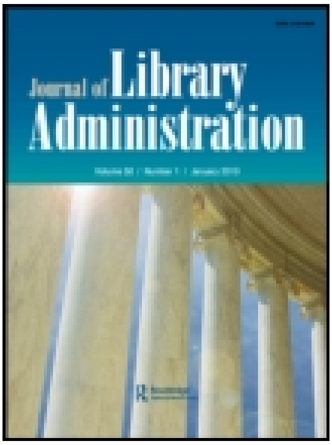

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Science Literacy and Lifelong Learning in the Classroom: A Measure of Attitudes among University Students

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Science Literacy and Lifelong Learning in the Classroom: A Measure of Attitudes among University Students

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ABSTRACT. *An important goal for educators, especially those in postsecondary education, is teaching students essential skills that will allow them to become lifelong learners. The Association of College and Research Libraries's Information Literacy Competency Standards for Science and Engineering/Technology address this issue in Standard Five. Library instructors who teach information literacy courses that focus on the natural sciences can use this standard to develop performance indicators and outcomes for their courses. This article reports on the results of a survey administered to the students in information literacy classes taught by the author. The survey examined students' attitudes toward science literacy and lifelong learning as addressed in Standard Five.*

KEYWORDS academic libraries, information literacy, lifelong learning, science literacy, standards

In 2000, an increasing need for standardization in library instruction resulted in the publication of the Association of College and Research Libraries's (ACRL) Information Literacy Competency Standards for Higher Education. Although, as Macklin and Culp (2008) have pointed out, these standards are sometimes criticized for being inflexible, they have brought clarity and direction to the field of information literacy librarianship. In 2006, a subsequent need for subject-specific guidelines brought about the publication of ACRL's Information Literacy Competency Standards for Science and Engineering/Technology as a joint effort of the Science and Technology Section of ACRL, the ACRL, and the American Library Association. A cursory review of

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these two documents reveals their significant distinctions. Among the most important of these distinctions is that the ACRL Standards for Science and Engineering/Technology include a new standard, Standard Five, which addresses the importance of lifelong learning.

Each of the standards is accompanied by performance indicators and outcomes. These outcomes provide focus for classroom activities, so that library instructors can make sure their students are accomplishing desired academic objectives. The outcomes of Standard Five include the recognition that "information gathering is an ongoing process" (American Library Association, Association of College and Research Libraries, & Science and Technology Section's Task Force on Information Literacy for Science and Technology, 2001). In other words, as new information emerges, students should be able to transfer information-seeking skills from one subject to another, archive information, master the use of emerging technologies and tools, and use scholarly publications for research. These skills are important to anyone aspiring to professional success in an information economy. In this sense, Standard Five speaks not only to information-seeking and research, but also to career building in contemporary society (Oh, Starkey, & Kissick, 2007).

It is therefore important for information literacy instructors to survey students' attitudes toward lifelong learning, to learn whether they think it is as important to the achievement of their educational goals as their instructors do. If such a survey should reveal that our students' expectations and attitudes do not coincide with our own, then we would need to revise our information literacy curricula to stimulate their interest. After all, we cannot hope for much in the way of positive learning outcomes if our students do not believe that what they are studying is of any real benefit to them. However, if our survey should reveal that students are "getting" the idea of lifelong learning, but perhaps perceive certain barriers in achieving this goal, we would be in a position to revise course curricula to remove these barriers. In short, any feedback a well-designed survey provides will help us to better achieve the goals of Standard Five.

Cultivating skills for lifelong learning is essential to science literacy, and an especially important goal for educators who teach subject-specific information literacy instruction in the natural sciences (see Welborn, 1999). Science literacy is commonly understood to be a general understanding both of the basic laws of science, and of the major discoveries and advances that have heralded the progress of scientific knowledge over time. Because such discoveries and advances are continually made as the result of ongoing research, it is necessary for the science-literate individual to be a lifelong learner. In this sense, lifelong learning is integral to science literacy. Information literacy courses, especially those that focus on the natural sciences, pose a unique opportunity for showing college and university students how to become lifelong learners, and so keep up with the continually evolving world of scientific information. This is why it is critical for information literacy educators to assess students' attitudes about lifelong learning; the results of such surveys will reveal students' attitudes toward lifelong learning, which, in turn, impacts the extent of their science literacy. Armed with the results of such a survey, the information literacy educator will be in a position to revise existing curricula to meet students' needs in both of these areas.

