Information literacy standards for science and engineering/technology

Approved at ALA Annual Conference, June 2006

by the ALA/ACRL/STS Task Force on Information Literacy for Science and Technology

Introduction

Information literacy competency and the purpose of information literacy competency standards are fully described in the ACRL document at www.ala.org/ala/acrl/acrlstandards/standards.pdf. This document states (page 4, Section 1:2) that information literacy "is common to all disciplines, to all learning environments, and to all levels of education." Information literacy in science, engineering, and technology disciplines is defined as a set of abilities to identify the need for information, procure the information, evaluate the information and subsequently revise the strategy for obtaining the information, to use the information and to use it in an ethical and legal manner, and to engage in lifelong learning. Information literacy competency is highly important for students in science and engineering/technology disciplines who must access a wide variety of information sources and formats that carry the body of knowledge in their fields. These disciplines are rapidly changing, and it is vital to the practicing scientist and engineer that they know how to keep up with new developments and new sources of experimental/research data.

Science, engineering, and technology disciplines pose unique challenges in identifying, evaluating, acquiring, and using information. Peer reviewed articles are generally published in more costly journals and, therefore, not always available. Gray literature requires knowledge of the agency/organization publishing the information. Much of science, engineering, and technology is now interdisciplinary and, therefore, requires knowledge of information resources in more than one discipline. Information can be in various formats (e.g., multimedia, database, Web site, data set, patent, Geographic Information System, 3-D technology, open file report, audio/visual, book, graph, map) and, therefore, may often require manipulation and a working knowledge of specialized software.

Science, engineering, and technology disciplines require that students demonstrate competency not only in written assignments and research papers but also in unique areas such as experimentation, laboratory research, and mechanical drawing. Our objective is to provide a set of standards that can be used by science and engineering/technology educators, in the context of their institution's mission, to help guide their information literacy-related instruction and to assess student progress. The field of mathematics is not included in the standards.

Based on the ACRL "Information Literacy Competency Standards for Higher Education," five standards and twenty-five performance indicators were developed for information literacy in science and engineering/technology. Each performance indicator is accompanied by one or more outcomes for assessing the progress toward information literacy of students of science and engineering or technology at all levels of higher education.

This is intended to be a living document with future opportunities for input from the community and will undergo periodic review and revision.

Standard one

The information literate student determines the nature and extent of the information needed.

Performance indicators

The information literate student:

1. Defines and articulates the need for information.

Outcomes include that the student:

a) Identifies and/or paraphrases a research topic, or other information need such as that resulting from an assigned lab exercise or project.

b) Consults with instructor/advisor for appropriateness of topic, research project, or laboratory exercise question.

c) Develops a hypothesis or thesis statement and formulates questions based on the information need.

d) Explores general information sources to increase familiarity with current knowledge of the topic.

e) Defines or modifies the information need to achieve a manageable focus.

f) Identifies key concepts and terms that describe the information need.

2. Identifies a variety of types and formats of potential sources for information.

Outcomes include that the student:

a) Identifies the purpose and audience of potential resources (e.g., popular vs. scholarly, current vs. historical, external vs. internal, primary vs. secondary vs. tertiary).

b) Considers experts or other researchers as potential information resources.

c) Identifies the value and differences of potential resources in a variety of formats (e.g., multimedia, database, Web site, data

About the guidelines

In January 2002, JoAnn DeVries, chair of the Science and Technology Section (STS), charged the STS Task Force on Information Literacy for Science and Technology with developing standards, performance indicators, and outcomes for library instruction in science and technology, based on the "Information Literacy Competency (ILC) Standards for Higher Education."

The STS Council approved the resulting product in June 2004 at the ALA Annual Conference in Orlando, Florida. The STS Task Force identified five standards, with the fifth standard being entirely new and different from the "ILC Standards for Higher Education." The STS standards are also available on the ACRL Web site at www.ala.org/ (click on "Standards and Guidelines").

