

Integration of Information Literacy Components into a Large First-Year Lecture-Based Chemistry Course

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Supporting Information

ABSTRACT: A first-year chemistry course is ideal for introducing students to finding and using scholarly information early in their academic careers. A four-pronged approach (lectures, homework problems, videos, and model solutions) was used to incorporate library research skills into a large lecture-based course. Pre- and post-course surveying demonstrated this to be effective and scalable way to teach these life-long skills, requiring minimal additional effort and time on the part of the lecturer.

KEYWORDS: First-Year Undergraduate/General, Curriculum, Interdisciplinary/Multidisciplinary, Physical Chemistry, Communication/Writing, Internet/Web-Based Learning, Student-Centered Learning

Knowing how to find appropriate scholarly information is an essential skill for all undergraduate students. During the past decade, greater interest has emerged among educators in teaching students how to search for, find, and use scholarly information. A variety of recent efforts centered around chemistry education have had considerable success in improving students' scholarly research skills and discipline-specific information literacy.^{1–5} For example, Forest and Rayne found that by including primary literature summary projects in the first-year chemistry curriculum, chemistry majors developed increased appreciation for chemistry and reported that they felt better prepared for subsequent chemistry classes.⁶ These efforts are not limited to classes for chemistry majors, some chemistry classes for nonscience majors also provide training on how to search for relevant scholarly chemical information.^{7,8} Although library search skills are taught in the context of a chemistry class, they are generalizable and of value regardless of the student's major. Moreover, a core first-year chemistry course provides an excellent environment for teaching basic information skills early in a student's academic career. In this light, the Discovering Scientific Information Program (DSIP) was introduced into the first-year, solid-state chemistry course: a class that includes more than 500 students, which is more than half of the first-year class. The program explores the nature of scholarly literature, and the processes and skills required to conduct successful literature searches.

Working with the teaching and learning laboratory staff, the course professor and librarian embarked on a two-year study to explore the impact of DSIP. The study was guided by the following questions:

- By the end of the semester, what value did students place on scholarly research skills?
- What impact did DSIP have on students?
- Did students' confidence as scholarly researchers increase?

The findings are summarized here.

CURRICULUM DESIGN AND DEVELOPMENT

A variety of factors were considered in the design and development of DSIP. These factors included the choice of database(s), the ease of integration of the project into the existing course content and structure, and minimization of the amount of additional work for the faculty member.

Choice of Articles and Materials

The large class-size imposed a considerable restriction on the databases and on the other online library resources that could be used for student assignments. Initially, the faculty member wanted students to experience the Chemical Abstract Service (CAS) database, SciFinder. However, with only 11 simultaneous seats available at this university and over 500 students enrolled in this course, this was not a viable option. Because access to the article database Web of Science does not have seat restrictions and it indexes the core literature for chemistry and physics, it was selected as the primary tool to use for the course. The article database Inspec was also included due to its coverage of physics literature. On the basis of the librarian's extensive knowledge of both the content and the accessibility of the library collections, she was able to create assignments and select electronically available articles for the assignments. This ensured equal access for all students and avoided a common outcome of many library assignments wherein all students are expected to find and use one, singular print resource.

Ease of Integration of the Project into the Existing Course Content and Structure

The history of important discoveries in chemistry and physics, with emphasis on the significance of primary sources, was an integral part of the curriculum *prior* to the inception of this program. In this regard, the introduction of a scholarly research component into this course was a natural addition to the course.

Published: February 14, 2012

Minimization in the Amount of Additional Work for the Faculty Member

On the basis of a 2005 survey to help chemistry departments identify difficulties in implementing chemical information instruction, “not enough time in courses” and “faculty too busy” were indicated as barriers.⁹ The design of DSIP enabled the faculty member to focus on the core domain specific scientific content of the course, while allowing the librarian to address the information literacy component. The librarian and faculty member met several times to select appropriate resources for the assignments, then the librarian created the assignments and brought them back to the faculty member and teaching assistants (TAs) for feedback. This close, yet highly specified collaboration between librarian and faculty member, as noted in previous studies,^{1,7} is essential to the success of this type of project.

DSIP was also informed by the results of a pilot course of 13 students taught in the fall of 2006.¹⁰ The current course consists of four primary components.

Lectures. As a part of the standard class meeting times (lectures), the faculty member periodically discussed various aspects of scholarly research. He or she also modeled the online search process by utilizing an online database (licensed by the university libraries) to locate primary sources of relevance to the current lecture material.¹¹ This component required approximately 5 min of lecture time and 30 min of preparation time by the faculty member.