LITERATURE REVIEW

Science Literacy and Libraries

There have been several attempts, mostly by science librarians, to bring attention to the subject of science literacy. Most of these articles include some explanation of what exactly science literacy is. The most widely cited definition of the term comes from Miller (1998, 2004, p. 274), who writes that *science literacy* can be broken down into three separate types of literacy—civic, practical, and cultural—that complement one another to create a "level of understanding ... sufficient to read and comprehend the Tuesday Science section of the *New York Times*." This definition may seem simplistic, but it makes an important point: while science literacy is instilled through formal education, its application is manifested in the ability to read and comprehend science literature written for the general reader. Clewis (1990, p. 109) echoes this perspective in stating, "Librarianship can contribute to ... science education by building strong collections in science at all levels, offering reference service based on the scientific literacy of librarians themselves, and by investigating science information sources for non-scientists." Sapp (1991, p. 43) similarly calls attention to the role of librarians in "good science popularization," arguing that it bridges the gap between academic science—understood only by a relatively small group of experts conducting research—and the majority of the general public, who cannot understand the terminology of scientific experts, but who nonetheless want to understand the implications of current scientific research. Slutsky (1993, p. 74) points out the importance of librarians' communicating scientific knowledge to the public, and explains why this task is often so difficult and what can be done to overcome these difficulties. He suggests that "If non-science librarians become more science literate, they can better understand how science books and periodicals complement collections in humanities, social sciences, and business." Clewis (1990) similarly suggests that the data collected by science librarians can be used in other academic disciplines, such as communications and education. Peterson and Kajiwara (1999) describe successful science literacy as the "bootstrap training" of nonscience librarians at their academic institutions, which results in their better understanding fundamental scientific principles and helps them become more confident in answering science-related questions at the reference desk.

Science literacy as a term for understanding the fundamental laws of science is sometimes used interchangeably with science information literacy or information literacy in science disciplines. This is illustrated in a survey by Welborn and Kanar (2000), which looks at various definitions of science literacy in the current literature and presents the two that the authors find most meaningful: Miller's (1998) definition of science literacy and Shapiro and Hughes's (1996) definition of science information literacy. Miller's approach, again, is to separate science literacy into civic, cultural, and practical literacies. Welborn and Kanar stress the importance of what Miller argues is the civic component of science literacy, because it implies that an individual must have a certain understanding of scientific laws and developments to make informed electoral decisions. For example, one must understand the environmental effects of air pollution to demand that his or her elected representatives sponsor laws and policies that will improve air quality. Shapiro and Hughes do not specifically use the phrase *science information literacy*, but their article presents an argument for science education of the general public, thereby providing a framework for Welborn and Kanar's definition of science information literacy. The two authors also propose organizing information literacy into seven categories: tool literacy, resource literacy, social-structural literacy, research literacy, publishing literacy, emerging technology literacy, and critical literacy. Of these seven, Welborn and Kanar suggest that the tool, resource, and social-structural literacies are most important.

Several library science publications address science literacy in conjunction with library instruction, especially those concerned with library instruction in subject-specific courses. The idea of bringing library instruction into subject-specific courses has been around for many years, and numerous articles have been published on this topic. Both librarians and faculty members have been concerned with students' abilities to think critically, and have therefore entered into a mutually beneficial collaboration. For example, Pestel and Engeldinger (1992, p. 54) report on the successful incorporation of library instruction into the curriculum of an undergraduate chemistry course, reporting that the library instruction helped to improve students' research skills and maintaining that these skills provide the tools for students to become lifelong learners: "Scientific literacy is not the content we teach students today. It is the skills we help them develop to access and evaluate scientific information for all of their tomorrows."

This can be considered an early example of successful faculty–librarian collaboration. Examples like this have prompted a conversation between librarians and administrators that has in turn fostered the development of information literacy as an independent curricular subject in many post-secondary educational institutions. It also suggests that collaboration between librarians and science faculty is viewed by both sides as an effective means of improving learning outcomes (see also Kearns & Hybl, 2005; Brown & Krumholz, 2002).

Pestel and Engeldinger (1992) write that one of the most important learning outcomes of science literacy education is lifelong learning. Similarly, Welborn (1999) recommends a number of Web resources for science literacy, the very first of which is a National Science Foundation (1996) report that lists several goals for educators to improve science literacy, and one of them is to "emphasize lifelong learning skills."

Standard Five

Many recent articles that address subject-specific—especially science subject–specific—instruction mention the ACRL's Information Literacy Standards for Science and Engineering/Technology (American Library Association, Association of College and Research Libraries, and Science and Technology Section's Task Force on Information Literacy for Science and Technology, 2006). When Baldwin (2005) reported on the process of developing these new standards, she stated that Standard Five on lifelong learning was "entirely new." According to Baldwin, the task force charged with the development of this standard synthesized standards and criteria used by accrediting agencies as well by discipline-specific entities such as engineering libraries and the American Chemical Society's Committee on Professional Training to come up with the standards for science-specific disciplines.

