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Irina I. Holden
University at Albany, SUNY, iholden@albany.edu

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PREDICTORS OF STUDENTS' ATTITUDES TOWARD SCIENCE LITERACY

Irina I. Holden
University at Albany, SUNY

ABSTRACT

Being information and science literate are crucial in an age when scientific developments influence the political arena and vice versa. In order to become active and responsible citizens, students must understand such issues as global warming and stem cell research. Furthermore, they must be lifelong learners, capable of researching and educating themselves about new scientific developments. These are some of the complex issues that information literacy educators must address. This article reports on the results of a survey of student's attitudes towards science literacy and lifelong learning, their assessment of their own levels of science literacy, and on variables associated with their attitudes. Most of the students' attitudes and self-ratings were positive, especially those who majored in one of the science disciplines.

INTRODUCTION

Science literacy describes an individual's ability to understand scientific laws, theories, and phenomena. In an article in *Public Understanding of Science,* Miller (2004) defines science literacy as "the level of understanding needed for scientific literacy to be sufficient to read and comprehend the Tuesday science section of *The New York Times*." Science literacy has been broken down into several categories, including cultural science literacy, civic science literacy, and practical science literacy (Shen, 1975). Cultural science literacy describes the understanding of science possessed by a person of average intelligence and education in a particular culture. Practical science literacy is the scientific knowledge a person needs to solve practical problems such as determining the most efficient way to heat his/her home. Civic science literacy is the level of scientific understanding necessary to make informed decisions about law and public policy, such as whether a state legislature should pass a bill in support of hydraulic fracturing.

The author teaches Information Literacy in the Sciences, a course that satisfies the information literacy general education requirement at University of Albany, State University of New York. The course goals and objectives derive from the ACRL Information Literacy Standards for Science and Engineering/Technology which emphasize that those disciplines "pose unique challenges" (ACRL, 2006) to the library research process due to the complexity of their ideas and their implementation. While not tailored to any particular scientific discipline, the course nevertheless narrows a general information literacy instruction curriculum to the natural sciences, medicine, and technology. For example, for their final research project, creating an annotated bibliography, students must select a topic related to one of the aforementioned disciplines.

The course also introduces students – science and non-science majors alike – to the concept of lifelong learning, as outlined in Standard Five of the ACRL Standards for Higher Education in Science and Engineering/Technology (2006). This standard is one of the most important; it speaks to the fact that information and information science are continually evolving, and that information literacy instructors must prepare students to meet the challenges of a constantly shifting information landscape to provide students with the tools they will need to stay current in their chosen field of study and, ultimately, in their chosen profession. In this respect, the meaning of information literacy has outgrown its initial definition as the ability to "recognize when information is needed and . . . to locate, evaluate, and use effectively the needed information" (ALA, 1989). Beyond these abilities, students must be ready to deal with an information landscape that is continually growing in size and complexity. Discussing science literacy and lifelong learning compels students to consider the practical applications and implications of their intellectual and professional pursuits.

For educators, understanding students' perceptions of science literacy enhances our understanding of their motivation to become science literate. This, in turn, helps us to design information literacy curricula and develop classroom activities that are tailored to students' attitudes and expectations. The author's research over the past several years has focused on the concepts of science literacy and lifelong learning and how information literacy students perceive the

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two. This research resulted in the publication of an article (Holden, 2010), which reported on the results of a survey of students' attitudes toward science literacy and lifelong learning. Due to the comparatively small number of survey participants (31), the decision was subsequently made to expand the study. The new study, the results of which are reported here, incorporated a larger sample as well as a redesigned survey that addresses variables that seemed to predict students' attitudes towards science literacy and lifelong learning in the initial study. The present study also uses statistical tests to assess the significance of the survey results.

