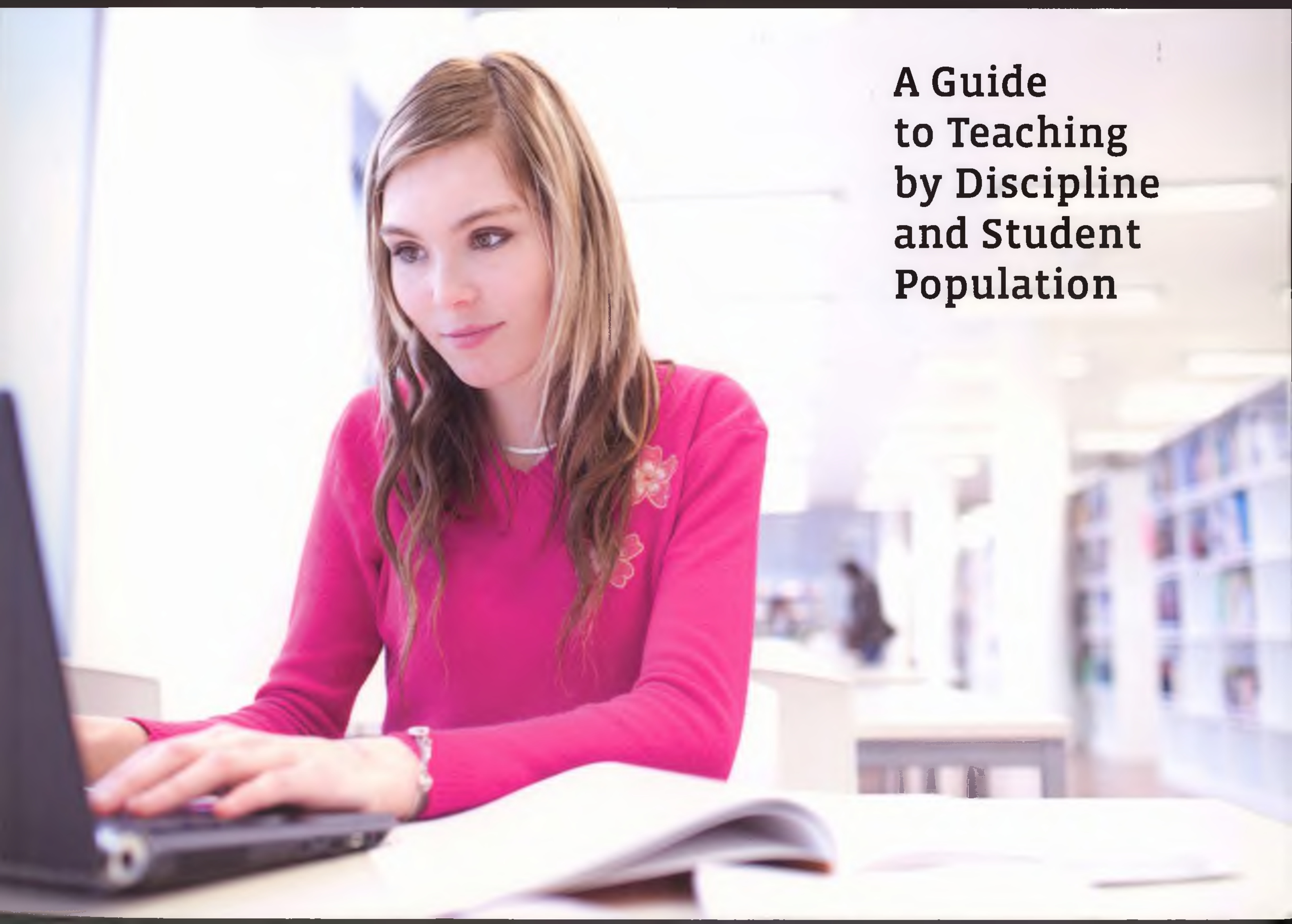
2013

Engineering

Martin K. Wallace
University of Maine - Main, martin.wallace@umit.maine.edu

SECOND EDITION EDITED BY PATRICK RAGAINS

Information Literacy Instruction That Works



A Guide to Teaching by Discipline and Student Population

CHAPTER SIXTEEN

Engineering

Martin K. Wallace

Introduction

This chapter describes a standards-based framework of information literacy instruction (ILI) for undergraduate engineering students. It begins by identifying characteristics of information literacy that are most relevant to the engineering curriculum, framed by a review of the ACRL's "Information Literacy Standards for Science and Engineering/Technology" (2012b). Recommendations for delivering ILI to undergraduate engineering students are given, drawing from a pilot program for integrating information literacy into the Mechanical Engineering Technology (MET) program at the University of Maine. Finally, assessment strategies for ILI curricula are provided, based on examples from the MET pilot. Throughout the chapter, core engineering information resources are identified, and a list of suggested resources is included.

Information Literacy Competency Standards in the Engineering Curriculum

Any librarian engaged in information literacy instruction for engineering students should be familiar with the core competencies (outcomes) expected of college engineering graduates. Fortunately, such competencies have already been outlined. It is useful for librarians providing information literacy instruction for engineering curricula to understand these standards. The "Information Literacy Standards for Science and Engineering/Technology" (hereafter, the STS Standards) emphasizes three areas of information literacy unique to science and engineering disciplines (ACRL, 2012b). First, the disciplines of science, engineering, and technology are rapidly changing—faster than in most other fields of research. Therefore, it is vital to the practicing scientist and engineer to know how to keep up with scholarly and professional communication and the full range of new developments in one's discipline, including sources of experimental research data.

