Survey Study of the Integration of Information Literacy Components into the First-Year Solid State Chemistry Course

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AUTHORS

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ABSTRACT

A first-year Chemistry course is ideal for introducing students to finding and using scholarly information research early in their academic careers. A four pronged approach 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, Learning Theories, Assessment, Interdisciplinary, Chemical Education Research, Internet/Web-Based Learning

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Introduction

Knowing how to find appropriate scholarly information is an essential skill for all undergraduates. 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 only to classes for chemistry majors, some chemistry classes for non-science 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, MIT introduced the Discovering Scientific Information Program (DSIP) into its first-year, solid-state chemistry course (*3.091 - Introduction to Solid State Chemistry*), a class that includes more than 500 students, which amounts to more than half of the freshman 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 MIT 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?

This paper summarizes the findings.

Curriculum Design and Development

A variety of factors were considered in the design and development of DSIP. These factors included: choice of database(s); ease of integration of the project into the existing course content and structure; 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 MIT and over 500 students enrolled in 3.091, this was not a viable option. Because MIT's 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 3.091. The article database Inspec was also included due to its coverage of physics literature. Based on the librarian's extensive knowledge of both the content and the accessibility of MIT's 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 3.091 was a natural addition to the course.

Minimization in the amount of additional work for the faculty member

Based on 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 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*) It currently 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 also modeled the online search process by utilizing an online database (licensed by the MIT Libraries) to locate primary sources of relevance to the current lecture material. (*11*) This component required approximately five minutes of lecture time and 30 minutes 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. These assignments were created by librarians with input from the faculty member and course teaching assistants (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. [supplemental material]

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 one to five minutes 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 Undergraduates (*13*), such as the scholarly publication cycle and searching the MIT Libraries catalog, but they did not relate directly to the assignments. All videos were created by librarians, taking approximately 60 minutes per video for initial creation. The videos are hosted on MIT'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 his 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. [supplemental material]

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 since 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.

Method

Subjects

Participants include freshmen enrolled in the Fall 2007 or Fall 2008 *Introduction to Solid State Chemistry.*

Survey 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; while 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* [Appendix] 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), *neutra*l (4), *slightly agree* (5), *agree* (6), and *strongly agree* (7).

We used *SPSS 17.0 for Mac* 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.

Description of statistical protocols used to construct survey scales: In order to provide stable and comprehensive measures of the impact of the DSIP curriculum, we developed three scales.

A survey scale consisted of a group of related survey items that collectively represented a given behavior. We initially identified a group of items from the *library skills survey* to represent a *confidence-in-library-skills scale (confidence)* and two groups of items from the *learning experience scale* to represent *beliefs about scholarly research skills scale (beliefs)* and *impact on search skills scale (impact-skills)*.

We followed a cross-validation design to determine scale homogeneity, stability, and viability. We first ran principal components analysis (PCA) and factor analysis (FA) on the 2007 cohort data to determine which survey items should compose each scale. We then confirmed these results by running PCA and FA on the 2008 data. See Table S1 in the Appendix 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], and 1.

Results & 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: Forty percent 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 MIT class assignments. Given that pre-survey responses suggested that many first semester freshmen 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 freshmen to acquire, are essential for academic and professional success, and play a significant role in judging the validity of information. Table S2 data 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" to "7" with "4" as neutral). This relatively high scale 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 non-scale items not only illustrate students' awareness of the importance of scholarly research, they indicate strong student support for the inclusion of scholarly research skills in 3.091. *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 3.091* (5.12). [Appendix, Table S2]

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). [Appendix, Table S3]

Students indicated that as a result of the DSIP training, they knew how to search for primary sources (Table 1, a). When this behavior is compared to two related behaviors (Table 1, b, c), an interesting pattern emerges.

Table 1
Differences in Knowing How to Search, Appreciating, and Actually Searching Primary Sources [a]

	Mean (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

[a] Students 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.

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).

Table 2
Repeated Measures Results Indicate the Means of the Primary Sources Items Differed at Statistically Significant Levels.