Homework Problems. As part of the course requirements, students were expected to complete three assignments designed to build scholarly research skills, accounting for approximately 2% of the final course grade. Librarians created these assignments with input from the faculty member and course TAs. Each assignment focused on a different primary source, but the skills and tools used, such as seeing how many times the paper was cited using ISI's Web of Science, were comparable in all three assignments (see the Supporting Information).

Video Tutorials. As reported by Maness, “video tutorials are indeed adequate alternatives to live lectures”.¹² With this in mind, students were encouraged to watch six online videos that were each 1–5 min in length. These videos addressed information literacy topics and demonstrated how to conduct online searches in ISI's Web of Science. In addition to the recommended video tutorials, a set of optional videos were also made available to students. These videos delved into other information competencies for chemistry undergraduate students,¹³ such as the scholarly publication cycle and searching the library catalog, but they did not relate directly to the assignments. All videos were created by librarians, taking approximately 60 min per video for initial creation. The videos are hosted on the university's free video service.¹⁴ By relying on online videos to teach the skills needed to complete the assignments, the faculty member did not need to alter the traditional course curriculum. In addition, it allowed students to review the material on demand.

Model Solutions. After completion of the homework problems, students received model answers provided by librarians (see the Supporting Information).

It should be noted that the program included neither visits to a physical library nor any face-to-face interactions with librarians; this was intentional. Students were encouraged to use the video tutorials for their assignments. Participants were not introduced to any one librarian as they are typically “assigned” a subject-specific librarian when they declare their

majors at the end of the first year. In fact, students were encouraged to complete the assignments without consulting a librarian. However, all service-desk staff and reference librarians were provided with the homework assignments and model solutions to refer to if questions were asked.

Prior to and immediately following the completion of each homework assignment, the course faculty and TAs met with the lead librarian. These sessions helped to clarify the wording of the assignments, guide TAs on how to answer common questions, and emphasize the importance of these assignments in the overall coursework.

■ SURVEY OF STUDENT LEARNINGS

Subjects

Participants include first-year students enrolled in the fall 2007 or fall 2008 introduction to solid-state chemistry course.

Description and Analysis

The study included three surveys: library skills pre-survey, library skills post-survey, and learning experience survey. Each survey was given twice. The pre-survey was administered once in September of 2007 and in September of 2008; whereas the other two surveys were administered in early December of each year.

The library skills pre-survey explored students' confidence in library skills. Students rated their confidence using a five-point scale: not confident at all (1), only slightly confident (2), somewhat confident (3), confident (4), and very confident (5). The library skills post-survey included the same confidence items as the pre-survey. The learning experience survey (see the Supporting Information) addressed scholarly research beliefs and impact on online search skills and scholarly research behavior. In contrast to the library skills pre and post-surveys, the learning experience survey required students to use a seven-point Likert scale to indicate their level of agreement with statements that addresses beliefs, impact, and learning experience. The following phrases represent seven possible levels of agreement: strongly disagree (1), disagree (2), slightly disagree (3), neutral (4), slightly agree (5), agree (6), and strongly agree (7).

SPSS 17.0 for Mac was used for all statistical procedures; descriptive statistics to profile scales, scale items, and related scale items; principal component analysis (PCA) and factor analysis (FA) to generate survey scales; coefficient alphas to provide measures of scale reliability; repeated measures analysis to examine differences among items related to primary source searches; and paired samples *t* test to compare students' pre-post scale means.

Statistical Protocols Used To Construct Survey Scales

To provide stable and comprehensive measures of the impact of the DSIP curriculum, three scales were developed. A survey scale consisted of a group of related survey items that collectively represented a given behavior. A group of items were initially identified from the library skills survey to represent a confidence-in-library-skills scale (confidence) and two groups of items were identified from the learning experience scale to represent beliefs about scholarly research skills scale (beliefs) and impact on search skills scale (impact-skills).

A cross-validation design followed to determine scale homogeneity, stability, and viability. Principal components analysis (PCA) and factor analysis (FA) were run on the 2007

cohort data to determine which survey items should compose each scale. These results were confirmed by running PCA and FA on the 2008 data. See Table S1 in the appendix (in the Supporting Information) for cross-validation FA factor loadings and description of the FA protocol. A list of each scale's items and its coefficient alpha can be found in Tables S2, S3 (appendix).