Second, science, engineering, and technology disciplines pose unique challenges in identifying, evaluating, acquiring, and using information—the cornerstones of information literacy in any discipline. Pertinent examples are that peer-reviewed articles are generally published in more costly journals than in other disciplines, making them less widely available; that understanding "gray literature" requires knowledge of the agencies and organizations that produce the information; that much of science, engineering, and technology is now interdisciplinary, requiring wider knowledge of information resources; and, finally, that information is made available in more varied formats, requiring one to manipulate data or understand specialized software. The third area highlighted in the introduction is that "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" (ACRL, 2012b).

Moving beyond the document's introduction, the following specific competencies are illustrated. Due to the fast pace of science and engineering research, communication of ideas often takes place in more informal forums than does research in other disciplines. In many cases, data and research results become widely known throughout a research community before they are ever formally published. At times the information one seeks simply is not available in any findable, published format. For this, the STS Standards place importance on turning to colleagues, consultants, subject experts, and other researchers as potential information sources.

Other information sources given prominence in the STS Standards are "gray literature," such as patents, technical standards and specifications, geographic information systems, 3-D technology, open-file reports, maps, and graphs. Gray literature can be described as the wide range of document types produced at all levels of government, academics, businesses, and organizations not controlled by commercial publishing, that is, where publishing is not the primary activity of the producing body.

Many of the just-mentioned types of sources (e.g., technical standards and specifications, geographic information system files) have proprietary restrictions on their use. Thus, the STS Standards place stronger emphasis on understanding laws, policies, and ethical issues surrounding access to information (ACRL, 2012b). Considering the open nature of academia in general compared to the relatively proprietary nature of much of today's scientific and technical research, this should not be surprising.

Specialized information sources often require specific bibliographic management tools, data management expertise, specialized software or programming skills, or an understanding of how particular data sources are collected and disseminated. Thus, the STS Standards emphasize the need for these skills as a part of information literacy. When thinking about the special software and indexing required to make scientific and technical knowledge findable and usable—Inspec codes, patent classification, and chemical-structure searching are just a few—it becomes obvious that scientists and engineers require more than the run-of-the-mill keyword and subject-heading search skills. Those who possess resource-specific search knowledge will be more successful researchers than those who do not.

The STS Standards emphasize the need for creativity in using information for a particular product or performance, advocating exploration 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" (ACRL, 2012b). A popular example of this is the "hockey stick" graph used as a communication device for representing climate change trends to the lay public (Mann, Bradley, and Hughes, 1998).

Connecting Information Literacy to the Engineering Curriculum

The STS Standards place information literacy squarely in the purview of the engineering curriculum, using language commonly found in engineering course syllabi, and perhaps more important, the accreditation guidelines used in nearly all accredited engineering programs. Since a number of these standards are highly (and increasingly becoming more) relevant to engineering programs' core educational outcomes, they are key to opening up the engineering curriculum to information literacy instruction.

Engineering programs are typically reaccredited every six years by the Accreditation Board for Engineering and Technology (ABET). When comparing ABET's *Criteria for Accrediting Engineering Technology Programs: Effective for Evaluations during the 2010–2011 Accreditation Cycle* (from here on referred to as the ABET Criteria, for brevity) and the STS Standards, it is apparent that the two share overlapping objectives. By integrating ILI into the program's curriculum, objectives for both the library and the academic department are satisfied.

The most obvious relationship between ILI and the ABET Criteria is the requirement that facilities have "Internet and information infrastructures, including electronic information repositories, equipment catalogs, professional technical publications, and manuals of industrial processes and practices adequate to support the educational objectives of the program and related scholarly activities of students and faculty" (ABET, 2009: 4). While that nearly sums up the need for good libraries and strong library services for engineering program accreditation, there are more ways that the ABET Criteria can be satisfied by formal ILI. Throughout the remainder of this chapter other overlapping objectives between the STS Standards and the ABET Criteria will be explored, with examples taken from the Mechanical Engineering Technology (MET) program at the University of Maine.

Information Literacy Standards in Context: Learning Outcomes from the University of Maine's MET Program

Engineering students have many information literacy–related learning needs, but four areas have been identified by faculty in the University of Maine's Mechanical Engineering Technology (MET) program as needing the most improvement (personal communication with MET faculty): (1) the ability to identify a research question and develop effective search criteria and strategies; (2) the ability to identify appropriate resources for use in a particular application; (3) the ability to evaluate resources critically; and (4) the ability to understand citations and to properly reference and cite information sources. Following is a discussion of each of these four areas.

Developing Research Questions and Search Strategies

MET faculty have observed that students often choose popular keywords over their scientific or technical synonyms when conducting searches or developing a research topic. According to Neely (2006), students consistently struggle to determine useful keywords and often skip this step. To ameliorate this tendency, librarians and faculty can teach students to use thesauri and subject headings. Additionally, subject encyclopedias are better resources than the open web for basic facts and preliminary research (Furno and Flanagan, 2008). In order to develop successful search strategies, engineering students may also need to develop knowledge of Inspec codes, patent classification, chemical structures, or other highly specialized means of classifying scientific and technological literature.