Before 2006, instruction librarians who taught subject-specific classes relied on the ACRL's general Information Literacy Competency Standards for Higher Education (Association of College and Research Libraries, 2000). Some found the standards sufficient to address subject-specific issues, but others insisted on adopting separate discipline-specific standards. Grafstein (2002) notes that "being information literate crucially involves being literate *about something*," explaining that after acquiring a generic set of skills students go on to learn some subject-specific approach to research and become information literate in that discipline. This explains outcomes 1a and 1b of performance indicator one of Standard Five. Outcome 1a states that the student "recognizes that, for a professional, it is necessary to keep up with new developments that are published in the literature of the field" and 1b states that the student "recognizes that learning about information gathering is an ongoing process as the source, format, software requirements, and delivery method of needed information changes and evolves with time."

However, some librarians argue that there is no need to create a separate subject-specific set of standards, as the Information Literacy Competency Standards for Higher Education addresses specific educational goals. For example, Manuel (2004) demonstrates the congruence between the National Science Education Content Standards (NSECS) and the Information Literacy Competency Standards for Higher Education by noting common areas of emphasis in the NSECS the ACRL standards.

The more recent literature tends to compare the two sets of standards—the general standards of 2000 and the science-related standards of 2006—by calling attention to distinctions rather than similarities between the two and analyzing the implications for library instruction. For example, Aydelott (2007, p. 23) examines Standard Five and concludes that librarians must teach "what can be called knowledge management skills." She also points out that the general ACRL standards fail to note the importance of developing these skills.

Macklin and Culp (2008) write that even though the new subject-specific standards for information literacy make the objectives for instruction more clear, there are still some obstacles that lie in the way of successful instruction, such as poor communication between librarians and science faculty and inadequate knowledge of science among librarians, which prevents them from providing advanced information literacy instruction.

METHODOLOGY

For the purposes of this study, a survey was created to measure students' attitudes toward science literacy, as well as Standard Five of the Information Literacy Standards for Science and Engineering/Technology.

Recruitment and Survey Protocol

The study sample was selected from two classes I taught, Information Literacy in the Sciences and Information Literacy. I taught these two information science courses during the spring and summer semesters of 2009, respectively. Because I not only knew but was also teaching and grading all of the prospective members of my study sample, it was important that the data collection guarantee that student participation was voluntary and anonymous. To meet these objectives, the survey was administered using a protocol similar to the one used for course evaluations. This design received Institutional Research Board approval.

The survey was administered by a library colleague in the last 10 min of the last class meeting of the session for each class, after I had left the room. Before administering the survey, this individual distributed letters of informed consent to the students explaining the purpose of the study and how their participation in the survey would support my research. While students read the letter, my colleague read from a prepared script outlining the letter's contents to reinforce its major points. The letter explained that the survey was anonymous, as the only identifying data students would be asked to enter was their academic year (freshman, sophomore, etc.), and their major. The letter also stated that their participation was wholly voluntary, that they were free not to participate, and that I would have no way of knowing which of them had filled out the survey form. In this way, students were free to leave the class before the survey was administered without fear of reprisal. Finally, the letter explained that after all of the students who chose to participate had completed their surveys, my colleague would seal them in an envelope that he would then store in a locked cabinet in his office, and which he would not hand over to me until I had posted final grades for all of my students. In this manner, students were assured that neither their participation nor nonparticipation in the survey could affect their standing in the course.

Class Activities that Provided Background for the Survey

The students in both classes had been introduced to the concept of science literacy by completing a blog posting assignment and through class discussions. The assignment asked students to read Hazen's (2002) "Why Should You Be Scientifically Literate?" and answer three questions about their understanding of science literacy and their own opinion as to the importance of one's being scientifically literate. The discussions revolved around the science section of the *New York Times*, from which students were required to read two or three articles that interested them before each class. Hazen (2002), like Miller (1998, 2004), cites the ability to comprehend and discuss the *New York Times* science section as a valid indicator of science literacy.

Survey Design

The survey comprised 13 questions and statements, each of which measured some dimension of student attitude about science literacy and lifelong learning. Each of the items in the survey measured student response using a Likert scale. For 10 of the prompts, the scale comprised 5 possible responses: *strongly disagree, disagree, agree, atrongly agree*, and *undecided.* Item 4 asked students to assess their science literacy using a Likert scale of six possible answers: *literate, somewhat literate*, *just a little bit literate*, *not literate*, *not literate at all*, and *undecided*. I hoped to receive more precise results by adding a sixth response to the scale, as this was one of the most important questions in the survey. Items 5 and 6 were also questions, asking students to compare their level of science literacy after completing high school (Item 5) and after completing my course (Item 6). Like Item 4, these also used a differently worded Likert scale: *excellent*, *good*, *satisfactory*, *unsatisfactory*, and *don't have an opinion*.

