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Ruth M. Owens

SUNY College of Environmental Science and Forestry, rmowens@esf.edu

Arthur J. Stipanovic

SUNY College of Environmental Science and Forestry, astipano@esf.edu

Mark A. Teece

SUNY College of Environmental Science and Forestry, mteece@esf.edu

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RESERVE THIS SPACE

Integrating Information Literacy and Research Strategies into a Sophomore Chemistry Course: A New Collaboration

Ruth M. Owens,*¹ Arthur J. Stipanovic,² Mark A. Teece²

¹F. Franklin Moon Library, SUNY College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY 13210, rmowens@esf.edu

²Department of Chemistry, SUNY College of Environmental Science and Forestry, 1 Forestry Drive, Syracuse, NY 13210, astipano@esf.edu,
mteece@esf.edu

Librarians at the State University of New York College of Environmental Science and Forestry (SUNY ESF) teach a one-credit information literacy course which is required for several majors. For many years, a section of this course was integrated into a senior level professional chemistry course. Students in this course work with chemistry faculty to develop a research proposal, and spend five weeks with the chemistry liaison librarian learning library and information research skills related to their topics. Recognizing that students need to begin learning research and career skills sooner than their senior year, chemistry faculty approached the library to work with them in integrating information literacy skills into a new sophomore level course. During this new course's pilot semester, the chemistry liaison librarian was invited to teach two class sessions and to develop an assignment for students to help them write a paper on a chemistry topic. This chapter discusses specific outcomes, topics covered, assignments, observations, and future directions of the information literacy instruction in this new sophomore level course.

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Introduction

Information literacy has a long history at the State University of New York College of Environmental Science and Forestry (SUNY ESF), and librarians have taught a one-credit course on information seeking skills for many years. Historically, this course has been integrated in the senior year of the chemistry curriculum. In recent years, chemistry faculty recognized the need for chemistry majors to learn information literacy skills sooner in their college career. This chapter presents a new collaboration between chemistry faculty and a librarian to develop a new chemistry course with an information literacy component.

In the published literature, librarians and chemistry faculty have reported on their collaborations, many of which go beyond the “one-shot” library information sessions and move towards integrating library and research information skills into course content and assignments. Information literacy skills taught by a librarian as part of chemistry labs have involved students working through guided exercises (1, 2). Jensen, Narske and Ghinazzi also reported on efforts made at Augustana College to develop what they call “chemical research literacy” into the organic chemistry course sequence (3). This effort included a presentation by the science librarian and three assignments that guided students through “evaluat[ing], interpre[ting], and incorporat[ing] chemical literature when communicating” (3). A deeply integrated approach from the University of Rochester has developed over several years into a chemical information instruction program spanning all four years of an undergraduate experience in lecture and laboratory courses (4). A one-credit chemical information literacy course was implemented at Goucher College with the purpose of developing chemistry major sophomores’ skills in information literacy to better prepare them for course work in upper-division chemistry courses (5). Librarians and chemistry faculty partnered together at James Madison University to update a Literature and Seminar course in which chemistry faculty and librarians team teach chemical information literacy skills (6). In this case, faculty and librarians indicated that research skills needed by students have changed to not just searching skills, but to filtering and evaluating skills as there is much more information to sift through (6). The chemistry faculty and librarians at SUNY ESF also made this observation, which was a major factor leading to the development of a new course for chemistry major sophomores.

Librarians are familiar with using the Information Literacy Competency Standards for Higher Education from the Association of College and Research Libraries (ACRL) to develop learning objectives for their library instruction

sessions (7). Regarding chemistry and information literacy, most of the models in the literature refer to the Information Competencies for Chemistry Undergraduates developed by the Special Libraries Association (SLA) and the American Chemical Society (ACS) (8). Both the ACRL standards and the SLA and ACS competencies were consulted as part of the development of the information literacy component of the new course described in this chapter. The most common competencies referred to include:

- Understand how information is organized in the library (databases, catalog, research guides, etc.) and the basics of how scientific information is communicated (i.e. peer-review process in publishing) (8).
- Know how to search for and find chemical information such as background information and journal articles (8).
- Clearly present research in an ethical manner, particularly as it relates to proper citation and formatting and use of a citation manager (8).