Identifying Appropriate Resources

Faculty often state that most undergraduate students will not willingly use any information source not found on the first page of their Google search results. Although this may be an exaggeration, Neely (2006) found that many college-level students do not use resources beyond what is housed in their own institution's libraries. Furno and Flanagan (2008) identified a related problem, namely, students' inability to identify links on the library website leading to an intended resource, for example, a scholarly article or book. These problems can be minimized by teaching students how to navigate their library's website—a solution that offers them the speed of the web, a vast storage of scholarly sources, and in many cases, several ways to acquire full text (including via interlibrary loan). Beyond using general information sources, faculty in the MET program identified the need for searching technical report databases, patents, handbooks and similar reference books, government and industry research, and standards.

Evaluating Information Resources

Librarians generally believe that students do not evaluate information and its sources for accuracy, authority, bias, currency, scope, timeliness, validity or audience, nor are they prepared to identify the characteristics of a scholarly article and distinguish it from a nonscholarly publication (Neely, 2006; Furno and Flanagan, 2008). These beliefs have some validity, as faculty frequently request librarians to discuss source evaluation during library instruction sessions. Two typical requests from engineering faculty for inclusion in library sessions are to explain differences between popular magazines, trade publications, and scholarly journals, and to explain the importance of using peer-reviewed content in college-level research.

Understanding Citations and Citing Sources

A study on citation analysis found that only 12.3 percent of senior computer science students could properly cite both web and print materials, while 31.5 percent could not properly cite either (Edzan, 2007). This same study found that over 68 percent of citations in the sample were either incomplete or undecipherable. Furthermore, based on a survey of students' competencies before and after a 60-minute information literacy session, Furno and Flanagan (2008) discovered that, while only 41 percent of students could properly decipher a provided citation prior to the session, only 45 percent of the students could properly decipher a provided citation after the session. Both studies indicate a need to provide more instruction on proper citation practice. This topic has been emphasized by all MET faculty and is perhaps the most neglected IL need in the program. The box on the facing page discusses Endnote Web, a robust citation and reference management service.

Inventory of Information Literacy Instruction Practices

An inventory of ILI efforts provides a picture of what is currently in use, what is missing, and what should be discarded or modified in order to most appropriately fit program needs and the institutional mission and goals. An example of such a survey is seen in the librarian self-assessment study conducted at the J. Paul Leonard Library at San Francisco State University (Van Cleave, 2008). In this study, survey questions were aligned roughly with the ACRL's

Creating and Sharing Bibliographies with EndNote Web

Although undergraduate engineering students are great problem solvers, they are not typically considered "word people" and have little patience for the meticulous routine of citing sources and properly referencing them in bibliographies. If you have been frustrated by students' lack of proper documentation of resources, you may be surprised at how quickly things turn around once you have shown them the basic capabilities of EndNote Web or a similar tool.

There is a wide variety of reference management software, from free to one-time purchase to subscription-based options. Some are accessible on the web while others can be installed on individual computer workstations. A wide range of features exists, including integration with word-processing software, automatic style formatting and bibliography creation, storage or direct linking to the original full text, and social features such as bibliography sharing. EndNote Web is a good choice for college and university students, based on its overall features and availability. EndNote Web comes standard with any Web of Knowledge product (such as Web of Science, BIOSIS Previews, or MEDLINE) and supports individual user accounts for every student enrolled in the library's institution. It is accessible on the web and requires no special installation for its basic functionality. After completing an easy registration procedure through their library's online gateway to Web of Knowledge, students may import and access their references from any computer on the Internet at http://www.myendnoteweb.com/.

There are several ways to import references into EndNote Web, making it extremely versatile. Users can add references manually using a form. To simplify processes and save time for students, librarians should focus on EndNote Web's searching and importing capabilities. EndNote Web can be configured as a direct search interface for a wide variety of academic databases (even the library's OPAC), and can save references directly from search results. But if a database's native search interface is preferred, EndNote Web can import citations records from the search results of practically all of the major licensed databases, such as Academic Search Complete and other EBSCOhost products.

EndNote Web can also export formatted bibliographies in many styles, including not only MLA, APA, and Chicago, but also publication-specific styles such as ASCE, ASME, and IEEE. More advanced users may want to use the free Cite While You Write plugin that enables the user to connect directly to their EndNote Web account from Microsoft Word in order to create bibliographies and insert citations on-the-fly.

EndNote Web includes social features that are handy for group assignments such as senior design projects. Students keep their references organized in tidy folders that can be shared with others in their group; shared folders may be read-only or they can be opened up to allow others in their group to add new references (Zhang, 2012).

"Characteristics of Programs of Information Literacy That Illustrate Best Practices: A Guideline," using Guidelines 5, 6, 7, and 10 (Van Cleave, 2008).

In the Mechanical Engineering Technology program at the University of Maine, four one-shot sessions of library instruction have been incorporated into four respective courses—one in the first year, two in the second year, and one in the fourth year. Additionally, a third-year course requires students to visit the library to complete an assignment and consult with the subject librarian. Together, these provide each MET student with a minimum of one library instruction experience per academic year. Each successive level/year focuses on increasingly sophisticated information literacy skills and subject resources based on course content and faculty preferences. Table 16.1 (p. 250) summarizes library instruction involvement in the MET program. This model provides for a minimum of four library instruction sessions during the undergraduate MET program, each session meeting curricular needs at an appropriate level.