LITERATURE REVIEW

Science literacy

A substantial body of literature has been produced on science literacy, primarily by scholars from the natural sciences, social sciences, and education. As previously noted, Shen (1975) divided science literacy into civic, cultural and practical science literacy. Trefil (2008) recently added to these categories aesthetic and consumer science literacy. Aesthetic science literacy speaks to the extent to which understanding scientific law and phenomena enhances our appreciation of life itself by revealing the "intellectual beauty of scientific ideas" (p. 63). Consumer science literacy addresses the necessity of being scientifically literate in order to make informed consumer decisions. Miller (2011), one of the most vocal proponents of science literacy in the United States, argues from the civic perspective, i.e. for the importance of science literacy for good governance and citizenship. Griffin and Ramachandran's (2010) report on an information literacy program for pre-service (student) science teachers similarly stresses the importance of science literacy "for all citizens." Science literacy is likewise deemed an important skill for physicians in training in the report of a joint committee of the Association of American Medical Colleges and the Howard Hughes Medical Institute (2009).

Miller (1983) has expressed concern that "the level of scientific literacy in the United States is deplorably low" (p. 29; see also Miller, 1989; Miller & Pardo, 2000). Miller's consternation has been echoed by educators from a number of disciplines who have called for an increase in the number of science courses offered to non-science majors (e.g. Hobson, 2003). A recent report by Impey, Buxner, Antonellis, Johnson, and King (2011) summarizes the results of a 20-year longitudinal study of science literacy among college undergraduates in astronomy classes at the University of Arizona. While some of their survey results are encouraging, such as a knowledge of fundamental scientific principles among respondents, others are disconcerting, such as a belief in astrology and other pseudo-sciences.

Miller (2011) uses a path model to identify the most reliable predictors of science literacy. The most reliable predictor is having taken three or four university-level science courses; the second is having obtained a college degree; and the third predictor of science literacy is the frequent use of "print and Internet information sources" (p. 251). Miller points out that "adults with better information acquisition skills are more likely to obtain and retain core scientific information and constructs than adults without those skills" (p. 251). Suleski and Ibaraki (2010) assess the level of science literacy by analyzing mass media coverage of current scientific research. They argue that the coverage has been insufficient and has contributed to a general decline in the level of science literacy. Electronic media have been the focus of a good deal of science literacy research as they are important tools for conveying scientific information to the public. For example, Zuccala (2010) analyzed Dutch citizens' perceptions of open access and its influence on civic science literacy and found that the availability of scientific information through open access, especially medical information, was considered a positive development that improves the civic science literacy of the general population.

A great deal of the literature focuses on science literacy in the general education curriculum. For example, at Worcester Polytechnic Institute, as a part of their first-year academic curriculum, undergraduate students participate in a Great Problems Seminar, a course that integrates engineering and humanities (Worcester Polytechnic Institute, 2011). Likewise, the Association of American Colleges and Universities has developed Project Kaleidoscope (1989) for the purpose of improving best practices in teaching the STEM (science, technology, engineering, and mathematics) disciplines across the country. Yang (2010) has students design "zines," small pamphlets on science topics which are posted in public spaces such as bus stops and coffee shops, where anybody can take a look. Miller (2010) notes that visiting science and technology and natural history museums and similar learning centers are essential to the cultivation of informal science education. This type of science education has fostered the development of so-called citizen science (Fenichel & Schweingruber, 2010). Citizen scientists are non-professionals whose informal science education – through reading, visiting museums, etc. – not only contributes to their own intellectual growth but culminates in their conducting actual research on a vocational basis. Citizen scientists actually help researchers with important data collection without large monetary investments. For example, amateur astronomers have posted images online which were later used by professional researchers (Hogg, 2011).

Information literacy

Information literacy has become an integral part of the curriculum in many different disciplines, especially science and engineering programs. For example, Firooznia and Andreadis (2006) discuss information literacy instruction in the college introductory biology class. Ferguson, Neely, and Sullivan (2006) report on assessing the information literacy of biology students. Schuetz (2009) reports on the collaboration between a librarian and chemistry instructor at Baylor University, which included bringing writing and information literacy instruction into the classroom over the course of several academic semesters. Walczak and Jackson (2007) also report on incorporating information literacy skills into an analytical chemistry class. Pritchard (2010), a science librarian from the University of Guelph, reports on her collaboration with the faculty from a nanoscience department as a member of the teaching team in a first-year undergraduate course. An especially interesting collaborative project between a physics professor and librarian was reported by Iber and Sherman (2009). The authors worked together to help students to evaluate science websites. The students were non-science majors, and for many of them the task posed a significant challenge. The teaching team therefore developed a sequence of steps students could use in order to conduct their evaluations. Russell, Martin, Curtin, Penhale, and Trueblood (2004) incorporated library instruction into their undergraduate human biology class for non-science majors to help students locate

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primary research articles in medicine. The authors, all biology professors, concluded that library instruction contributed to the lifelong learning of the students who learned to search for and critically evaluate medical primary research literature.