Librarians at SUNY ESF have also worked to integrate information literacy into the broader chemistry curriculum. The SUNY ESF campus community consists of about 2,000 students and 200 faculty and is situated adjacent to Syracuse University in Syracuse, New York. Librarians at Moon Library at SUNY ESF hold liaison responsibilities for each of the academic departments on campus. Each librarian teaches at least one section every semester of a one-credit information literacy course. Several of the undergraduate degree programs require completion of this information literacy course (often called ESF 200), and the chemistry Bachelor of Science degree is no exception.

The first exposure to information literacy concepts and library resources for chemistry major students at SUNY ESF is through the first-year orientation seminar. This required course introduces first-year and transfer students to the chemistry major program and orients them to various campus services (student affairs, career services, library resources, etc.) to help them be successful in their chemistry major and college in general. The chemistry liaison librarian (henceforth referred to as the CLL) is invited each year to a class period to introduce library services, databases (including SciFinder), and other informational resources. Historically, students have been advised to take the one-credit information literacy course (ESF 200) during their senior year in conjunction with the professional chemistry course. ESF 200 has been taught by SUNY ESF librarians since its inception in 1973 (9). This 200-level course, populated mostly by sophomores, meets three hours a week for five weeks each semester and is required by several degree programs. ESF 200 incorporates learning outcomes developed in accordance with the ACRL information literacy standards (7). Re-visioning of the course to reflect the new ACRL Framework for Information Literacy for Higher Education is currently in progress (10). The course is organized around five units which include: Catalog Searching, Database Searching, Internet Searching, Topic Selection, and a Final Project.

Each of these units has a specific graded assignment to assess student learning. Students also complete a final project of which examples include bibliographies (sometimes annotated) of a variety of sources on a research topic or posters of recommended books, journals, databases, and websites on a specific research topic.

In 1977, ESF 200 was made a requirement for chemistry students as part of the Professional Chemistry course (FCH 495) (11). And, since the 1990s, there has been a specialized section of ESF 200 integrated with FCH 495. The CLL has taught these specialized sections and linked them to the corresponding course. As part of the senior year professional chemistry course, students write a research proposal that is the basis of their research project in the following semester. These proposals require literature reviews and are submitted for a round of reviews by chemistry faculty before final grading. The intent for integrating the information literacy course with this professional chemistry course was to teach students literature searching skills to aid them in preparing their research proposals.

Table 1 shows the progression of information literacy instruction for chemistry students at SUNY ESF along with the changes that are discussed in this chapter. Based on the examples in the literature, the long history of information literacy at SUNY ESF, and the need to revise instruction to better meet students' needs, this chapter focuses on how the CLL and chemistry faculty members have worked together to integrate information literacy into a new sophomore level chemistry course, Career Skills for Chemists (FCH 232). In this new course, students are introduced to various aspects of chemistry, including career information, which they will need to work towards as they continue their studies and look for employment. FCH 232 does not replace ESF 200 because each has a different focus, but both courses are still a requirement for chemistry majors.

	First Year	Sophomore Year	Senior Year	
Course	FCH 132: Orientation Seminar	FCH 232: Career Skills for Chemists	FCH 495: Professional Chemistry	ESF 200: Information Literacy
Notes	CLL visits class each fall	-CLL teaches two classes and grades library assignment - New course since 2013 -Beginning 2015, students also take ESF 200		-Taught by CLL and previously integrated in FCH 495 - As of 2015 no longer integrated in FCH 495; students take first year or sophomore year