RESULTS AND DISCUSSION

Six hundred and fifty-nine freshmen completed the library skills pre-survey, library skills post-survey, and learning experience survey: 293 participated in 2007 ('07 cohort) and 366 participated in 2008 ('08 cohort) with response rates of 46% (293/632) and 67% (366/547), respectively. The two cohorts responded similarly on the three surveys. Because of this similarity, this section reports on beliefs and findings based on combined 2007 and 2008 data.

Learning Experience Survey-Scholarly Research Behavior during the Semester

Responses to several questions suggest that by the end of the semester students had begun to adopt DSIP behaviors: 40% reported using research tools (online library databases) during the semester for class assignments other than the chemistry course. In addition, 28% indicated use of such tools to look up articles unrelated to class assignments. Given that pre-survey responses suggested that many first-semester first-year students possessed limited knowledge of online skills, these usage responses are encouraging; they imply that during the semester students began to apply what they learned.

Learning Experience Survey-Beliefs about Scholarly Research Skills

The DSIP curriculum emphasizes that scholarly research skills are important for first-year students to acquire, are essential for academic and professional success, and play a significant role in judging the validity of information. Data in Table S2 reveal the degree to which students agree with these statements. The beliefs scale consists of four items that collectively measure how well students' beliefs reflect the DSIP themes. On average, students responded to each scale item with a 5.45 (scale range is 1–7 with 4 as neutral). This relatively high mean suggests that students value scholarly research skills. Means of several scale items demonstrate how strongly they hold these views:

- I believe scholarly research skills are valuable skills for freshman to learn. 5.75
- Knowing how to conduct scholarly research plays an important role in one's professional life in judging the credibility of information. 5.66
- I believe knowing scholarly research skills will be of value beyond my academic work. 5.47

Responses to three nonscale items illustrate students' awareness of the importance of scholarly research and indicate strong student support for the inclusion of scholarly research skills in the course.

- I believe the scholarly research skills I learned will be relevant to my academic work at MIT. 5.67
- I believe the scholarly research skills I learned will be useful during my undergraduate experience. 5.62
- I see the value of introducing scholarly research skills into the course. 5.12

Learning Experience Survey-Impact on Online Searching Skills

The impact-skills scale provides a measure of the impact of the curriculum on online search skills in terms of awareness, usage, and increased effectiveness. The scale's mean of 5.03 suggests that respondents view the program as having a significant impact. They responded positively to all seven-scale items; for four of the items, the means were greater than 5.00, which is a clear indicator of the program's impact. Their responses indicate that as a result of the scholarly research training they are more aware of the large number of resources they are able to access online (5.45), more likely than before to use the library's online research tools to identify relevant materials (5.25), and more able to function effectively as a researcher (5.05) (see Table S3 in the appendix in the Supporting Information)

Students indicated that, as a result of the DSIP training, they knew how to search for primary sources (Table 1, a). When this

Table 1. Differences in Knowing How To Search, Appreciating, and Actually Searching Primary Sources^a

Statement	Mean ^a (SD)	N
(a) As a result of the scholarly research training, I know how to search for primary sources.	5.05 (1.52)	656
(b) As a result of the scholarly research training, I appreciate the importance of primary sources.	4.75 (1.56)	653
(c) As a result of the scholarly research training, I am more motivated to search for primary sources.	4.57 (1.56)	656

^aStudents used a seven-point Likert scale to indicate their level of agreement with each statement: strongly disagree = 1, disagree = 2, slightly disagree = 3, neutral = 4, slightly agree = 5, agree = 6, strongly agree = 7.

behavior is compared to two related behaviors (Table 1, b, c), an interesting pattern emerges. The three statements represent a continuum from knowing to doing: knowing how to search for primary sources, appreciating their importance, and being motivated to search for them. The three means are respectively 5.05, 4.75, and 4.57; thus, as the behavior shifts from knowing to doing, the means decrease. A repeated measures procedure (Table 2) was performed on the three items. Results indicate that the three means differ from one another at statistically significant levels, which suggests that more than chance accounts for the differences. We speculate on the causes. Given their academic workload and pace, students may be reluctant to devote time to searching for primary sources, a process that they may view as too time-consuming. Another possible cause for the difference might be that greater instructional effort is necessary for students to change behavior such as overcoming reluctance to search for primary sources (doing) than to learn how to conduct online skills (knowing).