Lower-Level Undergraduates

MET 100: Introduction to Mechanical Engineering Technology is a first-year course taken by all students in the Mechanical Engineering Technology program at the University of Maine. Students are given a broad overview of subject matter that will be covered in greater depth as they advance through the MET program. An assignment titled Individual Library Project (see

Table 16.1. MET Library Instruction Inventory

Course	Year (Level)	Type	Topics Covered	Materials
MET 100: Introduction to Mechanical Engineering Technology	1	One-time, in class	Introduction to library resources, searching databases for scholarly articles, searching for technical reports, website evaluation criteria, citing references	Online subject guide, two library assignments, handout for citing references
MET 233: Thermal Science	2	One-time, in class	General resources for Mechanical Engineering Technology, website evaluation criteria, citing references	MET library resources handout, handout for citing references
MET 270: Manufacturing Technology	2	One-time, in class	Accessing course reserves, style manuals and writing guides, citing references, business and industry resources, resources for government data	Online subject guide, handout for citing references
MET 355: Engineering Materials	3	In-library consultation	Technical standards and materials properties, reference books, citing references	Two library assignments, handout for citing references, handout for locating ASTM standards
MET 462: Design I	4	One-time, in class	Intermediate/advanced patent searching using keywords and classification, technical standards	Patent searching handout

below) requires students to develop an outline and bibliography for a research paper on the topic of "technology and sustainability." Because this assignment is intended to be an exercise in literature searching and proper documentation of references, students are not required to write a narrative paper. Students may use any number or kind of sources as long as they reference a minimum of two scholarly journal articles and they properly cite each source used.

Mechanical Engineering Technology 100: Individual Library Project

Develop an outline about an emerging technology and its particular applications toward sustainability. The technology you choose is under development because it offers economic, environmental, or other human benefits. The outline is to be filled in with the information you would use if you were to write a paper on the topic.

Please adhere to the following five requirements:

1. Use the outline format on the second page of this assignment.
2. You must support every statement you respond to in the outline with a credible and reliable source and you must properly reference the sources at the top of your outline.
3. You must reference a minimum of two sources from two different technical societies, technical magazines or journals, government documents, or similar credible and reliable sources accessed via the library's electronic subscription databases.
4. You must print and submit the sources with your outline—but print only the pages relevant to your outline and the first page with the title and author information.
5. Conclusions must be supported by the referenced sources. This is not an opinion paper.

(Continued)

Mechanical Engineering Technology 100: Individual Library Project *(Continued)*

Grading Rubric

▪ Completely and correctly referenced two or more relevant articles from the databases (additional sources may also be used)	10 points
▪ Complete outline	20 points
▪ Clear facts provided for all categories	30 points
▪ Each fact referenced	10 points
▪ Copies of referenced articles submitted with outline	10 points
▪ In your conclusion, an evaluation of the emerging technology with rationale	10 points
▪ In your conclusion, a recommendation with rationale	10 points

Sample Outline Format

(Your outline may have more or fewer lines of "detail information" than shown.)

I. References. Here, create a numbered list of complete references to sources cited in your outline. List them in the order you cite them in the outline. Reference formats are given on the website http://www.library.umaine.edu/science/engtech.htm, under Citation Guides and Evaluation Criteria.

II. Introduction
  A. State the sustainability technology you are investigating.
    1. Provide a brief overview of the technology (cite your source here; after each outline point put the reference number and page number in parentheses).
  B. State benefits and drawbacks of the technology.
    1. Point 1 (cite your source)
    2. Point 2 (cite your source), etc.

III. Body
  A. Name the sustainability technology and the human benefits sought.
    1. Reason why the approach is important (cite your source)
    2. Economic outcomes (cite your source)
    3. Environmental outcomes (cite your source)
    4. Any additional human outcomes (cite your source)
  B. Describe the sustainability technology.
    1. How the technology is or could be implemented (cite your source)
    2. How the technology addresses the issues (provide evidence) (cite your source)
  C. State the ECONOMIC background of the sustainability technology as appropriate.
    1. Economic pressures on the technology (cite your source)
    2. Economic impact of the technology that has been implemented (cite your source)
    3. Economic impact of the technology that could be implemented (cite your source)
    4. How the technology would affect profitability (provide evidence) (cite your source)
  D. State the ENVIRONMENTAL background of the sustainability technology as appropriate.
    1. Environmental pressures on the technology (cite your source)
    2. Environmental impact of the technology that has been implemented (cite your source)
    3. Environmental impact of the technology that could be implemented (cite your source)
  E. State the relationship between any additional human outcomes and the sustainability technology.
    1. Evidence of the relationship (cite your source)
    2. Evidence of the relationship (cite your source), etc.

IV. Conclusion
  A. Evaluation of this sustainability technology with rationale (cite your source)
  B. Recommendation regarding future use of this sustainability technology with rationale (cite your source)

The Individual Library Project piggybacks an earlier assignment wherein students employ structured evaluation criteria (e.g., accuracy, authority, currency, objectivity, etc.) to evaluate websites. Therefore, students already have a general understanding of source evaluation before beginning this assignment, which should be evidenced by the sources they select to complete their outlines.

In the process of developing the Individual Library Project, the librarian and the instructor discussed and agreed upon the ILI objectives of the lesson, including the following:

- To help students identify and differentiate scholarly journals, trade publications, and popular magazines
- To introduce students to academic databases licensed for university use and to emphasize the value of these resources over web search engines such as Google
- To demonstrate basic strategies for searching scholarly databases and the web
- To reinforce proper citation of referenced resources

During the class session where the project is assigned, the engineering subject librarian presents a 30-minute demonstration of searching, identifying, retrieving, and documenting a scholarly article. The session lasts a full hour and a half, so the remainder is reserved for students to spend searching for sources on their topics, with the librarian available to assist them.