Two concepts that are at the forefront of information literacy research, and are especially relevant to information literacy instruction in the scientific disciplines, are transliteracy and metaliteracy. Transliteracy has been defined as "the ability to read, write and interact across a range of platforms, tools and media from signing and oral communication through handwriting, print, TV, radio and film, to digital social networks" (Thomas, et al., 2007). Mackey and Jacobson (2011) more recently proposed a new term for the interaction of various literacies: metaliteracy. "Information literacy," they write, "is the metaliteracy for a digital age because it provides the higher order thinking required to engage with multiple document types through various media formats in collaborative environments" (p. 70). Transliteracy and metaliteracy are especially important to information literacy in the science disciplines because of the proliferation of open access materials, various digital data repositories available online for sharing, and online research blogs and forums.

At the same time, there are still numerous materials that are accessible only through subscription databases or in costly scientific journals to which un-affiliated researchers have limited access. Interdisciplinary studies present another challenge because they require the individual to be familiar with a variety of resources in several disciplines. Moreover, the availability of these resources can vary from one discipline to another. For example, most astronomers make their research and data available to the general public, while biologists and chemists typically keep their information proprietary. Information literate individuals need higher level skills in order to function successfully in the complex information environment created by these variations in media, discipline, and practice.

Science and non-science majors

There have been a number of studies comparing science and non-science majors with regard to different variables. Johnstone, Haines, and Wallace (2001) looked at how variables such as gender, family background, vocational interests, and cognitive disposition vary between science and non-science majors, and whether these variables predict students' majoring in a science discipline. (Surprisingly, the answer was no.) Miller, Montplaisir, Offendahl, Cheng and Ketterling (2010) compared views of the nature of science between two groups of biology students, ones enrolled in introductory environmental science (i.e., non-science majors) and ones in upper level animal behavior (i.e., science majors). The study suggested that the views of science and non-science majors were mostly similar. Sundberg and Dini (1993), who also compared the academic performance of science and non-science majors in biology courses, concluded that, surprisingly, science majors did not perform considerably better compared with the non-science majors. In fact, the latter group had better scores on questions about ecological and evolutionary concepts. A follow-up study (Sundberg, Dini & Li, 1994) compared pre- and post-test scores on a comprehensive examination, as well as attitudes towards studying science, among science and non-science majors enrolled in freshman biology courses. Non-science majors had lower scores at the beginning of the course, but their scores had improved considerably by the end of the course, with practically no difference from the science majors. Non-science majors were also found to believe that the undergraduate science requirements at their university were reasonable and that those requirements benefit the undergraduate students regardless of major.

These studies suggest that science and non-science majors do not significantly differ with regard to academic preference, academic performance, or attitudes. There are, however, no extant studies comparing the two groups in terms of their attitudes toward science literacy and lifelong learning. This gap in the knowledge base, along with the author's teaching and research interests in science literacy and lifelong learning, is what prompted this study.

RESEARCH QUESTIONS

In designing this study the following research questions were formulated:
1. What are students' attitudes toward science literacy?
2. What are students' attitudes toward lifelong learning?
3. Are students' attitudes toward science literacy and lifelong learning influenced by academic major and academic year?

METHODS

Survey design

As with the author's first study (2010), data were collected by administering a survey to students in her information literacy in the sciences course. The survey (see Appendix 1) was a revised version of the survey used for the initial study. The modified survey resolved ambiguities that responses to the first survey had revealed and provided concrete examples for further clarification. Like the original, it was approved by the university's Institutional Review Board. The survey consisted of three sections: attitudes, skills, and self-rating. There were four, six, and two items, respectively, in each of these areas, for a total of 12 survey items. Most of the items reflected the course's goals and objectives, as well as Standard Five of the ACRL Information Literacy Standards for Science and Engineering/Technology performance indicators and outcomes (see p. 2).