Library Skills Survey-Confidence

On the pre-survey, students expressed confidence using Google, understanding the meaning of plagiarism, and understanding the difference between primary and secondary sources. They reported less confidence about using EndNote and RefWorks, the libraries' Web page, article databases, and print or online library resources. They also reported little confidence in both understanding the scientific publication cycle and in knowing which library to use to research a specific topic. On the post-survey, students expressed confidence in the use of citations, call numbers, and publications such as

Table 2. Repeated Measures Results Using the Wilks' Lambda Distribution^a

Primary Sources (I)	Primary Sources (J)	Mean Difference (I - J)	SE	Sig
I know how to search for primary sources.	2. I appreciate the importance of primary sources.	0.296	0.041	0.000
	3. I am more motivated to search for primary sources.	0.470	0.044	0.000
	1. I know how to search for primary sources.	-0.296	0.041	0.000
I appreciate the importance of primary sources.	3. I am more motivated to search for primary sources.	0.174	0.036	0.000
	1. I know how to search for primary sources.	-0.470	0.044	0.000
I am more motivated to search for primary sources.	2. I appreciate the importance of primary sources.	-0.174	0.036	0.000

^a $F = 55.958$, hypothesis $df = 2$, error $df = 647$.

handbooks, encyclopedias, and journals as well as confidence in the three areas they indicated on the pre-survey. They showed the least confidence in the use of EndNote and RefWorks, understanding the scientific publication cycle, and knowing which library to use. These areas of least confidence were not covered in primary content, although they were included in the optional videos.

In terms of pre-post comparisons, the results are positive. For 15 of the 18 library skills, students showed improvement. Moreover, the mean of the confidence scale increased from 3.24 to 3.67 on a five-point scale, a statistically significant difference that demonstrates the strength of the impact of the curriculum on students' library skills. These results, added to the evidence of the impact data from the learning experience survey, present a strong case for the effectiveness of the curriculum.

The largest pre-post increases relate to using citations, libraries' Web page, article databases, and print and online library resources such as journals and full-text articles. The three skills in which students reported no gains relate to the meaning of plagiarism, use of Google, and knowing how to contact library staff for assistance. In each case, the lack of gain can be explained. Because students reported a high level of confidence about their understanding of plagiarism on the pre-survey, a ceiling effect precluded the likelihood of their making additional gains. As for Google, it was not the aim of the curriculum to increase students use of Google, but to introduce them to other search engines. That students made no gain in learning how to contact library staff for assistance may relate simply to the curriculum not discussing the roles of librarians, how they may serve as resources, or the context in which first-year students may want to seek support from the library staff (see Table S4 in the appendix).

CONCLUSION

Students strongly support the inclusion of scholarly research skills in the solid-state chemistry course. They see the value of introducing these skills into this course and believe that the skills will be relevant to their academic work. They reported that the DSIP experience had an impact on their online search skills in terms of awareness, usage, and increased effectiveness. They rated highly four of seven items that compose a scale that measures the curriculum's impact on online search skills. Students indicated that as a result of the scholarly research training they are more aware of the large number of resources they can access online, more likely to use the library's online research tools to identify relevant materials, and more able to function effectively as a researcher. Pre-post comparisons provide additional evidence of the impact of the curriculum: students' library skills post-scale mean was statistically significantly higher than the pre-scale mean, and students reported gains in 15 of 18 library skills.

The results of the assessment of the program suggest that scholarly research skills can be successfully integrated into a fast paced, chemistry course numbering over 500 students: the concept is scalable. The library staff and collections were not overburdened in the days prior to the homework due dates. TAs were able to grade the homework as part of their regular grading schedules. In staff meetings to discuss and provide feedback on the program, TAs also reported increased confidence in their own library research skills. A longitudinal study to determine whether students' exposure to scholarly research skills had a lasting impact on their research behavior is underway. The results of this study will be presented in a future publication.

Future revisions of the assignments are planned to create even stronger connections between the assignments and the course material. These revised assignments will not only require that students find appropriate articles, but also that they read and understand the articles. Additional assessment will be needed once the new assignments are incorporated. Librarians will continue to work closely with recitation class instructors and TAs to ensure that assignments are clear, videos are informative, and the student experience is positive. This project has resulted in permanent inclusion of this topic in the course curriculum and an ongoing partnership with librarians to ensure its success. In addition, the libraries are pursuing possible collaborations with faculty in other first-year and core science courses such as biology and chemistry.

ASSOCIATED CONTENT

Supporting Information

Sample homework with model answer; appendix including Tables S1-S4; student learning experience survey 2008. This material is available via the Internet at <http://pubs.acs.org>.

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ACKNOWLEDGMENTS

The authors would like to thank the d'Arbeloff Fund for Excellence in Education for their support of this project.

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