Although there are many high-quality databases and web search engines that could be demonstrated, it only takes one or two to fill the small amount of time allotted in these types of sessions. One strategy is to spend roughly 20 minutes demonstrating Engineering Village, emphasizing its built-in thesauri, search fields, Boolean operators, and truncation and proximity modifiers. The next 10 minutes are spent demonstrating Google Scholar, emphasizing its superiority over the "regular" Google, its inability to retrieve many full-text articles, and how to use the library's catalog and licensed databases to retrieve those Google-proof full texts.

It is always advisable to go into one of these sessions with a "canned" search that demonstrates each of the learning outcomes. For this, the instructor may provide sample topics in advance of the class session, ideally granting the librarian plenty of time to devise and practice the best canned demonstration.

This assignment and the librarian's demonstration is designed to satisfy learning objectives and outcomes for both the STS Standards and the ABET Criteria. Application of information literacy performance indicators and outcomes should be obvious—this assignment cuts straight to Standard One of the STS Standards. Students identify "a research topic . . . resulting from an assigned lab exercise" and explore "general information sources to increase familiarity with current knowledge of the topic" (ACRL, 2012b). There are more connections between the assignment and the Standards, but more important is how the assignment overlaps the learning outcomes in the ABET Criteria. In Criterion 5, Curriculum, students must develop the ability to "plan, organize, prepare, and deliver effective technical reports" and "utilize the appropriate technical literature and use it as a principle means of staying current in their chosen technology" (ABET, 2009: 2).

Further, the high degree of importance placed on proper documentation of references instills a core ethical and professional value into students—to always give credit to the source of information used, rather than bypassing that responsibility or taking credit for it themselves. This need is articulated in the learning outcomes under STS Standard Four, Performance Indicator 2: the student "demonstrates an understanding of what constitutes plagiarism and does not represent work attributable to others as his/her own" (ACRL, 2012b). There are multiple references to professional and ethical behavior in the ABET Criteria, not the least of which states that graduates will have "an ability to understand professional, ethical and social responsibilities" (ABET, 2009: 2).

Upper-Level Undergraduates

All students in the Mechanical Engineering Technology program at the University of Maine must also take the course MET 355: Engineering Materials. This is a junior-level course that focuses on the properties of materials. Materials covered include metals, plastics, wood, ceramics, and concrete. The required laboratory for the course explores uses of heat treatment and its effects on the mechanical properties of steels.

For the One-Page Research Assignment: Mechanical Properties of Steel (shown in the following box), students visit the library during one of their scheduled laboratory sessions.

Mechanical Engineering Technology 355: Engineering Materials
One-Page Research Assignment: Mechanical Properties of Steel

Objectives of the Assignment

1. Follow a written procedure to locate an ASTM standard in the library.
2. Locate standard references of the properties of steel in the library.
3. Become familiar with one of the standard references (e.g., *ASM Handbooks*).
4. Report on the relationship between a material property of steel and a treatment the steel has received.

Standard References

The following is a list of standard reference titles that may be of use in completing this assignment. You may search for other information in the library catalog.

Ferrous Materials: Steels and Cast Iron

- *ASM Handbooks; ASM Handbook Comprehensive Index*
- *ASM Metals Reference Book*
- *Metallic Materials Specification Handbook*
- *Smithells Metals Reference Book*
- *SAE Handbook*
- *ASTM Standards*

Research Specimens

Choose any single steel of interest to you. If you don't have a preference you might choose a type of steel from the following list, generated from Robert L. Mott's book *Applied Strength of Materials,* 5th ed. (Upper Saddle River, NJ: Prentice Hall, 2008).

- Material AISI no.: 1020, 1040, 1080, 1141, 4140, 5160
- Material AISI no. stainless steel: 301, 430, 501
- Material ASTM no.: A36, A53, A242, A500, A501, A572, A913, A992

For the steel you chose, also choose one of the following steel treatments or tests to investigate: any heat treatment (including annealing, normalizing, spheroidizing, quenching and tempering, austempering), cold work (cold forging, cold drawing, etc.), hot work (hot forging, etc.), surface treatment (carburizing, nitriding, etc.), any other steel treatment that interests you, or the hardenability curve that results from a Jominy Quench Test. If you are interested in a steel or in a treatment not listed, you are free to use that topic as long as it is of similar technical depth.

Research Procedure

Part One

1. Go to the library.
2. Follow the attached instructions to locate an ASTM standard.

(Continued)

Mechanical Engineering Technology 355: Engineering Materials
One-Page Research Assignment: Mechanical Properties of Steel *(Continued)*

Part Two

1. Locate one of the references listed earlier, or any book in the library that addresses steel treatments. Ask a librarian for help if you don't know how to use the catalog.
2. Use the index of the reference book to find the chosen type of steel and its corresponding test or treatment.
3. Read about how the treatment or the test influences the mechanical properties such as strength, ductility, surface hardness, etc. The mechanical properties addressed depend on the steel and treatment you pick.
4. Make copies of the relevant pages to submit with your research report.
5. Write a correct citation for the reference before you leave the library. Ask a librarian if you need help.

One-Page Research Report

1. State the steel, the treatment, and the mechanical properties your report will address.
2. Write 150–300 words (about half a page) describing the influence of the chosen treatment on the mechanical properties of the chosen steel; or, the method of the chosen test performed on the chosen steel.
3. Correctly cite the reference.
4. Attach the copied pages.

I recommend that if you have a laptop computer, bring it to the library to complete this assignment. The assignment is short enough to be completed during the laboratory period.