Attitudes: This section of the survey addressed students' attitudes toward science literacy, the extent to which science literacy impacts civic and political life, and the relation between science literacy and lifelong learning. All items were worded as statements to which students responded with one of five Likert options: "Strongly agree," "Agree," "Not sure," "Disagree," and "Strongly disagree."

Skills. This section of the survey solicited students' opinions about the skills they had acquired in their information literacy class and whether those skills were likely to facilitate their continued academic and professional advancement. The skills referred to in this part of the survey included conducting library research to write a paper, annotating a scientific article, and using emerging communication technologies such as blogs and social networks. As with the first section, survey items were worded as statements, and students could respond "Strongly agree," "Agree," "Not sure," "Disagree," or "Strongly disagree."

Self-rating. The last section of the survey consisted of two items. The first directed students to rate their science literacy level when they were graduated from high school and the second rated their science literacy level at the time they took the survey. The

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rationale was that a comparison of the responses would reveal whether respondents felt their science literacy had improved over the intervening period. The items used a Likert scale with four options: "Excellent," "Good," "Satisfactory," and "Poor."

Variables

The study's independent variables were academic year – freshman, sophomore, junior, or senior and major – science or non-science. The dependent variables were students' attitudes toward science literacy, their assessment of their information literacy skills mastery, and their rating of their science literacy level.

Recruitment

The sampling frame for the study consisted of all students enrolled in three sections of the information literacy in the sciences course which the author taught during the Fall 2009 and Spring 2010 semesters. Out of a total enrollment of 58 students across three sections, 55 completed surveys. Students were recruited to fill out the survey during the last 15 minutes of the final class meeting. Each time, the author made a brief announcement about the survey and left the room. A colleague who had been recruited to administer the survey then explained the conditions of the survey, according to the research protocol. Among these was that the survey was anonymous; the only identifying information students were asked to provide was their academic major and year. Students were further informed that their completed surveys would not be made available to the author (i.e., the course instructor) until after final grades for the course had been submitted. Students were then given the choice of either leaving the room or staying to complete the survey.

RESULTS

Response rate

This response rate (55 out of 58) was significantly higher than in the first study, where only 14 out of 21 students in one of the classes completed surveys. In the first study, it had been hypothesized that the class time (4:15-6:15 p.m.) contributed to the poor response rate; that is, students were tired, possibly hungry, and decided to leave the classroom early rather than take a survey. However, one of the classes surveyed in the second study met at the same time, and the response rate – 19 out of 20 students – was almost perfect. This suggests that class time does not significantly influence response rate, though it would require further iterations to say with any degree of certainty.

Demographics

As stated above, demographic data collected in the surveys included only academic major and year (i.e., freshman, sophomore, junior, senior). Out of 55 completed surveys, three did not list an academic major, and one of these also omitted the respondent's academic year. These three surveys were consequently excluded from the data analysis. Among the remaining 52 surveys, 22 respondents were seniors, 11 were juniors, 16 were sophomores, and three were freshmen. The academic majors of the participants varied widely from art to psychology to biology and computer science. After these data were collected, academic majors were categorized into two groups, science and non-science majors. Science majors included students in the following disciplines: biology, biochemistry, human biology, physics, environmental science, computer science, and chemistry. Altogether, 30 students fell into this category. The non-science majors included economics, finance, accounting, criminal justice, psychology, anthropology, art, English, history, and information science. There were 22 students in this group. Three of the students had dual majors, but all were either science (biology/neurosciences) or non-science (criminal justice/psychology or finance/accounting).

Survey Results

Overall, mean scores for the dependent variables were relatively high and frequency distributions were negatively skewed. Table 1 shows mean scores and standard deviations for attitudes toward science literacy described by the four items in the first section of the survey. Students were asked to answer questions on a scale from 1 to 5, where 1 was "Strongly disagree," 2 was "Disagree," 3 was "Not sure," 4 was "Agree," and 5 was "Strongly agree." The highest mean, 4.48, describes student responses to the life-long learning item and suggests that they recognize the importance of ACRL Standard Five. The second highest mean was 4.44, in response to the importance of knowing political leaders' stands on scientific issues. The item on the importance of science literacy to responsible

