented chemistry-related resources with two simultaneous user seats on SciFinder Scholar. Both of these products allow online searching of science-related texts. Web of Science was known in paper format as Science Citation Index; Web of Science allows topics and author searches as well as citation searches. The SciFinder Scholar search engine and citations database are produced and maintained by Chemical Abstracts Service of the American Chemical Society. Over the past four years we have not found any detrimental effects from the small number of permitted simultaneous users to SciFinder Scholar. Online access to all the ACS Journals was negotiated through the Minitex consortium and a site-license to EndNote soon followed. EndNote is a software tool that allows the acquisition and management of bibliographic records. EndNote permits users to search Internet bibliographic databases; organize references, images, and PDF files; use MS Word manuscript templates; and create bibliographic entries while working in a MS Word document. With these powerful resources available, we were able to integrate literature searching more broadly into our courses.

Data Analysis and Information Technology Assignments

The four DAIT assignments are designed to help the companies work together to develop expertise in two important aspects of data analysis and information technology. Some of the assignments are geared at developing proficiency with software, and other assignments are designed to use our suite of information tools. The assignments are brief and conducted in a role-playing mode. Manager has the responsibility to ensure that the outcomes of the assignment are met. At the beginning of the semester, when students are still learning how to work together in a role-playing mode, the specific roles of the company members are explicitly described (see the MSDS Information section below). As the semester continues, Managers are left to direct their company members to complete the task as they determine. The other three assignments described are completed in the second half of the semester, so specific instructions for the various roles are not included. While we have little direct evidence that the companies carry out these assignments playing their assigned roles, our observations of the companies working together in the lab and outside it suggest that they take their role responsibilities seriously.

Assignment: MSDS Information Gathering

In our role-playing analytical chemistry laboratory *(12),* the company Chemist is responsible for providing "right-to-know" safety specifications to others in the company. Using

material safety data sheet (MSDS) information, the Chemist must determine the safety, handling, and disposal procedures for the chemicals used in the laboratory. In addition, these chemicals must be bottled and labeled based on their hazards. For each experiment, the company Chemist locates MSDSs for all the chemicals used. One of several available sources of MSDSs *(15, 16)* can be used, although most Chemists choose to find MSDS information on the Web. Having found the necessary MSDSs, Chemist completes a Local MSDS listing health hazards, descriptive chemistry, NFPA codes, solution properties (for mixtures), and waste disposal and precautions. Once all the Local MSDSs have been completed, Chemist submits them to the Manager, who circulates them within the company for questions and "sign off" before submitting them to Upper Management (the Lab Instructor) for final approval. The company may not begin working with chemicals until Upper Management has approved the Local MSDSs. This exercise permits a short review of the source of the MSDS and brief discussion about the rationale for selecting what MSDS information to highlight.

Assignment: Planning To Attend a Professional Meeting

Attending professional meetings is an important part of all scientists' careers. The purpose of this assignment is to acquaint students with scientific meetings and to determine and justify expenses associated with sending one or two company members to a professional meeting. Since we use actual meetings as the basis of the assignment (the Eastern Analytical Symposium in fall and The Pittsburgh Conference in spring), students see for themselves the interesting array of scientific topics presented at such a meeting. The complete assignment is a written report that relates the professional significance of the meeting in three parts: (i) a schedule of two days worth of activities; (ii) a travel budget; and (iii) an annotated bibliography of at least five sources from the primary literature related to a specific scientist or presentation topic at the conference that the company member(s) will attend. Inspiration for this assignment was generated by Mabrouk's work *(17)*.

To plan a two-day schedule students are referred to preliminary programs published online, or, depending on the timing of the assignment relative to the meeting, hardcopy programs. In addition to attending plenary sessions, poster sessions, and contributed papers, students are asked to seriously consider visiting the vendor exhibit, paying particular attention to laboratory instrumentation. To guide the planning process, the students are asked to consider these questions:

- What do you want to learn at this meeting?
- What talks, posters, short courses, and exposition booths do you plan to attend?
- How will this benefit you and your company?
- What are the sociological aspects of being a professional analytical chemist and attending a scientific meeting? (Think of any sociological issue(s) you wish to investigate, e.g., gender equity in speakers, award receptions, etc.)
- How will you report back to the entire group after the meeting?