Grading Rubric

▪ Found an ASTM standard following the attached instructions:	10 points
▪ Clearly stated the chosen steel and test/treatment:	10 points
▪ 150–300 word summary	40 points
▪ Correctly cited the reference	30 points
▪ Copies of references included	10 points

Finding ASTM Standards at the Library

The following process is the recommended approach for obtaining an ASTM standard. When searching for standards, it is very important to know the standard's number, title, or both. In this example we will search for a standard titled Standard Test Methods for Tension Testing of Metallic Materials.

Part One: Identify the ASTM Section and Volume Your Standard Is Located In

1. Start at the ASTM website: http://www.astm.org/.
2. At the top of the left-hand column, click the link labeled Standards.
3. In the search box, type (or paste) the title or number of your standard. In this example: Standard Test Methods for Tension Testing of Metallic Materials.
4. Click on the title of your standard in the search results. In the example, it is the first search result, designated ASTM E8/E8M-11.
5. You should now be on the page for ASTM E8/E8M-11. Find the Book of Standards volume number. In this example, the number is 03.01. Write down this number, since you will need it when you get to the library.
6. If you do not already know the standard's number, write it down, too. For this example, the standard's number is E8/E8M-11.

Part Two: Find the Standard in the Library

1. Go to the library reference room; standards are shelved [list the location in your library].
2. Locate the *Annual Book of ASTM Standards*. These volumes span several shelves.
3. Each book has a section number and a volume number on its spine label. You identified these numbers in Part One. For this example, the section number is 03 and the volume number is 01. Find the corresponding section/volume on the shelf.
4. The standards are organized alphanumerically within the book by the standard's number (not by its title). For our example, standard E8/E8M-11 begins on p. 64 of section 03, volume 01.

The assignment requires completion of two exercises, each simple enough for students to complete both during the time allotted for the lab. Students may work together in small groups or work individually.

The first exercise requires students to locate a specific ASTM standard in the engineering reference collection and make a photocopy of the first page to be turned in to the instructor. The second exercise asks students to write a brief summary of a treatment or test method performed on a type of steel. In order to accomplish this, students must locate an appropriate reference book and find relevant entries for their chosen types of steel, and tests or treatments on those steels (typically by way of the book's index). The students must then write summaries of the test or treatment along with a proper citation to the reference.

Although undergraduate engineering students may be familiar with the library's Internet-based resources, many have never visited the library building, and fewer still have used the library's print reference holdings. This is why both exercises in this assignment require students to gain familiarity with the engineering reference collection and to seek assistance from a librarian when they have trouble finding the information they need. In addition, both exercises are designed to impress upon students that the highest-quality engineering reference information is often not freely available on the Internet. Thus, the ILI objectives of this assignment include the following:

- To demonstrate use of the library catalog for locating items within the library's engineering reference collection
- To promote the utilization of high-quality print reference materials when no online equivalent is available
- To encourage students to seek reference assistance when needed
- To reinforce proper citation of referenced resources

The One-Page Research Assignment, like the assignment for MET 100 described previously, is designed around the STS Standards and the ABET Criteria. STS Standard One, Performance Indicator 2 requires that students be able to identify "a variety of types and formats of potential sources for information" (ACRL, 2012b). Going beyond electronic and print-based sources, the standards list peers, professionals, and subject experts as potential information sources. Since the majority of students in the MET 355 lab have never used the materials in the engineering reference collection, they tend to instinctively approach a librarian for assistance.

Mirroring the MET 100 assignment, as stated in ABET Criterion 5, Curriculum, students must develop the ability to "utilize the appropriate technical literature and use it as a principle means of staying current in their chosen technology" (ABET, 2009: 2). The ASTM Standards prescribed in the first task of the assignment, and the many and varied metals handbooks that could have been used to complete the second task, are wellsprings of high-quality, current technical information.

Although resource selection for the second task was left open-ended by the instructor, the ASM Handbook Series has been and remains the most commonly cited reference for this assignment. The ASTM Standards are also frequently used. The *ASM Handbooks* are widely used for locating treatments, while ASTM Standards are widely used for locating test methods. Both of these series contain comprehensive indexes that are relatively easy to navigate, making them ideal for completing the One-Page Research Assignment. Finally, this assignment provides structured opportunities for students to practice formatting citations, as per the indicators and outcomes listed for the earlier MET 100 assignment (which is appropriate for IL assignments at any level).

Graduate Students

While not unheard of, it is less common for librarians to deliver information literacy instruction to graduate students in a classroom setting than with undergraduate classes. It is more likely that graduate students will approach the librarian with specific needs, and the moment for ILI will occur at the reference desk. Graduate students, fortunately, will usually have a grasp of the fundamentals of searching and using resources housed in the library. They often need help brainstorming for additional resources to mine, such as gray literature. At the University of Maine, all MET students have been given bibliographic instruction in gray literature by their senior years. Under ideal circumstances, all engineering students would gain the same exposure to gray literature before their graduation.

There are three excellent starting places on the web for finding gray literature in any number of engineering disciplines: GreyNet, ACRL's "Gray Literature: Resources for Locating Unpublished Research," and the University of Maryland Library's Virtual Technical Reports Center. The URLs for these websites are listed at the end of this chapter under Selected Information Resources for Engineering.

It is also common for graduate students to ask about methods of keeping their research current and organized. This presents libraries with an opportunity to promote citation management tools such as EndNote Web, if they have an institutional license. If your university does not have a license, there are plenty of inexpensive or freely available citation management tools on the web, including Zotero and Connotea. Students who use citation management tools plus the handy search alert features available in most academic literature databases will be able to manage and organize high volumes of citations while staying on top of the latest research in their fields.

