Promoting Information Literacy for Science Education Programs: Correlating the National Science Education Content Standards with the Association of College and Research Libraries Information Competency Standards for Higher Education

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Abstract

Librarians who want to collaborate with faculty to incorporate information literacy into science education programs should understand the theories, pedagogies, and standards that serve the academic discipline. Understanding the National Science Education Standards (NSES) is beneficial for librarians seeking to partner with disciplinary faculty because librarians familiar with NSES will understand better the science educators' fields of reference and be equipped with the requisite vocabulary to communicate with science faculty. In this paper I map the commonalities between the NSES and the Association of College and Research Libraries Information Competency Standards for Higher Education and discuss the implications these commonalities have for promoting information literacy for science education programs.

Background

As a result of a recent posting to STS-L and BI-L asking about the incorporation of information literacy in undergraduate science programs and searching the Internet, I serendipitously discovered the National Science Education Standards (NSES). At the time of my query, I was preparing to teach a one-unit course, Fundamentals of Information Literacy (LIBY 1010), for the seventh time. This quarter-long course satisfies the information literacy requirement for all entering freshmen at California State University, Hayward. The information literacy course is part of a general education cluster system in which students satisfy their **{general education requirements}** by taking classes centered around the three major disciplines -- sciences, social sciences, humanities. The course I teach articulates with two of the five science clusters offered. I have been trying to incorporate what is taught in the disciplinary classes (in my case, biology and chemistry) into what I teach in the information literacy course. One major difficulty I have encountered in accomplishing this is stimulating interest and assistance from the disciplinary faculty. My students and I find the information literacy class more relevant and productive when the material the students are learning in biology and chemistry is integrated with the concepts and sources I teach.
Having discovered the NSES and reviewed the Association of College and Research Libraries Information Literacy Competency Standards for Higher Education, I found it useful to correlate the two sets of standards. Exploration of the correlation between the NSES and ACRL information literacy standards suggests the foundations for increased

integration of information literacy into science education programs by highlighting shared goals and enabling shared discourse. This paper first maps the commonalities between the NSES and ACRL information literacy standards and then discusses their implications for promoting information literacy for science education programs. With this correlation comes better understanding of the science educators' fields of reference and the requisite vocabulary to communicate with my science faculty, talking seriously about ways to work together to ensure students the best preparation for their information needs in life, work, and further study. As the Institute for Information Literacy advocates, "Information literacy depends on cooperation among classroom faculty, academic administrators, librarians and other information professionals. In order to effectivlely implement a program all parties must be involved."

From my review of the literature and as a result of my queries, I discovered numerous librarians who report successful collaborations with science faculty in achieving information literacy within the various science disciplines. The literature strongly suggests that we need to "un-box" information literacy; a number of authors propose it should be integrated into the disciplinary curriculum. Stoan (1984) is particularly forceful in advocating this position, saying, "Instruction in bibliographic resources is useless unless wedded to a course project in which students are simultaneously acquiring subject knowledge and direction from the professor and bibliographic skills from the librarian." I agree with those librarians, like Sapp (1992), who argue that if librarians want to collaborate with faculty, then we should understand the theories, pedagogies, and standards that serve the discipline in addition to being somewhat literate in the discipline itself. Librarians who are conversant with the discourses of their liaison disciplines have, in Sapp's argument (1992), an important role in the promotion of science literacy precisely because "science is a process of information discovery, dissemination, application (or analysis), and retrieval."

The Standards

For ease, I have reprinted below, with permission, the five ACRL Information Literacy Standards, and the seven Content Standard categories from the National Science Education Standards, as well as the definitions of both "information literacy" and "scientific literacy."

ACRL Definition of Information Literacy

"Information literacy" is a set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information. Information literacy forms the basis for lifelong learning. It is common to all disciplines (meaning it is found in all disciplines, not that it is the same in all disciplines), to all learning environments, and to all levels of education.[1]

ACRL Information Literacy Standards

1. The information literate student determines the nature and extent of the information needed.
2. The information literate student accesses needed information effectively and efficiently.
3. The information literate student evaluates information and its sources critically and incorporates selected information into his or her knowledge base and value system.