The company is required to submit a proposed budget for one or two members to travel to the meeting. Students need to research the airfare, hotel accommodations, registration, ground transportation and other anticipated expenses. The expenses are submitted on a travel expense form (included in the Supplemental Material[W]), anticipating what they can expect from professional employment. Students are quite resourceful at finding detailed expense information. One student called a taxi driver in New Orleans to find out the cab fare between the airport and the convention center.

To bolster their case for attending the meeting to learn about analytical chemistry, the company is required to submit an annotated bibliography containing at least five entries. The entries in the bibliography need to be related to a scientific topic about which the attending company members intend to learn. Students are asked to use SciFinder Scholar, Web of Science, and the ACS journals to find journal articles, review papers, monographs, or books on the topic or written by the scientist selected.

For many of our students, this will be their first occasion to write an annotated bibliography for a scientific topic. Therefore, we provide them some detailed information about annotated bibliographies *(18, 19)*.

In addition to the three components required in the written proposal (a two-day meeting itinerary for one or two of the company members, a travel budget and an annotated bibliography), the company should address the questions listed previously, the rationale used to select the activities, why the travel should be funded, and how attending this meeting will help the company's bottom line.

Exploring intrinsically social aspects of being a chemist brings up several issues that students may not have considered previously. If the company has both males and females, as is typical, or if the personnel selected to attend are of unequal seniority (e.g., Manager and one of the other company members), issues related to lodging with co-workers are raised. We raise these ethical questions when we introduce the assignment to the class and remind them to consider them as they put together their proposal. In only one case out of approximately 30 companies have students chosen to ignore such ethical issues in their proposal.

Assignment: Preparing and Issuing a Seminar Invitation

The purpose of this assignment is for the company to explore the topics and scientists working in an area of analytical chemistry. Furthermore, these people would be eligible for an actual invitation to campus based on the company's efforts. The assignment is in two parts. First, the company must make a case for why resources should be allocated to bring expertise in this area of analytical chemistry to campus. Second, the company crafts a letter inviting a scientist to campus to present a seminar.

To assist the company, the students are reminded of the first day of class, when an overview of the field of analytical chemistry was presented. We discussed what kinds of questions analytical chemists ask (what, where, why, when, who?) and brainstormed examples from our experiences. In addition, a list of local and national and international places of employment for analytical chemists (e.g., 3M, Cargill, Valspar, colleges and universities, Minnesota Pollution Control Agency,

Smithsonian Institution, Mayo Clinic, Food and Drug Administration) is included.

A recommended first step is to browse the online editions of related publications, such as *Analytical Chemistry*, *Environmental Science and Technology*, and *Journal of Chromatography A,* to discover contemporary research topics in analytical chemistry prior to doing a SciFinder search. Once a possible topic is identified, SciFinder Scholar and Web of Science are used to find publications on that topic and the scientists doing the work. In some cases, students refine their search to target specific organizations or places of employment. Using EndNote, students build a custom bibliography on the topic or scientist.

The first written part of the assignment is to compose a memo to Upper Management that outlines the case for allocating resources to invite the selected scientist to give a seminar as part of the St. Olaf College Chemistry Department seminar series. The memo briefly describes the significance of the scientist's work, her or his educational background, if available, and current place of employment; furthermore, it articulates what topic this scientist will be asked to present. The bibliography is included to bolster the case for inviting this individual and to serve as a resource if a reading group is established prior to the visit. The bibliography must contain at least eight citations, formatted in the style found in *Analytical Chemistry,* and the title of journal articles should be included.

The second written component of this assignment is a formal letter of invitation from the role-playing company to the scientist asking them to come to St. Olaf College and present the specified topic. We provide an example letter[W] to assist the students in crafting a suitable letter. To date, we have hosted two seminar speakers invited through this assignment. In these cases, the company has sent their invitation letters to the scientist and acted as hosts during the visit.