Both the STS Standards and the ABET Criteria specify the need for students to learn and apply data management techniques and to utilize appropriate technologies for keeping abreast of current information in their fields. STS Standard Two, Performance Indicator 5, the information-literate student "[e]xtracts, records, transfers, and manages the information and its sources." Examples of relevant outcomes under this indicator are use of "bibliographic management software, text conversion software, and spreadsheet software" (ACRL, 2012b).

Assessment

In addition to listing an inventory of current library instruction practices, a second inventory should be taken of IL assessment practices. Guideline 10 of ACRL's "Characteristics of Programs of Information Literacy That Illustrate Best Practices: A Guideline" (ACRL, 2012a) is specifically about program assessment, and survey questions suited to Guideline 10, from the self-study mentioned earlier, are shown in the Sample Self-Evaluation Questions about IL Assessment sidebar.

Sample Self-Evaluation Questions about IL Assessment

1. Indicate which methods you use to assess your teaching and/or student learning:
   - Student evaluation form—standard ______
   - Student evaluation form—customized ______
   - Faculty evaluation form—standard ______
   - Faculty evaluation form—customized ______
   - Learning outcomes assessment ______
   - Pretest ______
   - Posttest ______
   - Peer evaluation—formal ______
   - Peer evaluation—informal (formative, off the record) ______
   - Assist instructor with grading (e.g., review bibliographies) ______
   - Conversation with instructor ("How did it go?" "How did the students' papers turn out?") ______
   - Other (please indicate) ______
2. Please discuss how you have used assessment to inform your teaching. Discuss successes and challenges.

At the time of this writing, no formal IL assessment has been conducted in the MET program. However, the librarian has conducted an annual evaluation of library-related assignments in two courses in the program, and an evaluation for a third course is currently underway. Following the evaluation, the materials used in these library instruction sessions are updated to reflect the needs of the program. Three examples of assessment follow.

Formative Assessment: Using Completed Assignments as Feedback

The engineering librarian reviews graded Individual Library Project assignments in order to assess citation quality and baseline skills in citing references. The librarian can make note of students' common mistakes and address them in subsequent instruction sessions. The following list highlights particular problem areas, identified over several years of reviewing this assignment. Many students have difficulty with these tasks:

- Identifying authors (e.g., personal name, organization, federal office, corporation). Some students cite the name of the webpage's host or webmaster as author, when they should have used the corporate or organization name instead. Also, students often have difficulty citing multiauthored works.
- Citing complete titles.
- Distinguishing between the name of a database, the title of a source or journal, and the title of an article.
- Correctly citing URL and date viewed for Internet sources. For example, students often supply a nonpersistent URL (which does not lead to the source cited) for an article retrieved from a subscription database.
- Distinguishing an article's full text from its abstract.
- Identifying and using the appropriate type of citation format for particular sources (e.g., webpages versus journal articles).
- Citing unsigned encyclopedia articles as references, including *Wikipedia*.
- Distinguishing reputable sources from those that are nonscholarly or nonprofessional sources (e.g., http://www.answers.com/ or http://www.howstuffworks.com/).

Formative Assessment: Using Completed Assignments as Feedback to Improve the Library Website

The Individual Library Project described previously requires students to evaluate one website linked to the library's MET subject guide and one webpage selected from a Google web search on a topic of the student's choosing. A review of this assignment is conducted annually in order to assess the usefulness of the library's MET subject guide and to update, add, or remove links as appropriate. Assignments such as this not only teach students critical resource evaluation skills, but also inform librarians about how their subject guides are being used. If faculty use an assignment such as this, ask them to share the completed assignments with you after they have been graded.

Assessment Results

As a result of the assessment of assignments in this IL pilot project, several changes have been made in the delivery of ILI to engineering students. The largest change has been made in the first-year MET 100 course. Previously, the librarian would spend an entire session presenting a typical lecture and demonstration of resources. The scope of the session has been narrowed to demonstrating only two key resources (Engineering Village and Google Scholar) in the first half hour, allowing students to spend the remaining hour searching for references for their assignments. The professor and the librarian spend this time helping students revise their search queries, locate full-text documents, and cite sources. Since implementing this change, there has been a documented improvement in the quality of the completed assignments, as well as increased visits, e-mails, and phone calls to the librarian.

One of the biggest concerns voiced by the MET faculty has been the dreadful citation habits of students. Because this has been an ongoing problem, the librarian has begun promoting the use of citation management tools (in particular, EndNote Web) instead of encouraging students to look up citation formats and construct references according to style guides. This has resulted in marked improvement of students' use of proper citation.

Finally, it is worth mentioning that the preferred resources of faculty members for their students are still largely kept in paper format at our library or otherwise not yet available on the open web. Since implementing this pilot, there has been an increase in use of the library's *ASM Handbooks* and *ASTM Standards* collections, as well as an increase in students seeking help with searching gray literature databases. Prior to this instructional effort, students were (predictably) trying and failing to find this information online. It has been rewarding to note students' improvement in tandem with increased use of library materials purchased for engineering students and faculty.

Standardized Assessment Techniques

Librarians can make rough determinations about students' IL skills by evaluating completed assignments. However, this comes at a cost of time and labor for the librarian, and may not be suitable for larger classes, programs, or departments. For those, standardized assessment tools and techniques are invaluable. The professional literature describes a variety of possibilities, ranging in complexity, with each method having its own pros and cons. Three of the most commonly used methods are rubric-based evaluation, citation analysis, and pre- and posttesting.