Survey Administration

In the first class surveyed (the *science group*), 13 out of 22 students (59%) elected to participate; 4 of these students were freshmen, 1 was a sophomore, 4 were juniors, and 4 were seniors. In the second class (the *nonscience group*), 18 out of 20 students (90%) completed the survey; 7 of the participants were juniors and 11 were seniors. This made for a total sample of 31 study participants.

The disparity between the two classes in terms of survey participation was surprising, as I would have expected a higher rate of participation on a survey of attitudes toward science literacy from the class that consisted predominantly of science majors. There are two possible explanations for the stronger response in the nonscience group. One is that the first class met late in the afternoon, 4:15–6:15 p.m., and the students were typically tired and eager to leave by the end of class. The second class met late in the morning, from 10:00–11:45 a.m. Students in this class were not only less tired, but had been sitting in class for slightly less time by the end of the period. The second likely factor is maturity, assuming that age was reflected in academic standing; the second class was made up almost entirely of upperclassmen, and it was not unlikely that these students were more willing to keep their seats for an extra 10 min to support a research study.

In both samples, academic major varied widely. In the science group—students enrolled in Information Literacy in the Sciences—there were two physics majors, two human biology majors, three biology majors, one forensic chemistry major, one biochemistry major, one math major, one sociology major, one English/French major, and one student whose major was undeclared. In the nonscience group, which was selected from students in Information Literacy, there were two sociology majors, two business administration majors, one theater major, one philosophy/English major, one psychology/criminal justice major, one biology major, one information science and policy major, and one English major, one Spanish major, and one East-Asian studies major. Two students from this group did not state a major.

RESULTS

Importance of Science Literacy

The survey's first item was the statement "Science literacy is an important component of civic literacy." Most of the students in both groups either agreed or strongly agreed with this statement; there were no disagrees, and only one student was undecided. The science group was more likely to strongly agree (7 out of 13 respondents from this group) with this statement, as compared with the nonscience group, only 2 of whom strongly agreed; 16 students from the nonscience group agreed with the statement, in comparison with 5 students from the science group. The two frequency distributions for this item are compared in Figure 1.

Item 2 asked students to respond to the statement, "A general course on science literacy should be taught at every undergraduate institution of higher learning in the United States." This item generated a wider range of responses than the first, including disagree and undecided. The science group generally supported this statement. Although 1 student disagreed, and 1 was undecided, 4 students agreed, and 7 students strongly agreed. Conversely,

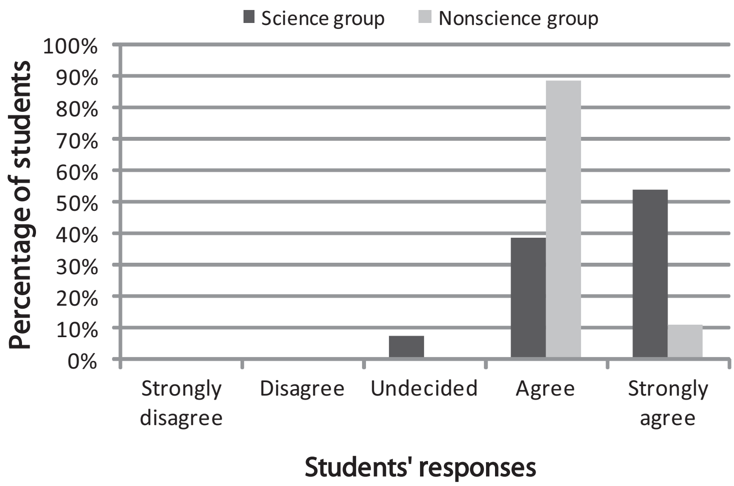

FIGURE 1 Responses to prompt "science literacy is an important component of civic literacy."

the nonscience group showed a wider range of response: 3 students disagreed, 1 student was undecided, 8 students agreed, and 6 students strongly agreed. Figure 2 compares the frequency distributions for the science and nonscience groups for this item.