A Need for Change

Although integrating the one-credit information literacy course with the senior professional chemistry course was valuable, this arrangement was ultimately not the most helpful to students since they were not learning searching and information retrieval skills until their senior year. Chemistry faculty who taught the professional chemistry course and other lower division chemistry courses realized that students lacked basic skills needed to locate literature for lab courses, independent research experiences, and term papers in various science and engineering courses. There was too much of a gap between the CLL visiting the freshman chemistry orientation seminar class and students taking the information literacy course during their senior year. Chemistry major seniors would indicate on the end-of-course surveys that they wished they had learned these skills and taken the course sooner. Librarians and chemistry faculty at SUNY ESF were in agreement that information literacy skills are valuable throughout an undergraduate's time in college; and these concepts should be taught in the freshman or sophomore year. This chapter focuses on one solution that began in the fall semester of 2013.

Chemistry faculty noted that students' main source of information was the internet and the information students were finding was not peer-reviewed, often biased, and frequently incorrect. They also observed that students would typically find one research article from a Google search that may or may not have been recent or peer-reviewed. Students then assumed this was sufficient to proceed with a project. They lacked the ability to do a structured search focused on key words or concepts and they generally did not use critical thinking when evaluating the relevance of prior work that they found. Upper-division chemistry courses require proper citation of sources, and students lacked knowledge of the elements of a citation and a specified citation style. Often they would copy and paste a citation from the internet into their papers without properly using in-text citations and a correctly formatted bibliography.

To address the undergraduate students' need for certain skills earlier in the chemistry curriculum, the chemistry faculty authors of this chapter decided to design a new sophomore-level course called Career Skills for Chemists (FCH 232). Reasons for starting this course included the following:

- Faculty wanted students to start thinking about chemistry as a career rather than simply an academic subject.
- Chemistry students needed to become familiar sooner in the curriculum with skills that had been historically taught in the senior year so they could utilize and practice them. These skills include various aspects of technical writing

and public speaking, information literacy, concepts in academic integrity and professional ethics, and the ability to find jobs and internships coupled with interviewing skills.

- The development of *esprit de corps* within the cohort taking the course (mainly sophomores and transfer students) to enhance retention in the chemistry curriculum.
- To facilitate student interaction with successful alumni of the chemistry program who have pursued a diversity of careers.

To assist with teaching information literacy skills, chemistry faculty asked the CLL to lead two class sessions in the new course. Those sessions focused on locating literature to inform a position paper, one of the course's assignments. Chemistry faculty recognized that the librarian's knowledge and experiences in teaching the required information literacy course for chemistry seniors would benefit the development of this new course. Chemistry faculty also recognized that librarians are far more familiar with current databases, search techniques, availability, and location of information; and by working with librarians who know the newer resources and techniques, they have been informed of the multitude of databases which are easier to use. Furthermore, chemistry faculty recognized that librarians are more adept at teaching and explaining the fundamentals of literature searches and citation styles whereas chemistry faculty indicated that, in many instances, they assume a much greater understanding of students' knowledge of web searching for specific information.

A New Collaboration

In the summer of 2013, the two chemistry faculty who were developing this new course for chemistry sophomores began working with the CLL to develop the information literacy portions of the course. One demonstrable outcome of this new course would be that students would be able to develop skills in information literacy to facilitate conducting a survey of technical publications for the purpose of writing a position paper on a subject in polymer, environmental, biochemistry, or natural products chemistry. The librarian visited FCH 232 twice, once each in the sixth and seventh weeks of the 14-week-long semester, to discuss literature searching and formulating citations for the position paper assignment. There were eight students enrolled in this course. Each class was fifty minutes long and met once a week. The CLL developed an assignment to guide students through a research strategy, and graded it to gauge their success (see Figure 1).

Name _____

FCH 232 Library Assignment - Develop a Search Strategy

INSTRUCTIONS: Fill in the blanks below and answer the questions about how you conducted your search strategy for your position paper. Using APA style, please list at least 8 citations of articles and/or sources you found for your paper. Add more lines or another sheet of paper if you need more room. See the FCH 232 Research Guide (<http://libguides.esf.edu/FCH232>) for more information. This assignment is due October 15, 2013 and is worth 100 points.