TABLE 1 — ATTITUDES FREQUENCY DISTRIBUTION

Attitudes/ Description	**Mean General**	**Standard Deviation General**	**Mean Science Majors**	**Standard Deviation Science Majors**	**Mean Non-science Majors**	**Standard Deviation Non-science Majors**
Attitude One Being scientifically literate is an important part of responsible citizenship	4.35	0.738	4.30	0.794	4.41	0.666
Attitude Two It is important to know where political leaders stand on scientific issues such as global warming and stem cell research	4.44	0.752	4.40	0.724	4.50	0.802
Attitude Three Acquiring science literacy skills is an important part of becoming a life-long learner	4.48	0.7	4.53	0.681	4.41	0.734
Attitude Four A general course on science literacy should be taught at every college and university	4.12	0.943	4.23	0.898	3.95	0.999

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citizenship had a mean score of 4.35. The lowest mean score, 4.12, was in response to the suggestion that a general science literacy course should be a requirement of every college and university curriculum. This score is still high, but shows a comparative lack of enthusiasm on the part of some students for having actually to take a course to learn how to be science literate.

Overall, student's attitudes toward science literacy were positive which further supports the results of the previous study. Mean comparisons of Attitudes One and Two show that science majors did not always score higher in comparison with non -science majors.

Skills

Table 2 shows mean scores and standard deviations for students' rating of their mastery of science literacy skills. There were six items in this part of the survey. The highest overall mean, 4.62, belongs to Skill Six, being able to comprehend articles from the Science section of *The New York Times*. This might be attributed to the fact that it was required reading for every class and every class began with its discussion. Skill One, understanding what it means to be scientifically literate, received 4.6, the second highest score. Skill Four, mastery of the information literacy skills needed to annotate a scientific article, had a mean score of 4.4. Skill Two, having witnessed an increase in ones' level of science literacy as a result of one's university studies, received the same mean score, 4.4. Skill Three, mastery of the skills necessary for researching and writing a paper on an unfamiliar scientific topic, received a mean score 4.33. Skill Five, knowing how to use emerging communication technologies to keep up in one's field of study, received the lowest mean score, 4.19. This question echoes Standard Five of the ACRL Information Literacy Standards for Science and Engineering/Technology, performance indicator 2.

Overall, measures of central tendency in this part of the survey were quite high, especially considering that 22 students out of 52 respondents were non-science majors. Again, non-science majors scored higher than science majors in some responses.

Self-rating

Table 3 shows mean scores and standard deviations for students' self-rating of their science literacy level. Students were asked to rate their science literacy level on a scale from 1 to 4, where 1 was "Poor," 2 was "Satisfactory," 3 was "Good," and 4 was "Excellent." For the level upon graduation from high school, the overall mean was 2.81. For the level at the time of the survey, the overall mean was 3.59. This is a notable increase, one that can be attributed to several factors. One, of course, is the fact that they had just completed a course in information literacy in the sciences. Furthermore, most of the students had been taking university courses for at least three semesters (only three students in the entire sample were freshmen), and it is safe to assume that some of these were science courses.

DATA ANALYSIS

Analysis of variance

Survey data were analyzed using SPSS predictive analytics software. As the third research question was whether either of the two independent variables – academic year or major – is a better predictor of science literacy and lifelong learning, analyses of variance were conducted to detect differences between the two independent variables in their effect on attitudes, skills,

TABLE 2 — SKILLS FREQUENCY DISTRIBUTION

Skills/ Description	**Mean All Majors**	**Standard Deviation All Majors**	**Mean Science Majors**	**Standards Deviation Science Majors**	**Mean Non-science Majors**	**Standard Deviation Non-science Majors**
Skill One I understand what it means to be "scientifically literate"	4.6	0.534	4.67	0.479	4.50	0.598
Skill two My studies at the University at Albany have increased my level of science literacy	4.4	0.721	4.43	0.817	4.36	0.581
Skill Three I have mastered the information literacy skills necessary for conducting research and writing a paper on unfamiliar scientific topics	4.33	0.834	4.47	0.681	4.14	0.990
Skill Four I have mastered the information literacy skills necessary for annotating a scientific article	4.4	0.869	4.40	0.932	4.41	0.796
Skill Five I know how to use emerging communication technologies such as blogs, social networks, and RSS feeds to stay current in my field of study	4.19	0.715	4.13	0.819	4.27	0.550
Skill Six I can read and comprehend articles from popular scientific publications such as *Scientific American* or the Science section of *The New York Times*	4.62	0.631	4.63	0.669	4.59	0.590