Item 3, "Every responsible citizen should be aware of the latest scientific discoveries," showed the greatest variance of response. Between the two groups, every response was given at least once, which was unusual on the survey. Students in the science group were more consistent in their responses, with 2 students disagreeing, 7 students agreeing, and 4 strongly agreeing. The nonscience group presented a broader and more uneven distribution; 1 student strongly disagreed, 4 students disagreed, 2 were undecided,

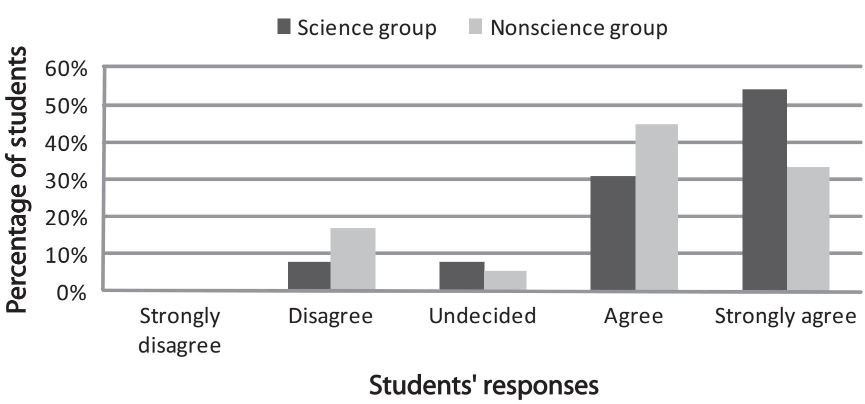

FIGURE 2 Responses to prompt "science literacy should be taught at every undergraduate institution in the United States."

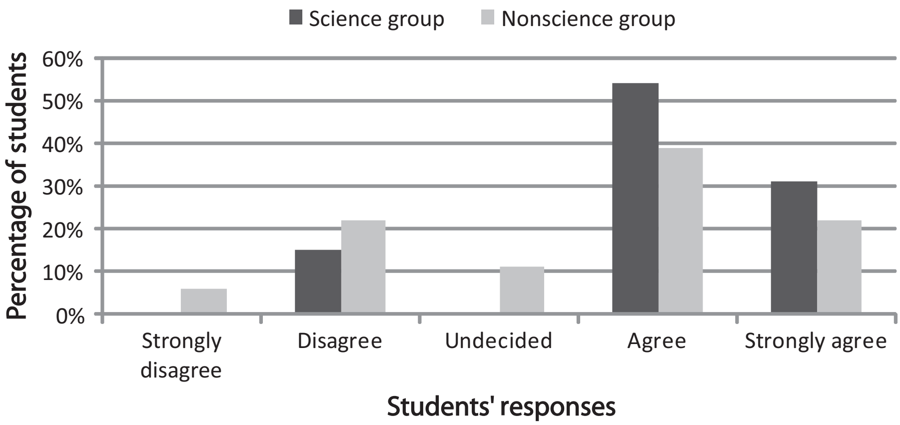

FIGURE 3 Responses to prompt "every responsible citizen should be aware of the latest scientific discoveries."

7 students agreed, and 4 students strongly agreed. These data are graphically represented in Figure 3.

Student Self-Assessment of Science Literacy Level

Items 4, 5, 6, and 7 of the survey were devoted to students' opinions about their own level of science literacy. Item 4 asked respondents to evaluate their own science literacy. Potential responses were *literate*, *somewhat literate*, *just a little bit literate*, *not literate*, *not literate at all*, or *undecided*. None of the respondents selected undecided, and just one chose not literate. The rest of the participants deemed themselves science literate at various levels. Figure 4 compares the science group to the nonscience group with regard to this variable. The modest Just a little bit literate was proportionately similar in both groups; that is, 2 students out of 13 (15%) from the first group and 3 out of 18 (17%) from the second group selected this answer. Somewhat literate was chosen more frequently in the nonscience group (10 out of 18, or 56% of the respondents) in comparison with the science group (5 out of 13, or 38% of the respondents). Six out of 13 (46%) members of the science group deemed themselves literate, whereas only 4 out of 18 (22%) member of the nonscience group chose this response.

Items 5 and 6 asked students to rate their science literacy at two distinct points in time: immediately following their graduation from high school and when they were taking the survey (i.e., after completing a college-level course in information literacy). For each item there were five possible answers: *excellent*, *good*, *satisfactory*, *don't have an opinion*, and *unsatisfactory*. Of the total sample of 31 students, none chose the don't-have-an-opinion option, and only 2 (6%) considered their levels of science literacy