This work is the product of more than two years of reviewing sources, communication, conference meetings, soliciting reviews through several science/technology electronic lists, and collaboration among the members of the task force who serve as liaison librarians for major science and engineering disciplines. Those members were:

- Virginia Baldwin, University of Nebraska-Lincoln, Engineering, Physics, and Astronomy Librarian, task force chair
- C. J. (Catherine Woodworth) Wong, Quinnipiac University, science librarian
- Sheila Young, Arizona State University, science reference librarian/engineering, on ARL Learning Outcomes Workgroup
- Ibironke Lawal, Virginia Commonwealth University, engineering and science librarian, biotechnology, chemistry, mathematics
- Daureen Nesdill, University of Utah, science and engineering librarian
- Barbara MacAlpine, Trinity University, science librarian

Former members also made contributions to the development of the final product:

- Sherry Durren, Georgia Perimeter College, information literacy librarian
- Jennifer Laherty, California State University-Hayward, biological sciences, chemistry, communicative sciences and disorders, geology, health sciences, and nursing
- Elizabeth I. Hanson, Indiana University, life sciences.

set, patent, Geographic Information Systems, 3-D technology, open file report, audio/visual, book, graph, map).

d) Realizes that information may need to be constructed with raw data from primary sources or by experimentation.

e) Recognizes that potentially useful information or data in a variety of formats may be proprietary, have limited access, or may be freely available online.

f) Recognizes that potentially useful information may require specific data management expertise and that an understanding of the structure of organizations involved in producing the information aids in the identification of that information.

3. Has a working knowledge of the literature of the field and how it is produced.

Outcomes include that the student:

a) Knows how scientific, technical, and related information is formally and informally produced, organized, and disseminated.

b) Recognizes that primary, secondary, and tertiary sources vary in importance and use with each discipline.

c) Is aware of the professional associations of the field and their literature.

d) Is knowledgeable of sources that are specific to the field (e.g., manuals, handbooks, patents, standards, material/equipment specifications, current rules and regulations, reference material routinely used in industry, manuals of industrial processes and practices, and product literature).

e) Recognizes that knowledge can be organized into disciplines and combinations of disciplines (multidisciplinary) that influence the way information is accessed and considers the possibility that the literature of other disciplines may be relevant to the information need.

f) Recognizes the value of archival information, recognizes how its use and importance may vary with each discipline, and recognizes the importance of preservation of information.

4. Considers the costs and benefits of acquiring the needed information.

Outcomes include that the student:

a) Determines the availability of needed information and makes decisions on broadening the information-seeking process beyond locally held resources. Some examples would be consulting with colleagues, independent information brokers, experts, and consultants in the field in addition to using interlibrary loan, nearby libraries, and information centers.

b) Recognizes that there may be a tradeoff between the value of the information and the time and cost to obtain it.

c) Formulates a realistic overall plan and timeline to acquire the needed information.

d) Recognizes the importance of a variety of information research areas that can be used to gain competitive advantage, track new products, improve processes, and monitor competitors and their marketing strategies. Some examples would be consulting with experts and consultants in a field, research into licensing opportunities, and patent and intellectual property research.

e) Recognizes that information needed may be in a foreign language and that translation may be necessary.

Standard two

The information literate student acquires needed information effectively and efficiently.

Performance indicators

The information literate student:

1. Selects the most appropriate investigative methods or information retrieval systems for accessing the needed information.

Outcomes include that the student:

a) Identifies appropriate investigative methods (e.g., literature search, laboratory experiment, simulation, fieldwork).

b) Investigates the scope, content, and organization of information retrieval systems.

c) Selects efficient and effective approaches for accessing the information needed from the investigative method or information retrieval system.