What is your research topic? Write a short paragraph describing your topic. List keywords relating to your topic:

Describe, in detail, how you combined your keywords to search for articles on your topic.

List at least two (2) databases you searched and explain why you chose each one.

Which database did you like searching best? Why? What did you not like?

According to what you learned in class, what is a peer-reviewed article or journal? (Remember most of your sources must be peer-reviewed!)

Source Citations: Format in APA style as you would in your references page at the end of your paper. You must have at least eight (8) sources listed and six (6) of those must be peer-reviewed.

Figure 1. Library Assignment for FCH 232 in Fall 2013. These questions were spaced out over two pages.

Information Literacy Class Sessions

The information literacy class sessions took place in a computer lab so that students could actively work on their assignments. PowerPoint and live database demonstrations were used by the CLL to teach during these sessions. The authors of this chapter collaborated to decide on the desired outcomes for these

information literacy sessions. These outcomes (listed below) were informed by the ACRL Information Literacy Competency Standards and the Information Competencies for Chemistry Undergraduates as discussed earlier.

- Outcome 1: Students will be able to develop a search strategy to find literature on a topic.
- Outcome 2: Students will be able to search in designated library databases.
- Outcome 3: Students will be able to identify a peer-reviewed article.
- Outcome 4: Students will be able to correctly format literature citations according to APA style.

The first class session introduced strategies for finding a topic in which students were interested and then locating a corresponding news article that they could use as they developed their position for their paper. The CLL reviewed databases such as Opposing Viewpoints from Gale and Newspaper Source Plus from EBSCO as places to help students begin to refine a topic and find a popular news source. The New York Times Science section and Scientific American were also suggested as sources for the news article. Also during this first information literacy class session, the librarian introduced basic search strategies such as developing a list of keywords and concepts, using connectors (Boolean and other), and applying limiters within databases. Students would begin to use these strategies in the next class as they searched for scholarly articles on their topics.

The second information literacy class session built upon the search strategies taught in the first session and required that students apply them by using databases to locate peer-reviewed articles. Chemistry faculty had asked that only two databases be discussed as they had observed students being overwhelmed with the number of databases available to them. The two databases discussed were SciFinder, from Chemical Abstracts Service, and ScienceDirect, from Elsevier. SciFinder was requested by the chemistry faculty because students will use it throughout their time as chemistry undergraduates and in their careers. ScienceDirect was chosen by the CLL because it contains a wide range of science and chemistry related publications. Students were instructed on the basics of searching each of these databases to retrieve relevant articles. The CLL then taught students the essentials of APA style (which was the required style for this course), particularly for journal articles, and provided a two-page guide with examples. The CLL also created an online guide via LibGuides to reiterate some of the information taught in class and point students to relevant resources such as citation managers (12). Students were given about ten to fifteen minutes at the end of the second class session to work on searching for articles in the databases. This time of searching was unstructured, but students asked questions and the CLL and chemistry faculty were able to provide assistance. At the end of the session, the CLL told students they were welcome to seek help from her, or other librarians, as they completed their assignments. Only

one student of the eight-person class asked the CLL for assistance outside of class.

Library Assignments

The chemistry faculty asked the CLL to create and grade a library assignment to help students work towards what was needed for the position paper. The library assignment was due one week after the second information literacy class session and each student completed their own assignment. The assignment asked students to:

- Write a short paragraph describing their topic
- Write down keywords they planned to use for searching databases for literature on their topics
- Demonstrate how they planned to combine and search those terms
- Identify which databases they searched and any problems they encountered
- Give a definition of a peer-reviewed journal article
- Include a list of references formatted according to APA style

Figure 1 shows the full library assignment as given to students. Table 2 shows the library assignment questions and point values as they correspond to the outcomes for the information literacy class sessions. Initial observations indicated that students encountered the most trouble generating a correctly formatted references list, even when using citation manager software; however, most students were able to find relevant sources for their paper.