4. The information literate student, individually or as a member of a group, uses information effectively to accomplish a specific purpose.
5. The information literate student understands many of the economic, legal, and social issues surrounding the use of information and accesses and uses information ethically and legally.

NSES Definition of Scientific Literacy

"Scientific literacy" is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. People who are scientifically literate can ask for, find, or determine answers to questions about everyday experiences. They are able to describe, explain, and predict natural phenomena.[2]

National Science Education Standards, Content Standard Categories

Included in the list below is a brief, suggestive description of the Standards. For the purposes of this discussion, content standards B, C, and D, covering specific subject matter, will not be considered.[3]

A. **Science as inquiry.** Studying the "processes of sciences," requiring that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understandings of science, rather than studying "science as a process," learning step-by-step skills such as observation, inference, and experimentation.
B. **Physical science.** This refers to the subject matter.
C. **Life science.** This refers to the subject matter.
D. **Earth and space science.** This refers to the subject matter.
E. **Science and technology.** Understanding the link between the natural and designed world. Emphasizes decision-making abilities associated with identifying and stating a problem, designing a solution, and evaluating the solution. Includes fundamental understandings about science's various linkages with technology, giving examples of technological achievement in which science has played a part and examples in which technological advances contributed directly to scientific progress.
F. **Science in personal and social perspectives.** Students' seeing the personal and social impacts of science and developing decision-making skills.
G. **History and nature of science.** Helping students see science as a human experience that is an ongoing and ever-changing enterprise.

Correlation:

Though the NSES are K-12 standards and the ACRL standards apply to higher education, it is useful to correlate them since general education science requirements at institutions of higher education essentially resemble the kinds of science courses taught in grades 9-12. Knowledge of the NSES should supplement librarians' awareness of discipline-specific standards or goals from various national associations and organizations, such as the American Chemical Society (Somerville 1990), and information competency goals determined by college and university departments and individual faculty members for their students (Peterson & Kajiwara 1999).

The NSES were developed, in part, to change the emphasis of science education throughout the primary and secondary educational system. The NSES stresses the following:

less emphasis on	**more emphasis on**
knowing facts	understanding concepts and developing abilities of inquiry
studying subject disciplines (physical, life, earth sciences) for their own sake	learning subject matter disciplines in the context of inquiry, technology, science in personal and social perspectives, and history and nature of science
separating science knowledge and science process	integrating all aspects of science content
covering many science topics	studying a few fundamental science concepts
implementing inquiry as a set of processes	implementing inquiry as instructional strategies, abilities, and ideas to be learned

Science Education Standard A (science as inquiry) is directly related to ACRL Standards 1 and 3. As librarians we strive to teach the important process of evaluation. This process includes understanding authority, credibility, content, timeliness, the larger discourse, etc. Rather than simply teaching students a set of specific skills that typically only apply to a particular situation, we offer them a repertoire of questions to ask themselves when reading, hearing, or seeing new information. These questions need to be combined in various ways depending on the nature of their inquiry. Students need to understand that everything they have learned in the past will influence how they gather and use information in the present and that scientific discovery is an iterative process.[4] This is the nature of NSES A's focus on gathering knowledge as a lifelong process. In addition, ACRL Standard 1 seems to be best correlated with the notion of hypothesis, the basis for scientific inquiry. Hypothesis is one of the fundamental abilities and concepts that underlie NSES A. Without a hypothesis, there is no plan; without a plan, very little effective and efficient information gathering and research is accomplished.

Science Education Standard E (science and technology) relates to ACRL Standards 2 and 4. NSES E says that the relationship between science and technology is so close that any presentation of science that does not develop an understanding of technology would portray an inaccurate picture of science.[5] Likewise, it is foolish to present information without a sound explanation of the role technology plays today in locating and using information effectively and efficiently.