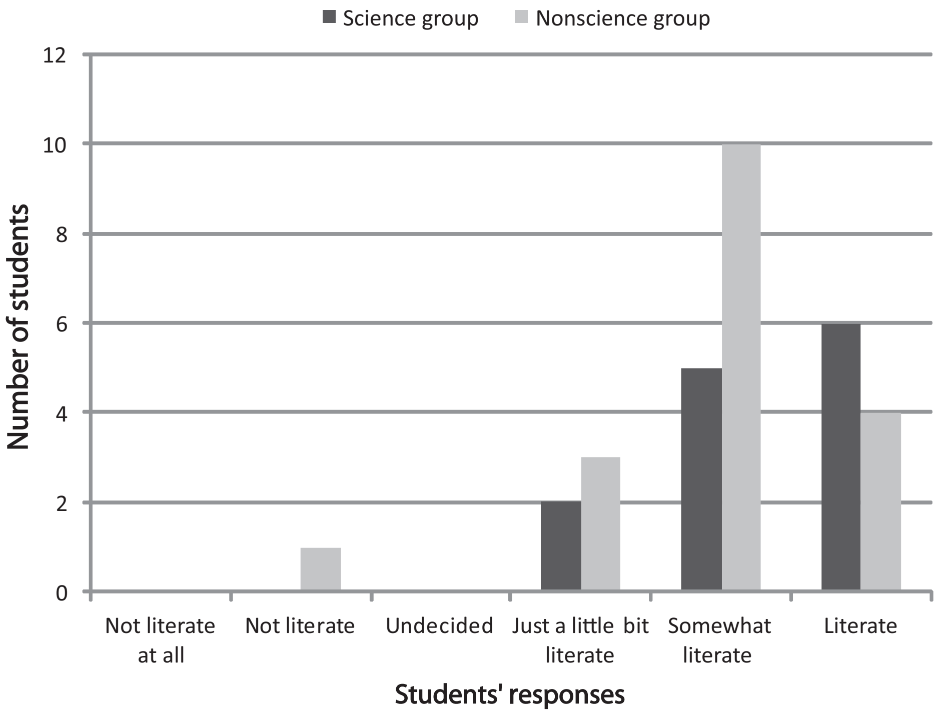

FIGURE 4 Students' self-evaluation regarding science literacy.

unsatisfactory before college. Fourteen (45%) students thought of their levels as satisfactory, 10 (32%) students considered it good and 5 (16%) excellent. These numbers shifted significantly between this assessment and the next. In the second assessment, none of the students deemed their science literacy level unsatisfactory, and only 5 (16%) students considered their science literacy satisfactory. Eighteen of the students (58%) rated their science literacy good and 8 (26%) excellent. Figure 5 compares the data from these two measures of science literacy.

Item 7 was a follow up to Items 5 and 6, and prompted students to respond to the statement, "Studies at the university have helped me to increase my level of science literacy," using the standard Likert scale. Only 3 students (10%), all from the nonscience group, disagreed with this statement; the remaining responses were divided equally between agree and strongly agree, with 14 (45%) students each.

Standard Five and Lifelong Learning

Items 8–13 of the survey address Standard Five and its several performance indicators and outcomes, using the standard Likert scale. Item 8 asks students

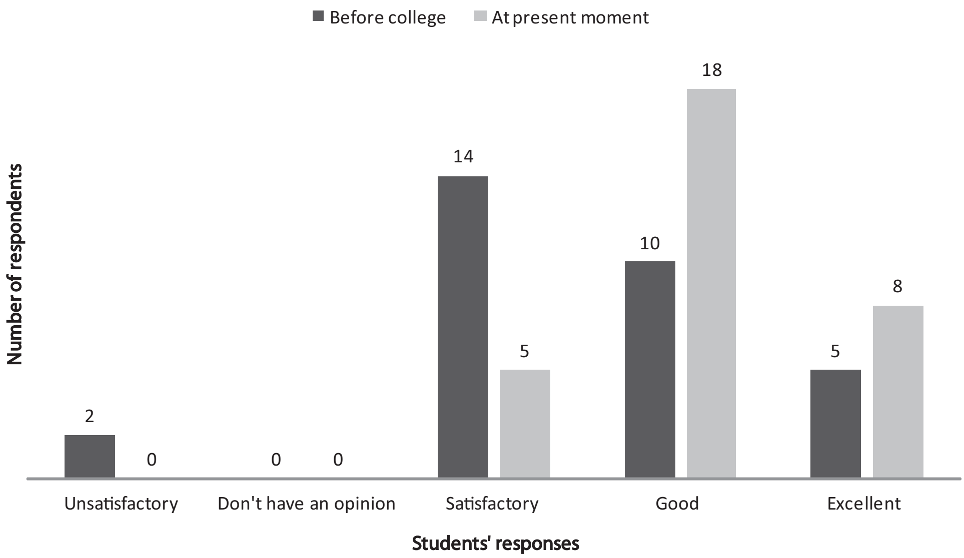

FIGURE 5 Comparison of students' self-evaluation of their science literacy before entering the college and at present moment.

whether they agree with the definition of Standard Five, that is, that "information literacy is an ongoing process" and lifelong learning is necessary to keep up with new developments in their respective fields. Only one student in the total sample disagreed and one was undecided. Of the remaining students 14 (45%) agreed and 15 (48%) strongly agreed. These results are presented in Table 1.