The Position Paper

For the position paper assignment, students were asked to locate a current event or issue reported on in a newspaper or popular magazine on a topic related to environmental chemistry, biochemistry, natural product chemistry, or polymer chemistry. This topic needed to be something arguable so that students could take a stance on the subject matter. Students were then asked to find 8-10 scholarly, peer-reviewed articles to help develop their argument in a written paper. A correctly formatted APA references list, including the popular news article, was also required for the paper. Position papers were due six weeks after the information literacy sessions.

Table 2. Information Literacy Outcomes and Library Assignment		
Corresponding Outcome	Library Assignment Question	Grade Value (100 points possible)
Outcome 1: Students will be able to develop a search strategy to find literature on a topic.	What is your research topic? Write a short paragraph describing your topic.	5 points
Outcome 1: Students will be able to develop a search strategy to find literature on a topic.	List keywords relating to your topic.	5 points
Outcome 1: Students will be able to develop a search strategy to find literature on a topic.	Describe, in detail, how you combined your keywords to search for articles on your topic.	15 points
Outcome 2: Students will be able to search in designated library databases.	List at least two (2) databases you searched and explain why you chose each one.	5 points
Outcome 2: Students will be able to search in designated library databases.	Which database did you like searching best? Why? What did you not like?	5 points
Outcome 3: Students will be able to identify a peer-reviewed article.	According to what you learned in class, what is a peer-reviewed article or journal?	10 points
Outcome 3: Students will be able to identify a peer-reviewed article. Outcome 4: Students will be able to correctly format literature citations according to APA style.	APA References List with at least eight sources, six of which must be peer-reviewed.	55 points: -30 points for at least 8 sources -5 points for "References" title -20 points for APA formatting

Evaluating the Information Literacy Class Sessions in FCH 232, Fall 2013

The CLL assessed the students' achievement of the information literacy outcomes by grading the library assignments and sending the grades to the chemistry faculty. The CLL and chemistry faculty discussed students' performance on the assignments later in the semester. Overall, students did well on the assignment and achieved grades in the range of 80-100 percent. Students were able to articulate variations of search terms and how they combined those terms to search for sources on their topic (Outcome 1). They struggled, however, with correctly titling their references list in accordance with APA style, which relates to Outcome 4. Even though it was discussed in class that the correct list title is "References," most students did not title their lists. This further indicates that students did not use (or correctly use) a citation manager/generator as suggested in class.

The library assignments were graded according to the point values shown in Table 2. Rather than using a rubric, the CLL assigned grades for each question based on whether the student answered the question correctly and included a description of their thought process, particularly for the more open-ended questions. Students lost points if they consistently missed elements of citations, such as not listing references alphabetically, not listing enough authors, missing publication titles, volume, and issue numbers, etc. Because APA style was the required format for this part of the assignment and the elements of APA style were discussed in class, it was important that students be able to employ this style.

Students achieved similar grades on the position paper as they did on the library assignment. Formal mapping and assessment of the information literacy outcomes was not done with the position papers. However, chemistry faculty observed that students still struggled with properly citing their work and formulating their reference lists. It was also evident that students did not completely understand the position paper genre as many students did not find a news source that informed the student authors in taking a stance on the topic. Many students wrote typical research papers, with no discussion of the pros and cons of the topic they wrote about.

At the end of the semester, the chemistry faculty and the CLL discussed how the course and the information literacy sessions went. All had positive reactions regarding the new course and the information literacy class sessions as a whole. As the CLL later reflected on the experience and discussions with the chemistry faculty, a few issues rose to the surface to address in the future. First, it would be beneficial to have more time in class for students to work on searching the literature and have the librarian there to help. Second, instruction on citations needed to be more specific on each piece of a citation and give more of an

indication of what is expected of students by way of correct citation format. Lastly, the assignment should be reformatted to include more critical thinking questions, such as discussing why it is important to cite sources correctly and how to determine what type of source (popular, scholarly, newspaper, peer-reviewed, etc.) is needed or has been found. With only observations (no data) on the background of skills that students possessed before taking the Career Skills for Chemists course, the authors were not able to truly assess improvement of information literacy skills. The next section discusses the method addressing this issue the chemistry faculty and librarian are presently working towards.