Science Education Standards F (science in personal and social perspectives) and G (history and nature of science) relate to ACRL Standard 5. NSES F aims to equip students with the means to understand and act on personal and social issues. It proposes that students learn to weigh risks and benefits; that science and technology have local, national and global meanings; and that there are natural and human-induced hazards. NSES G helps students see science as a human experience that is on-going, ever-changing, and reflective of past happenings. In the course of studying science, students should also understand that science has a role in the development of cultures. For example, scientists have ethical norms including valuation of the peer review process, truthful reporting about methods and outcomes of investigations, and making public results of their work. Both Standards F and G offer students a foundation upon which to base decisions they will face as citizens. Librarians and faculty can easily use examples from the scientific world to explain the ethical use of information, and truthful reporting can be linked to the process of evaluation. Though many students do not become scientists, they still need to be scientifically literate since science plays an important role in driving our economy and environment. Jon Miller (1998) says "... there has been a growing recognition of the importance of increasing the proportion of citizens who are sufficiently scientifically literate to participate in the resolution of public policy disputes over issues involving science and technology."[6]

Finally, there is one NSES standard underlying the other seven content standards. This standard concerns conceptual and procedural schemes unifying science disciplines and providing students with powerful ideas to help them understand the natural world. There are five schemes in this one standard. The two most relevant are: (1) the relationship between systems, order, and organization; and (2) the relationship between evidence, models, and explanation.[7]

The systems, order, and organization scheme states that since the natural and designed world is complex, as well as too large and complicated to investigate and comprehend all at once, scientists and students learn to define small portions for the convenience of investigation. These units of investigation can be called systems. Systems have boundaries, components, resources flow, and feedback. Students should think and analyze in terms of systems, which will help them keep track of what they are learning and how it relates to what they have learned. Libraries are part of a system of information organization, and I advocate that we teach the library as a part of this larger system, using science's definition of "system" since students are familiar with it. Thus, we would be making the library a part of their natural course of study, not something tangentially related.

The concept of evidence, models, and explanation states that: (1) evidence consists of observations and data on which to base scientific explanations, (2) models can be structures corresponding to real objects and events, and (3) explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. Students need to understand that past and present information drives the creation of new information and thus new knowledge and new discoveries. The NSES also states that as students develop and understand more concepts and processes, their explanations should become more sophisticated, reflecting a rich scientific knowledge base and showing evidence of logic, higher levels of analysis, and greater tolerance of criticism and uncertainty. If students are aware of systems of information, they can predict where to go for the information needed.

Conclusion

Clearly, strong correlations between the two sets of standards exist. However, much of the burden of integrating information literacy with science education falls on librarians as is evidenced by Cecilia Brown's (1999) statement that , "Strong partnerships with faculty are imperative for these plans to succeed." Our understanding of science education theories, pedagogies, and standards, as well as our own ideas of how to integrate information literacy into science education, should provide us with the tools to communicate with our science faculty. Eventually we should be able to offer a variety of solutions that work for our particular situations. Understanding the National Science Education Standards is one step in the appropriate direction.

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Notes

1 ACRL further describes an information literate individual as one able to: determine the extent of information needed; access the needed information effectively and efficiently; evaluate information and its sources critically; incorporate selected information into one's knowledge base; use information effectively to accomplish a specific purpose; understand the economic, legal, and social issues surrounding the use of information; and access and use information ethically and legally.
2 The definition of "scientific literacy" is itself problematic and evolving. Being scientifically literate might mean knowing a particular list of facts or exhibiting certain behaviors. Cultural, civic, and practical scientific literacy are yet three more formulations of scientific literacy. The definition of science information literacy also varies and can be based on tool literacy, resource literacy, and social-structural literacy. (Welborn & Kanar 2000).
3 In addition to the content standards, the NSES includes other standards. They are: science teaching standards, standards for professional development for teachers of science, assessment in science education, science education program standards, and science education system standards.
4 Affirmation of this can be found in Pressley's and Afflerbach's (1995) explanation that readers automatically activate prior knowledge related to a new text before attempting to read it: prior knowledge is generally seen as enhancing the interaction between reader and text.
5 Wiggins (1998) recognized the role computers have on information in the sciences.
6 Miller (1998) as quoted in Welborn and Kanar (2000).
7 The other three schemes concern: (3) the relationship between change, constancy, and measurement; (4) the relationship between evolution and equilibrium; and (5) the relationship between form and function.