2. Constructs and implements effectively designed search strategies.

Outcomes include that the student:

a) Develops a research plan appropriate to the investigative method.

b) Identifies keywords, synonyms, and related terms for the information needed and selects an appropriate controlled vocabulary specific to the discipline or information retrieval system.

c) Uses other methods of search term input, such as structure searching and image searching, specific to the discipline or information retrieval system.

d) Constructs a search strategy using appropriate commands for the information retrieval system selected (e.g., Boolean operators, truncation, and proximity for search engines; internal organizers such as indexes for books).

e) Implements the search strategy in various information retrieval systems using different user interfaces and search engines, with different command languages, protocols, and search parameters, while recognizing similar search features across the systems (such as e-mail alerts and save search options, search fields, and controlled vocabulary).

f) Follows citations and cited references to identify additional pertinent articles.

3. Retrieves information using a variety of methods.

Outcomes include that the student:

a) Uses various relevant search systems to retrieve information in a variety of formats.

b) Uses various classification schemes and other systems (e.g., call number systems or indexes) to locate information resources within the library or to identify specific sites for physical exploration.

c) Uses specialized online or in-person services as needed to retrieve information and whenever unable to identify or locate appropriate materials (e.g., interlibrary loan/document delivery, librarians, library staff, professional associations, institutional research offices, community resources, subject experts, and practitioners).

d) Uses surveys, letters, interviews, experiments, and other forms of inquiry to retrieve information or data, as appropriate for the research area or discipline.

4. Refines the search strategy if necessary.

Outcomes include that the student:

a) Assesses the quantity, quality, accuracy, currency, and relevance of the search results and the limitations of the information retrieval systems or investigative methods to determine whether alternatives should be sought and used.

b) Identifies gaps in the information retrieved and determines if the search strategy should be revised.

c) Repeats the search using the revised strategy or new systems or methods as necessary.

5. Extracts, records, transfers, and manages the information and its sources.

Outcomes include that the student:

a) Selects the most appropriate technology for the task of extracting the needed information (e.g., copy/paste software functions, photocopier, scanner, audio/visual equipment, exploratory instruments, export of the information or record, or note taking). Examples of technologies to export information would be bibliographic management software, text conversion software, and spreadsheet software.

b) Creates a system for organizing the information, including tracking results of laboratory experiments, fieldwork, etc.

c) Differentiates between the types of sources cited and understands the elements and correct syntax of a citation for a wide range of resources.

d) Records all pertinent citation information for future reference by downloading, printing, e-mailing, or manual notation. Uses various technologies to manage the information selected and organized, e.g., bibliographic management software.

Standard three

The information literate student critically evaluates the procured information and its sources, and as a result, decides whether or not to modify the initial query and/or seek

additional sources and whether to develop a new research process.

Performance indicators

The information literate student:

1. Summarizes the main ideas to be extracted from the information gathered.

Outcomes include that the student:

a) Applies an understanding of the structure of a scientific paper and uses sections, such as the abstract or conclusion, to summarize the main ideas.

b) Selects main ideas from the text.

c) Identifies verbatim material that can then be appropriately quoted.

2. Selects information by articulating and applying criteria for evaluating both the information and its sources.

Outcomes include that the student:

a) Distinguishes between primary, secondary, and tertiary sources, and recognizes how location of the information source in the cycle of scientific information relates to the credibility of the information.

b) Distinguishes among facts, points of view, and opinion.

c) Examines and compares information from various sources in order to evaluate reliability, validity, accuracy, authority, timeliness, and point of view or bias.

d) Analyzes the structure and logic of supporting arguments or methods.

e) Understands and uses statistical treatment of data as evaluative criteria.

f) Recognizes prejudice, deception, or manipulation in the information or its use.

g) Recognizes the cultural, physical, or other context within which the information was created, and understands the impact of context on interpreting the information.

3. Synthesizes main ideas to construct new concepts.

Outcomes include that the student:

a) Recognizes interrelationships among concepts and combines them into potentially useful primary statements and/or summary of findings with supporting evidence.

b) Extends initial synthesis, when possible, at a higher level of abstraction to construct new hypotheses that may require additional information.

c) Utilizes computer and other technologies (e.g., spreadsheets, databases, multimedia, and audio or visual equipment) for studying the interaction of ideas and other phenomena.