Assignment: Literature Review, Creating a Bibliography, and Manuscript Review

The purpose of this assignment is to have students explore the primary literature to find information on a given analytical chemistry topic and conduct a simulated peer review of the published manuscript. As motivation for their searching, we point out that numerous analytical methods—currently practiced by analytical chemists everywhere—began as publications in the primary literature. Thus, knowledge of the primary literature constitutes a key component in the professional arsenal of any chemical analyst. Furthermore, we state that Upper Management plans to expand the capabilities of the laboratory and requires critical feedback from each company regarding recent advances published in the literature. In fact, we are always seeking to update our laboratory experiments and instrumentation, and have used this assignment to generate ideas to implement in the future. Each company, designated as specialists in an area of analytical science, is asked to develop an EndNote library (e.g., a database) on a specific literature topic and review a current paper of their choice from within that literature database.

The assigned topics have been both general and very specific. Examples from recent offerings are found in List 5. Students are asked to compile a set of citations for their topic that have been published within the last five years. They use SciFinder Scholar, Web of Science, or any other suitable online searchable database to collect citations (book, journal, reviews, etc.). The collected citations are imported into an EndNote library. From this set of citations, the company members choose a journal article to review. Articles available electronically or in bound format are both acceptable.

List 5. Literature Review Assignment Topics

- Affinity chromatography
- Analysis of basic drugs by HPLC
- Electrochemical detection of environmental toxins
- Environmental analysis using solid phase microextraction
- Forensic or drug testing application of solid phase microextraction
- Inductively coupled plasma mass spectroscopy
- Liquid chromatography coupled to NMR spectroscopy
- Miniaturized ion-selective electrodes
- Monolithic columns for high resolution chromatography

In a fashion similar to many publishers, companies submit the paper review as a MS Word document based on the template available.[W] The template contains a series of questions that the company should address in its review about the specific paper. Questions on the template are adapted by the instructors to fit the general subject that the company is researching. For example, a template (provided in the Supplemental Material[W]) is adapted for use with papers about separations science topics. A hardcopy or electronic submission of the paper review is acceptable. The companies submit the EndNote library in electronic form.

The emphasis on primary literature in this assignment is usually one of the first few experiences students have with primary sources and likely the first time they have been asked to review a scientific paper. This opportunity allows us to discuss the culture of peer review in science. The EndNote library constructed by the group can be an important resource. We have used these as the basis of a new research project, a grant proposal, a new lab experiment, and to illustrate the challenges of file management from year to year or term to term when sharing the work of companies from the previous term.

Conclusions and Implications for Chemistry Teachers

The data analysis and information technology assignments implemented in analytical chemistry have been well received by students. Upper Management gathered feedback through two vehicles—management interviews and electronic surveys. Throughout the term the Managers regularly met with Upper Management for performance reviews, namely, management interviews. In this construct Managers discussed how the company executed the assignment and raised questions or provided suggestions for improving the assignment.

In a formal electronic survey distributed at the end of two different semesters students were asked about the extent that the DAIT assignments contributed to their learning. A total of 27 out of 29 students surveyed agreed that these assignments significantly contributed to their learning. When given the opportunity to further express their perspective in open-ended responses a small ($N = 4$) yet articulate group of students found the assignments tedious, too time consuming, or expressed concerns about all company members contributing. The complaint mentioned the most was the nature of the spreadsheet work and not the information literacy assignments described herein. Overall, most students see the value inherent in the skills they develop in carrying out the exercises. For most of our students analytical chemistry is the first course in which they are introduced to some of these tools, so for the foreseeable future instruction will be necessary. Students will likely have used Web of Science in a previous course, but EndNote and SciFinder Scholar are almost always new to students.

Since analytical chemistry is a required course that is usually followed by one or more advanced courses that also make use of information technology, we used a survey to ask the instructors of the subsequent courses whether students were prepared in this regard. In general, the faculty report that students carry forward basic skills to these advanced courses taken 1–1.5 years after analytical chemistry. They also report that some students need a short refresher on the mechanics of using a particular tool, although this is usually conducted one-on-one, as instruction of the entire class does not seem necessary.