Overall Significance				
Test	**F**	**hypothesis df**	**error df**	**Sig**
Wilks' Lambda	55.958	2	647	.000
Pairwise Comparisons				
(I) primary sources	**(J) primary sources**	**mean difference (I-J)**	**SE**	**Sig**
I know how to search for primary sources.	2. I appreciate the importance of primary sources.	.296	.041	.000
	3. I am more motivated to search for primary sources.	.470	.044	.000
I appreciate the importance of primary sources.	1. I know how to search for primary sources.	-.296	.041	.000
	3. I am more motivated to search for primary sources.	.174	.036	.000
I am more motivated to search for primary sources.	1. I know how to search for primary sources.	-.470	.044	.000
	2. I appreciate the importance of primary sources.	-.174	.036	.000

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/RefWorks, MIT Libraries' web page, article databases, and print/online library resources. They also reported little confidence in both understanding the scientific publication cycle and in knowing which MIT library to use in order

to research a specific topic. On the post-survey, students expressed confidence in the use of citations, call numbers, and publications such as 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/RefWorks, understanding the scientific publication cycle, and knowing which MIT 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 very 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, 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, MIT 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. Since 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 freshman may want to seek support from the library staff. [Appendix, Table S4]

Conclusion

Students strongly support the inclusion of scholarly research skills in 3.091. They see the value of introducing these skills into 3.091 and believe that the skills will be relevant to their academic work at MIT. 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 than before 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 MIT Libraries 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 MIT Libraries are pursuing possible collaborations with faculty in other first-year and/or core science courses such as biology and chemistry.

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SUPPLEMENTAL MATERIAL

Sample homework with model answer

Appendix including Tables S1-S4

Student learning experience survey 2008

APPENDIX

Table S1

Factor Analysis [a,b] of Two Learning Experience Survey Scales:

Comparison of 2007 and 2008 Cohorts' Rotated Component Matrices Which Provides Cross Validation of Each Scale's Item Membership

	2007		2008	
	impact-skills	beliefs	impact skills	beliefs
I believe knowing scholarly research skills will be of value beyond my academic work.	0.327	0.751	0.305	0.755
I believe scholarly research skills are valuable skills for freshmen to learn.	0.397	0.698	0.323	0.756
Knowing how to conduct scholarly research plays an important role in one's ability to think critically as a student.	0.188	0.864	0.158	0.867
Knowing how to conduct scholarly research plays an important role in one's professional life in judging the credibility of information.	0.22	0.836	0.212	0.807
As a result of the scholarly research training, I am more likely to use the library's online tools to search for articles of interest.	0.875	0.241	0.855	0.281
As a result of the scholarly research training, I am more likely to use the library's databases to search for information of interest.	0.824	0.312	0.853	0.288
In the future, when I am assigned a research paper in a class, I am more likely than before to use the library's online research tools to identify relevant material.	0.813	0.305	0.846	0.202
As a result of the scholarly research training, I can function more effectively as a researcher.	0.778	0.335	0.833	0.249
As a result of the scholarly research training, I am more likely to go to the library's home page.	0.813	0.228	0.816	0.226
As a result of the scholarly research training, I am more likely to use the library's electronic databases.	0.851	0.235	0.877	0.232
As a result of the scholarly research training, I am more aware of the large number of library resources I can access online.	0.729	0.265	0.716	0.286

[a] Extraction Method: Principal Component Analysis; Rotation Method: Varimax.

[b] The analysis for each cohort occurred in two phases. In phase 1, PCA was applied separately to each of the three scales in order to reduce the number of scale items. In phase 2, FA with varimax rotation was applied only to the two *learning experience survey* scales. Phase 2 did not include the confidence scale because the library skills survey used a different rating scale system (five-points with no neutral midpoint) than the learning experience survey (seven-point rating scale with a neutral midpoint). In addition, several of the *confidence scale's* items were similar to items included in learning experience survey scales. Such redundancy would have weakened the clarity of the factor analysis results.

Table S2

Beliefs about Scholarly Research Skills
Profile of Scale, Scale Items and Relevant Non Scale Items [a]

	Total	
Scale and Scale items	Mean (SD)	N
beliefs about scholarly research skills scale (coefficient alpha =.86)	*5.45 (1.12)*	*656*
I believe knowing scholarly research skills will be of value beyond my academic work.	5.47 (1.34)	658
I believe scholarly research skills are valuable skills for freshmen to learn.	5.75 (1.24)	658
Knowing how to conduct scholarly research plays an important role in one's ability to think critically as a student.	4.95 (1.50)	658
Knowing how to conduct scholarly research plays an important role in one's professional life in judging the credibility of information.	5.66 (1.26)	659
Relevant Non Scale Items		
I see the value of introducing scholarly research skills into 3.091.	5.12 (1.59)	659
As a result of the scholarly training, I gained an appreciation for primary sources.	4.58 (1.67)	659
I believe the scholarly research skills I learned will be relevant to my academic work at MIT	5.67 (1.37)	659
I believe the scholarly research skills I learned will be useful during my undergraduate experience.	5.62 (1.37)	658

[a] Students 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.