Item 9 solicited responses to the statement "Becoming a lifelong learner inevitably increases one's level of science literacy." This statement was broadly supported. Only 2 students (6%) were undecided, 1 from each group. Of the remaining students, 12 (39%) agreed and 17 (55%) strongly agreed.

Item 10 addressed outcome 1c, which states that the science literate student "is able to apply information access skills learned in one subject area to another." The students were asked to say whether they would feel comfortable conducting research on an unknown topic given the information literacy skills they possess. Responses to this item reflected a generally high level of confidence in their skill sets. Only 1 person was undecided, 20 (65%) agreed and 10 (32%) strongly agreed.

Item 11 addressed one skill that had been covered in class in detail: how to annotate a scholarly article. Students in both of the information literacy courses were required to write critical annotations. The item solicited their response to a statement comparable to the one in Item 10, that if required to annotate a scientific article from a peer-reviewed journal, they would feel comfortable doing so. This time, their responses did not express quite as

TABLE 1 Students' Attitudes toward Standard Five

	Strongly disagree			Disagree			Undecided			Agree			Strongly agree		
Questions 8–13 that address Standard Five	*n*	*SG*	*NSG*	*n*	*SG*	*NSG*	*n*	*SG*	*NSG*	*n*	*SG*	*NSG*	*n*	*SG*	*NSG*
Standard 5 of the Association of College and Research Libraries (ACRL)'s Information Literacy Standards for Science and Engineering/Technology says: "The information literate student understands that information literacy is an ongoing process and an important component of lifelong learning and recognizes the need to keep current regarding new developments in his or her field." Do you agree? *(Strongly agree, agree, etc.)*	0	—	—	1	0	1	1	1	0	14	4	10	15	8	7
Becoming a life-long learner inevitably increases your level of science literacy.	0	—	—	0	—	—	2	1	1	12	3	9	17	9	8
If asked to write a research paper on a topic unknown to you, you will feel comfortable starting your research since you have already mastered your information literacy skills.	0	—	—	0	—	—	1	1	0	20	6	14	10	6	4
If asked to annotate a scholarly scientific article, you will feel confident that you have enough skills to do so, such as examining the abstract, briefly scanning the text, concentrating on conclusion, checking references, etc.	0	—	—	1	0	1	3	2	1	11	3	8	16	8	8
You feel comfortable using emerging communication technologies (e.g., blogs, social networks, really simple syndication feeds) for keeping current in your field.	0	—	—	1	1	0	1	0	1	16	5	11	13	7	6
An information-literate individual should feel comfortable using emerging communication technologies (e.g., blogs, social networks, really simple syndications feeds) for keeping current in his or her field.	0	—	—	2	1	1	2	1	1	15	4	11	12	7	5

SG = science group; NSG = nonscience group.

much confidence. One student disagreed, 3 students (10%) were undecided, 11 students (35%) agreed, and 16 (52%) strongly agreed.

Item 12 addresses outcomes 1b and 2e of Standard Five. The first states that the information literate student "recognizes that learning about information gathering is an ongoing process as the source, format, software requirements, and delivery method of needed information changes and evolves with time." The second states that the information literate student "recognizes emerging forms and methods of scholarly publishing in the field." The survey item asked students to respond to the statement that they were "comfortable using emerging communication technologies such as blogs, social networks and really simple syndication feeds." The students used blogs in our class, many of them for the first time. However, they all were familiar with social networking because it was discussed in a classroom. The responses to this item reflected a strong level of confidence among the students. Only one student disagreed with the statement, 1 was undecided, 16 students (52%) agreed, and 13 (42%) strongly agreed.

Finally, Item 13 asked the students to address outcomes 1b and 2e, that is, ease with "emerging communication technologies," as a requisite for information literacy in general. The item prompted them to respond to the statement, "The information literate individual should feel comfortable using the emerging communication technologies, such as blogs, social networks, really simple syndication feeds." This statement was broadly supported by the survey respondents; 2 students (6%) disagreed, 2 (6%) were undecided, 15 (48%) agreed, and 12 (39%) strongly agreed.