FCH 232 and Information Literacy Since Fall 2013

The Career Skills for Chemists course (FCH 232) was offered again in Fall 2015. Between 2013 and 2015 the course was made a requirement for the sophomore chemistry majors. Additionally, the one-credit information literacy course (ESF 200) is no longer integrated into the Professional Chemistry course for senior chemistry students, but it is still a required course for the chemistry program. Students are advised to take ESF 200 as first-years or sophomores.

Fourteen students enrolled in FCH 232 in the Fall of 2015, and the CLL again visited the class twice in the middle of the 14-week-long semester. Much of what was done in the Fall of 2013 was repeated as described above, but some changes were made based on the CLL's reflections on the first course. Instead of one library assignment, students were given two assignments to complete. Students partially completed these assignments during the class sessions taught by the librarian. The questions were similar to the original assignment from 2013, but split into two groups. The first assignment focused on finding a popular news source and brainstorming keywords and developing a search strategy. The second assignment focused on searching for scholarly articles and putting together a reference list in APA style. The librarian graded the assignments and by having two assignments, students were able to get feedback throughout the process of beginning to research for their position paper. Students did well on the assignments much like the students two years prior. Grading of the library assignments was similar to what was described above, and grades were better overall compared to the grades given in Fall 2013. Position paper grades were also better than the first time the course was offered, particularly the pro/con arguments and use of peer-reviewed articles. The authors discussed how the Career Skills for Chemists course went this second time and observed that the information literacy class sessions were useful for the students and they were better able to complete the position paper assignment. By having two library assignments, students were able to receive some feedback before moving to the

next library assignment, which likely helped them work through their research process for finding sources for the position paper.

As the Career Skills for Chemists course continues with the information literacy component, more and better assessment is needed to determine its effectiveness formally. Developing a better rubric for grading the library assignments and matching that to the outcomes for the information literacy component is critical and is currently in progress for Fall 2016. As students move through the chemistry curriculum after taking the Career Skills for Chemists course (and the one-credit information literacy course), it will be necessary to develop a process to see how students' information literacy skills improve. This might be accomplished by developing a metric that measures senior students' success in research proposals from the Professional Chemistry course and how that compares to what they learned as sophomores, or through a departmental graduation or exit survey. It would also be prudent to link the Career Skills for Chemists information literacy assignment to those used in the one-credit information literacy course assignments that chemistry majors also complete.

Conclusion

From the CLL's perspective, this collaboration with chemistry faculty in working with the new Career Skills for Chemists course has been valuable. It was important to get to know the chemistry major students earlier in their time at SUNY ESF. It was also valuable to begin to assist them with information literacy skills that not only help them in their studies, but are also skills they will use throughout their careers. From the faculty's perspective, this collaboration strengthened students' use of literature sources and library resources. In particular the relevance of literature that was cited in papers was of a higher level than in previous classes. A few students who were in the pilot FCH 232 class in 2013 took a graduate level course with one of the authors of this chapter in the Spring 2016 semester. He observed that those students' term papers were more inclusive of peer-reviewed journal papers compared to website citations as seen in the past. One student even included a section on search strategy. Clearly, these students better understand the quality distinction between peer-reviewed articles versus openly sourced (website) information. Instruction in chemistry-specific library resources was particularly helpful for students as they are often overwhelmed by the abundance of databases available and invariably rely on Google, whereas through this collaboration with the CLL these students used scientific databases more extensively. As the course continues in future semesters, it will be essential to formally assess students' learning, possibly in

conjunction with the one-credit information literacy course and the senior professional chemistry course. An assessment of this nature would be useful to see how information literacy skills are needed and developed throughout the chemistry undergraduate experience at SUNY ESF.

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