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and self-rating. The four categories of academic year (freshman, sophomore, junior and senior) were collapsed into two, lowerclassmen (19) and upperclassmen (33) in order to underscore the effect of this variable on the dependent variables (Monette, Sullivan, & DeJong, 2008). As mentioned above, the other independent variable, academic major, had already been collapsed into two categories, science (30) and non-science (22). Items from the Attitudes, Skills, and Self-rating sections of the survey were collapsed together and treated as single dependent variables.

Two-way ANOVAs did not reveal statistically significant interaction between the effects of academic level and major on science literacy attitudes ($F(1, 48) = 0.069$, $p = 0.794$), skills ($F(1, 48) = 2.122$, $p = 0.152$), or self-rating ($F(1, 47) = 0.800$, $p = 0.376$). Nor did main effect analyses of the two independent variables indicate significant effects on attitudes and skills. However, main effects analyses of the self-rating ANOVA did indicate that science majors rate themselves higher ($p = 0.002$) on science literacy than their non-science counterparts. This finding corresponds with Miller's (2011) findings that taking at least three university level science courses is the strongest predictor of science literacy. Academic level, on the other hand, was not found significantly to impact this variable.

Discussion and Implications for Future Research

Just as college education in general and taking science courses in particular are good predictors of science literacy *per se* (Miller, 2010, 2011), they also appear to be good predictors of students' attitudes toward science literacy and lifelong learning. The results of this survey indicate that most of the respondents have positive opinions and attitudes about a range of aspects of science literacy. Furthermore, data analysis indicated that science majors are significantly more confident than their non-science counterparts in their level of science literacy.

Table 3 — Self-Rating of Science Literacy Frequency Distribution

Description	Mean All Majors	Standard Deviation All Majors	Mean Science Majors	Standard Deviation Science Majors	Mean Non-Science Majors	Standard Deviation Non-Science Majors
Self Rate One How would you rate your level of science literacy upon graduating from high school?	2.81	0.742	3.07	0.691	2.45	0.671
Self Rate Two How would you rate your level of science literacy at the current time?	3.59	0.536	3.77	0.430	3.33	0.577

The majority of students surveyed agreed that being science literate is requisite to civic responsibility. They also agreed that understanding political leaders' outlook on topical scientific issues such as global warming and stem cell research is important, and that acquisition of science literacy skills supports life-long learning. Finally, student respondents generally endorsed the proposal that a general science literacy course should be taught at every institution of higher learning, though not quite so enthusiastically as was the case with the other surveyed attitudes.

Both science and non-science majors expressed positive attitudes toward the concept of lifelong learning and the research skills they had acquired in the information literacy course they had just completed. In fact, analyses of variance between the two groups revealed no statistically significant difference. Likewise, there was no significant difference between science and non-science majors, or upper- or lowerclassmen, with regard to science literacy skill mastery. In other words, neither of these independent variables predicted the respondent's rating of his/her own mastery. Of course, this should not be taken to suggest that formal college education does not positively influence a student's attitudes toward lifelong learning and research skills, only that the area of a student's academic interest and his academic year do not significantly determine those attitudes. Moreover, students' self-rating of their level of science literacy proved to be one of the most important findings of this study, as this was the one dependent variable that was significantly influenced by one of the independent variables, academic major. Science majors in the study were significantly more likely than their non-science counterparts to rate their level of science literacy positively.

One of the limitations of this study, of course, is the possibility of a social desirability bias. That is, students' responses to the survey may have been influenced by their wanting to think of themselves as science literate because they are pursuing bachelor's degrees, or even their reluctance to admit to relative ignorance about this or any other subject. On the other hand, the study does not purport to provide an objective measure of students' science literacy, but rather a subjective one; the survey sought to assess what students think and feel about science literacy, both as a general concept and as a skill which they are striving to develop. And overall, the survey is a positive indicator of those attitudes. The clear majority of the respondents deemed science literacy and lifelong learning a valuable asset to their academic, professional, and civic attainment. This finding should give some reassurance to educators like Miller who have expressed concern about the current state of science literacy. Hopefully, it also suggests that information literacy educators will be able to obtain the resources necessary to develop further this important intellectual, professional, and civic skill set among post-secondary students.