4. Compares new knowledge with prior knowledge to determine the value added, contradictions, or other unique characteristics of the information.

Outcomes include that the student:

a) Determines whether information satisfies the research or other information need.

b) Uses consciously selected criteria to determine whether the information contradicts or verifies information used from other sources.

c) Draws conclusions based upon information gathered.

d) Tests theories with discipline-appropriate techniques (e.g., simulators, experiments).

e) Determines probable accuracy by questioning the source of the information, limitations of the information-gathering tools or strategies, and the reasonableness of the conclusions.

f) Integrates new information with previous information or knowledge.

g) Determines whether information provides evidence relevant to the information need or research question.

h) Includes information that is pertinent even when it contradicts the individual's value system, and includes it without skewing it.

5. Validates understanding and interpretation of the information through discourse with other individuals, small groups or teams, subject-area experts, and/or practitioners.

Outcomes include that the student:

a) Participates in classroom and virtual/electronic discussions (e.g., e-mail, bulletin boards, chat rooms) and uses discussions for validating understanding and interpretation of the information.

b) Works effectively in small groups or teams.

c) Seeks expert opinion through a variety of mechanisms (e.g., interviews, e-mail, discussion lists).

6. Determines whether the initial query should be revised.

Outcomes include that the student:

a) Determines if original information need has been satisfied or if additional information is needed.

b) Reviews search strategy and incorporates additional concepts as necessary.

c) Reviews information retrieval sources used and expands to include others as needed.

7. Evaluates the procured information and the entire process.

Outcomes include that the student:

a) Reviews and assesses the procured information and determines possible improvements in the information-seeking process.

b) Applies the improvements to subsequent projects.

Standard four

The information literate student understands the economic, ethical, legal, and social issues surrounding the use of information and its technologies and either as an individual or as a member of a group, uses information effectively, ethically, and legally to accomplish a specific purpose.

Performance indicators

The information literate student:

1. Understands many of the ethical, legal and socioeconomic issues surrounding information and information technology.

Outcomes include that the student:

a) Identifies and discusses issues related to privacy and security in both the print and electronic environments.

b) Identifies and discusses issues related to free versus fee-based access to information.

c) Identifies and discusses issues related to censorship and freedom of speech.

d) Demonstrates an understanding of intellectual property, copyright, and fair use of copyrighted material and research data.

2. Follows laws, regulations, institutional policies, and etiquette related to the access and use of information resources.

Outcomes include that the student:

a) Participates in electronic discussions following accepted practices (e.g., "Netiquette").

b) Uses approved passwords and other forms of ID for access to information resources ethically.

c) Complies with institutional policies on access to and distribution of information resources.

d) Preserves the integrity of information resources, equipment, systems, and facilities.

e) Legally obtains, stores, and disseminates text, data, images, or sounds.

f) Demonstrates an understanding of what constitutes plagiarism and does not represent work attributable to others as his/her own. This includes the work of other members of research teams.

g) Demonstrates an understanding of federal, state, and institutional policies related to the use of human and animal subjects in research.

3. Acknowledges the use of information sources in communicating the product or performance.

Outcomes include that the student:

a) Selects an appropriate documentation style for each research project and uses it consistently to cite sources.

b) Posts permission granted notices, as needed, for copyrighted material.

c) Acknowledges all contributors, funding sources, grants, etc. Complies with reporting and other requirements related to grants.

4. Applies creativity in use of the information for a particular product or performance.

Outcomes include that the student:

a) Selects, analyzes, organizes, summarizes, and/or synthesizes information from a variety of resources.

b) Explores the use of advanced information technologies, such as data mining and visualization to move beyond retrieval and

identify trends and patterns within large sets of complex research data.