Table S3

Impact of the DISP Curriculum on Online Search Skills [a]

Impact on Search Strategies Scale & Items	**Mean (SD)**	**N**
Impact on Search Strategies Scale	*5.03 (1.30)*	*650*
As a result of the scholarly research training, I am more likely to use the library's online tools to search for articles of interest.	4.90 (1.61)	659
As a result of the scholarly research training, I am more likely to use the library's databases to search for information of interest.	4.80 (1.58)	658
In the future, when I am assigned a research paper in a class, I am more likely than before to use the library's online research tools to identify relevant material.	5.25 (1.47)	657
As a result of the scholarly research training, I can function more effectively as a researcher.	5.05 (1.45)	659
As a result of the scholarly research training, I am more likely to go to the library's home page.	4.66 (1.53)	655
As a result of the scholarly research training, I am more likely to use the library's electronic databases.	5.06 (1.48)	658
As a result of the scholarly research training, I am more aware of the large number of library resources I can access online.	5.45 (1.39)	656

[a] Students 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.

Table S4

Pre-Post Comparisons of Confidence in Library Skills [a]

Paired t-test of pre-post confidence scale means indicate students made statistically significant gains by end of the semester. Students showed improvement in 15 of 18 skills.

	Pre-Survey	Post-Survey	
Scale and Scale Items (5-point rating scales)	**Mean (SD)**	**Mean (SD)**	**N**
Confidence in Library Skills Scale (coefficient alpha: pre-survey = .84; post-survey = .87) paired t-test: p<.001	*3.24 (0.74)*	*3.67 (0.71)*	*641*
Use online library catalogs to find materials quickly and efficiently	3.41 (1.07)	3.55 (0.96)	653
Use article databases such as InfoTrac, ProQuest, or Web of Science to find materials quickly and efficiently	2.69 (1.16)	3.49 (0.99)	658
Use the MIT Libraries website to access the materials you need	2.60 (1.16)	3.52 (1.00)	658
Recognize the parts of a citation	3.35 (1.04)	3.84 (0.95)	658
Understand the different types of information that can be found in encyclopedias, handbooks, journals, books, or other types of materials	3.60 (0.95)	3.80 (0.94)	654
Understand the difference between primary and secondary sources	3.93 (1.02)	4.10 (0.90)	653
Know how to contact library staff for assistance	3.43 (1.12)	3.45 (1.12)	655
Know how to access both print and online library resources (e.g., books, journals, and full text articles and databases)	2.89 (1.10)	3.59 (1.00)	653
Relevant Non Scale Items			
Use Google or another search engine to find materials quickly and efficiently	4.48 (0.72)	4.37 (0.75)	654
Use call numbers to find books (and other materials) on library shelves	3.55 (1.21)	3.70 (1.18)	654
Understand WHEN to cite others' contributions to your research	3.54 (1.03)	3.78 (1.00)	656
Understand HOW to cite others' contributions to your research	3.34 (1.03)	3.76 (1.00)	655
Know the difference between the major Boolean operators (And, Or, Not) and how to use them correctly	3.41 (1.48)	3.56 (1.33)	653
Use EndNote, RefWorks (or some other software) for managing references and citations	2.05 (1.19)	2.50 (1.32)	651
Understand the scientific publication cycle	2.36 (1.13)	2.89 (1.17)	653
Understand the meaning of plagiarism	4.22 (0.81)	4.23 (0.81)	653
Critically evaluate information that you find, regardless of the source (print, electronic, video, etc.)	3.56 (0.90)	3.65 (0.94)	650
Know which MIT Library to use to do research on a particular topic	2.23 (1.16)	3.00 (1.18)	654

[a] For the Library Skills Survey's confidence questions, 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).