Furthermore, students who have taken our organometallic chemistry course (a second-year-level, writing-intensive course with heavy emphasis on the primary literature) are extremely well versed in information literacy and require very little guidance later in the program. This suggests that students can become comfortable and proficient with the tools by using them intensively in a course. Further studies might address the effectiveness of intermittent use of information literacy tools versus an immersion experience with heavy use over a short period of time as well as the development of more substantial measures of learning outcomes related to these topics.

Acknowledgments

We are grateful to our science librarian, Charles Priore, for his enthusiastic support of our information literacy efforts. We also thank our analytical chemistry students for their spirited approach to the data analysis and information technology assignments.

[W]Supplemental Material

Several items described in this paper are available in this issue of *JCE Online,* including: a travel support and reimbursement request form; an example seminar invitation letter; and a template for an analytical chemistry literature review.

Note

1. St. Olaf College is a residential college located in southeast Minnesota approximately 35 miles south of Minneapolis and 50 miles north of Rochester. The 2005–2006 enrollment of the College numbers 3058 students, representing 48 states and the District of Columbia, and 18 foreign countries. Of the incoming students, 49% ranked within the upper 10% of their high school class. The St. Olaf College Chemistry Department has 11 faculty members and graduates between 30–50 chemistry majors each year, of whom 40% are women. For more information, go to *http://www.stolaf.edu/depts/chemistry* (accessed May 2007).

Literature Cited

1. American Chemical Society Committee on Professional Training. *Undergraduate Professional Education in Chemistry: Guidelines and Evaluation Procedures;* American Chemical Society: Washington, DC, 2003.
2. American Chemical Society Committee on Professional Training. *http://www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=education\cpt\index.html* (accessed May 2007).
3. Ricker, A. S.; Thompson, R. Q. *J. Chem. Educ.* **1999,** *76,* 1590–1593.
4. Paulson, D. R. *J. Chem. Educ.* **2001,** *78,* 1047–1049.
5. O'Reilly, S. A.; Wilson, A. M.; Howes, B. *J. Chem. Educ.* **2002,** *79,* 524–526.
6. Meyer, G. M. *J. Chem. Educ.* **2003,** *80,* 1174–1177.
7. Currano, J. N. *J. Chem. Educ.* **2005,** *82,* 484–88.
8. Christensen, S. B.; Franzyk, H.; Frølund, B; Jaroszewski, J. W.; Stærk; Vedsø, P. *J. Chem. Educ.* **2002,** *79,* 765–768.
9. Gallagher, G. J.; Adams, D. L. *J. Chem. Educ.* **2002,** *79,* 1368–1371.
10. Rosenstein, I. J. *J. Chem. Educ.* **2005,** *82,* 652–654.
11. Somerville, A. N.; Cardinal, S. K. *J. Chem. Educ.* **2003,** *80,* 574–579.
12. Walters, J. P. *Analyt. Chem.* **1991,** *63,* 977A–985A, 1077A–1087A, 1179A–1191A.
13. Jackson, P. J.; Walters, J. P. *J. Chem. Educ.* **2000,** *77,* 1019–1025.
14. Walczak, M. M.; Jackson, P. T. *CUR Quarterly* **2005,** *25,* 132–137.
15. Vermont Safety Information Resources, Inc. (SIRI). *http://hazard.com/msds/* (accessed May 2007). Chemical company and distributor provided resources, for example, Fisher Scientific. *https://new.fishersci.com/wps/portal/HOME?LBCID=04011725* (accessed May 2007).
16. U.S. Department of Health and Human Services. NIOSH Pocket Guide to Chemical Hazards. *http://www.cdc.gov/niosh/npg* (accessed May 2007).
17. Mabrouk, P. A. *J. Chem. Educ.* **1996,** *73,* A23–A25; *Anal. Chem.* **1998,** *70* (1), 44A–48A.
18. Brusaw, C. T.; Alred, G. J.; Oliu, W. E. *Handbook of Technical Writing,* 3rd ed.; St. Martin's Press: New York, 1987.
19. University of Maryland Libraries. Preparing an Annotated Bibliography. *http://www.lib.umd.edu/UES/annotate.html* (accessed May 2007).