5. Evaluates the final product or performance and revises the development process used as necessary.

Outcomes include that the student:

a) Maintains a journal or log of activities related to the information-seeking, evaluating, and communicating process.

b) Reflects on past successes, failures, and alternative strategies.

Works consulted in developing these standards

In developing the standards the Task Force reviewed six regional accreditation sources, standards and criteria for three disciplines, four monographs, engineering library information competencies, and a relevant university Web site:

Association Web sites

• MSA: Middle States Association of Colleges and Schools, www.msache.org.

• NCA-HLC: North Central Association of Schools and Colleges – Higher Learning Commission, www.ncahigherlearningcommission.org.

• NWCCU: Northwest Association of Schools, Colleges and Universities, www.nwccu.org.

• SACS: Southern Association of Colleges and Schools, www.sacscoc.org.

• WASC–ACSCU: Western Association of Schools and Colleges, www.wascweb.org.

• NEASC: New England Association of Schools and Colleges – Commission on Institutions of Higher Education, www.neasc.org.

Discipline standards

• EHAC: National Environmental Health Science and Protection Accreditation Council, www.ehacoffice.org.

• CHEM: American Chemical Society (ACS), Committee on Professional Training, 2003, Undergraduate Professional Education in Chemistry: Guidelines and Evaluation Procedures, Columbus, Ohio, American Chemical Society. Available at: www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=education\cpt\guidelines.html.

• ABET: Accreditation Board for Engineering and Technology, Inc., www.abet.org/criteria.html.

Monographs

• *Engineering Libraries: Building Collections and Delivering Services,* Conklin and Musser, eds., Haworth Press, Inc. NY 2001.

• By authors cited: *Information and the Professional Scientist and Engineer,* Baldwin and Hallmark, eds., Haworth Press, Inc., NY 2001, (Flaxbart, Joseph, Wild and Havener, Pinelli, Caracuzzo, Wagner).

• *Online Ecological and Environmental Data,* Virginia A. Baldwin, ed., Haworth Press, Inc., NY 2004.

• Communication Patterns of Engineers. Carol Tenopir, and Donald W. King, IEEE Press (Wiley-Interscience), Piscataway, NJ 2004.

Other

• ASEE Engineering Libraries Division, "Information Competencies for Engineering". Unpublished.

• Cal Poly University, "Introductory Competencies in Specific Disciplines," www.lib.calpoly.edu/infocomp/specific.html.

c) Applies devised improvements to subsequent projects.

6. Communicates the product or performance effectively to others.

Outcomes include that the student:

a) Chooses a communication medium and format that best supports the purposes of the product or performance and the intended audience.

b) Uses a range of information technology applications in creating the product or performance.

c) Incorporates principles of design in the product or performance.

d) Communicates clearly and succinctly, if appropriate, with a style that supports the purposes of the intended audience.

Standard five

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.

Performance indicators

The information literate student:

1. Recognizes the value of ongoing assimilation and preservation of knowledge in the field.

Outcomes include that the student:

a) Recognizes that, for a professional, it is necessary to keep up with new developments that are published in the literature of the field.

b) 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.

c) Is able to apply information access skills learned in one subject area to another.

d) Understands the importance of archiving information so that it will survive company mergers, outdated access technologies, personnel departures, etc.

2. Uses a variety of methods and emerging technologies for keeping current in the field.

Outcomes include that the student:

a) Establishes current awareness services and follows citation and cited references for pertinent articles.

b) Uses online table of contents scanning, review journals, and other forms of rapid communication literature.

c) Manages files of citations of articles read or accessed (such as through use of bibliographic management software).

d) Uses bibliometric analysis tools to update knowledge of changing technology and product life cycles (such as by analyzing a company's published papers and/or patent portfolio).

e) Recognizes emerging forms and methods of scholarly publishing in the field. Recent examples are: the use of blogs, RSS feeds, open access journals, and freely available online research data.