Another limitation is the study sample, which is, strictly speaking, self-selected. However, it would be wrong to assume that the students surveyed had positive attitudes toward science literacy simply because they had registered for a course whose subject was science literacy. The author made a habit of asking students during the first class why they had registered for the course, and the reasons most commonly cited were 1) to fulfill the undergraduate requirement for information literacy and 2) for scheduling convenience. Only a handful of the students questioned cited a general interest in the course topic as the reason they had

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registered for the course. This explains why almost half of the students in the study sample were non-science majors. That said, it is safe to assume that the students who made up this study sample were not especially *un*comfortable with science literacy, or else they would presumably have registered for one of the several other courses that meet the university's general education requirement for information literacy. Therefore, future research would do well to formulate study designs that allow for a comparison of science majors who have taken information literacy in the science courses and those who have not, as well as non-science majors who have taken information literacy in the science courses and those who have not. Of course, such experiments will require a greater dedication of time and resources than this one.

Future research in this area should further develop instruments with which student attitudes about science literacy are measured. The instrument used for this study measured students' general opinions about science literacy, but it did not capture the more subtle aspects of their attitudes. This would seem to be why mean responses in all three of the survey domains were comparatively high. Furthermore, while it is important to have determined that academic major and year do not significantly predict science literacy attitudes and skills (the self-rating variable was more a measure of confidence), it would be beneficial to find out which independent variables do predict science literacy. Perhaps it would be useful to capture data about the number of college science courses taken at the moment of conducting a survey. A new or revised survey should also be more sensitive to changes in students' attitudes over time, in order to demonstrate exactly how those attitudes change. For example, longitudinal studies would produce richer data on this important area of information literacy, and it would help educators identify new goals for information literacy instruction and develop frameworks for working towards these objectives in the future.

Future research should also focus on establishing partnerships between librarians and science faculty who would be willing to administer actual science literacy tests to their students, as in Impey et al. (2011), along with a survey of their attitudes toward science and science literacy. These would likely provide important new insights to researchers about the information literacy of science students. New developments in science and technology will require new real -life examples when studying students' opinions about science literacy. Some topical issues do not remain topical for more than a few years; stem cell research, for example, does not have the same political salience it had four years ago.

Finally, future research should revisit the concept of lifelong learning from the point of view of new conceptualizations of information literacy to make sure its practical and intellectual significance is reflected appropriately in guidelines for educators of information literacy-related disciplines.

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APPENDIX

Science Literacy Student Survey

Please provide the following information:
Academic Status: Freshman ___
Sophomore ___ Junior ___ Senior ___

Academic Major

____

ATTITUDES

Please respond to the following statements as they reflect your attitudes about science literacy.

1. Being scientifically literate is an important part of responsible citizenship.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

2. It is important to know where political leaders stand on scientific issues such as global warming and stem cell research.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

3. Acquiring science literacy skills is an important part of becoming a life-long learner.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

4. A general course on science literacy should be taught at every college and university.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

MASTERY

Please respond to the following statements as they reflect your own science literacy.

5. I understand what it means to be "scientifically literate."

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree

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◊ Strongly disagree

6. My studies at the University at Albany have increased my level of science literacy.

◊ Strongly agree

◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

7. I have mastered the information literacy skills necessary for conducting research and writing a paper on unfamiliar scientific topics.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

8. I have mastered the information literacy skills necessary for annotating a scientific article.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

9. I know how to use emerging communication technologies such as blogs, social networks, and RSS feeds to stay current in my field of study.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

10. I can read and comprehend articles from popular scientific publications such as *Scientific American* or the science section of *The New York Times*.

◊ Strongly agree
◊ Agree
◊ Not sure
◊ Disagree
◊ Strongly disagree

<u>SELF-RATING</u>

11. How would you rate your level of science literacy upon graduating from high school?

◊ Excellent
◊ Good
◊ Satisfactory
◊ Poor

12. How would you rate your level of science literacy at the current time?

◊ Excellent
◊ Good
◊ Satisfactory
◊ Poor