DISCUSSION

The results of this study lead to several important conclusions about attitudes toward science literacy and lifelong learning among university undergraduates. In general, the results of the survey show positive responses to the statements and questions posed. For example, in response to the statement that a science literacy course should be required in every college and university, four students disagreed, but the majority, 81% of the total sample, either agreed or strongly agreed with the statement. This outcome not only indicates that students are convinced of the importance of science literacy, but suggests that colleges and universities will want to give due attention to the place of such courses in their curricula.

Another significant result of the survey was the students' comparison of their science literacy levels before starting college and at the time of the survey. There was a significant shift upward in the responses for the two points in time. For example, 48% of the students in the total sample rated their science literacy skills as either good or excellent on the first measure, as compared with 84% on the second. Of course, it is difficult to parse out the variables that impacted this outcome. It is likely that college-level course work in the sciences was one predictor of this improvement. At the same time, a course in information literacy, which all of the respondents had just completed when they filled out the survey, was probably another predictor. After all, whether the students in my sample took Information Literacy in the Sciences or simply Information Literacy, they were regularly discussing scientific issues in class. Future research in this area may want to compare the impact of these two variables on science literacy outcomes.

This study also suggested significant differences between science and nonscience majors in various measures of this competence. On many of the survey items, a higher proportion of the students in the group that consisted mostly of science majors chose the more positive responses from the given options, as compared with their nonscience counterparts. For example, in response to the statement, "Every responsible citizen should be aware of the latest scientific discoveries," 54% of the students in the science group agreed and another 31% strongly agreed, as compared with 39% and 22% of the students in the nonscience group, respectively.

Standard Five

Standard Five of the Information Literacy Standards for Science and Engineering/Technology addresses lifelong learning, a concept that is recognized by educators as crucial to professional success in the modern world. Almost all of the students in the sample agreed with Standard Five that "information literacy is an ongoing process," and that it is important to helping students become lifelong learners. They also supported the statement that becoming a lifelong learner raises one's level of science literacy. The responses to the practical measures of information and lifelong learning—for example, the ability to conduct research and annotate scholarly articles—were also strong, although not quite as consistent. Most of the students believed they had acquired the skills necessary to research an unknown subject. This could be considered a successful outcome of an information literacy class. Almost as many felt they had mastered the process of annotating scholarly articles, also another important learning outcome of a college-level information literacy course. Finally, the last two items of the survey suggested that not only do students overwhelmingly affirm the importance of emerging communications technologies for information literacy, but the vast majority indicate that they are comfortable using these technologies. This, again, is a crucial learning outcome in information literacy courses.

Research Limitations

There are several limitations present in this study. First of all, the study did not use a random sample. Rather, the sample was one of convenience, consisting of students in information literacy courses I taught over the course of two semesters. Furthermore, the sample size was relatively small (N = 31), making it difficult to generalize the study results to the larger population of university students who have completed information literacy classes at the university. Subsequent research will want to address both of these limitations.

Another significant limitation of the study has to do with the survey itself, and on its reliance on self-assessment. Although this is a valid measure of student attitude and opinion, especially given the fact that the survey was anonymous, there was nevertheless potential for social desirability bias in the students' answers. For example, when asked to assess the change in their science literacy level over time, students may have been influenced by the belief that university students ought to be science literate, or to improve over time. Furthermore, a survey is not a precise measure of knowledge, such as science literacy and the various skills it comprises. Of course, the survey strongly suggests that the students in this sample made real progress in this area; nevertheless, subsequent studies will want to develop instruments that are able to measure science literacy and Standard Five's performance indicators more objectively.

CONCLUSION

The majority of students that participated in this study have strongly positive attitudes toward the importance of science literacy and the relationship between science literacy and lifelong learning, as addressed by Standard Five of the Information Literacy Standards for Science and Engineering/Technology. Science literacy entails a basic knowledge of science, which one continually builds on by following major scientific developments. This continual adding on to what one knows is where lifelong learning and science literacy intersect. And they are both necessary to responsible citizenship.

In considering how important lifelong learning is for people working in science and technology, one is inclined to wonder about people in other fields. Isn't lifelong learning important for lawyers, policy analysts, school teachers, and farmers? The answer is clearly yes, it is important to be a lifelong learner regardless of one's field of study or profession. This raises the question, why do the general standards for information literacy not include this important standard? By looking at the responses of the students that participated in the survey, we see that the skills addressed in the Standard Five are applicable to students in numerous fields of study, and therefore should not be limited only to the fields of science and technology. On the contrary, Standard Five should find its place in the general Information Literacy Competency Standards for Higher Education. Therefore, it is vital that science information literacy librarians bring this issue to the attention of their colleagues in information literacy who might not be aware of this important learning outcome.

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