Rubric-based evaluation, such as the Information Literacy Instruction Assessment Cycle (ILIAC), is gaining in popularity for its emphasis on outcomes-based learning and its adaptability to many teaching and learning methods. The rubric-based model uses only open-ended questions that are designed to test the student's IL knowledge. However, this technique requires a substantial amount of time to implement and may be too complex for libraries that are just starting out with IL assessment. Libraries that employ a dedicated IL librarian, or those that house an IL department, will be better situated to invest the amount of time into designing and testing rubrics.

Citation analysis can be profitable in some specific areas of IL assessment, but is of little value in a comprehensive and standardized assessment program. Edzan (2007) notes that citation analysis can only provide insight into a limited number of performance indicators, and only peripherally. These include (1) defining and articulating the need for information; (2) identifying a variety of types and formats of potential sources for information; and (3) understanding many of the ethical, legal, and socioeconomic issues surrounding information and information technology. The limited benefit of citation analysis, in conjunction with the effort involved, tends to belie its use for large-scale assessment.

Although rubric-based evaluation and citation analysis are measurable practices that can be implemented within any program of study (with some heavy lifting), IL assessment could be made less burdensome with the implementation of standardized pre- and posttesting. While lacking the depth of analysis that rubric-based evaluation provides, pre- and posttesting offers the benefit of being easily implemented and administered by libraries or programs of any size. With cooperation from faculty and academic departments, testing can be made mandatory within a program or course, which increases participation rates and improves the data derived from the tests. Pre- and posttesting also provides a starting point for IL assessment that may be later transformed into or administered along with rubric-based or other types of evaluation. One such pre- and posttesting assessment tool is Project SAILS—The Standardized Assessment of Information Literacy Skills. Project SAILS is a pre- and posttest system designed around the learning objectives of ACRL's "Information Literacy Competency Standards for Higher Education" (2000). The project is developed and administered by Kent State University and is funded in part by the Institute of Museum and Library Studies and supported by the Association of Research Libraries. More information can be found at the Project SAILS website (https://www.projectsails.org/). SAILS provides a flexible testing environment, adaptable to the needs of just about any library or IL program. Testing fees can be calculated based on head count of actual test-takers, or by FTE, and testing results are available at the level of individual student or cohort. One of its strongest features is that it is designed to assess students' IL skills at the cohort level. What this means is that a body of students can be pretested during their first year, before any IL instruction is ever delivered, and then posttested as seniors (or any time in between). Librarians and teaching faculty will be able to see how much a cohort has improved over time, and identify problem areas in need of further attention. This system of pre- and posttesting would be repeated for each successive cohort.

In order to succeed with the curriculum integration model described in this chapter, librarians should persuade faculty to incorporate the pre- and posttests into class time, with the librarian present to administer the test and to assist with any questions student may have about it. Students enrolled in the target first- and last-year courses should be required to take the tests. Instructors and librarians may decide to use pretests only for formative assessment, but figure posttest scores into course grades, after students have had opportunities to learn and practice the concepts taught.

Selected Information Resources in Engineering

This section provides an overview of key information resources used in delivering ILI to engineering students. It is not meant to be comprehensive; it highlights only those resources that are of general usefulness to the majority of engineering students, and omits many valuable resources reserved for specific areas of engineering research. For example, while SciFinder Scholar is an excellent tool for searching the scholarly literature by chemical structure, it is primarily used by chemical engineering faculty and graduate students and has little value in other disciplines.

Several other sources cover information resources in engineering more comprehensively, including *Using the Engineering Literature*, edited by Bonnie A. Osif (2006); *Information Sources in Engineering*, edited by Roderick A. MacLeod and Jim Corlett (2005); and *Guide to Information Sources in Engineering*, by Charles R. Lord (2000). Most university libraries maintain subject-specific webpages for each academic program at their institution and similar information can be found via a search of LibGuides (http://www.libguides.com/).

Primary Sources

As with other disciplines, primary sources in engineering include conference literature, dissertations and theses, and articles found in scholarly journals or other periodicals. Although too numerous to list here, most high-quality conference papers and articles will be indexed in any number of the scholarly databases listed further on in this section, and they are increasingly becoming available in electronic full text, either via subscription or freely available online.

Conference Literature

Conference literature is an important part of the primary literature in engineering. Often it is the case that certain research appears in conference materials long before it gets published in a scholarly journal, and sometimes conference papers will not be published anywhere else. Students should be aware of the cutting-edge content found in the conference literature and pursue its use as valuable primary research material.

Conference literature has posed a variety of problems for libraries, in that some types are cataloged and shelved as monographs whereas others are held as serials. Conference proceedings have proven exorbitantly expensive for most cash-strapped library budgets and holdings often seem random or sporadic. Fortunately, Open WorldCat (http://www.worldcat.org/) can assist the librarian in tracking down specific volumes at other libraries when a particular conference proceeding is not held locally. Students should learn to use their interlibrary loan systems to request conference papers, and because of the lengthy process of document delivery, students should know to do this early in the research process.

Dissertations and Theses

ProQuest Dissertations and Theses. http://www.proquest.com/en-US/catalogs/databases/detail/pqdt.shtml. This database is the leading source for dissertations and theses from 1861 to the present.

Technical Reports and Gray Literature

Technical reports and other types of gray literature comprise a large segment of the primary literature in engineering. There are nearly as many sources for this literature as there are organizations authoring them. The following are three authoritative directories for beginning research across this nebulous expanse of technical information.

GreySource Index. http://greynet.org/greysourceindex.html. This site offers a useful indexing schema for locating gray literature by field of research.

Mathews, Brian S. 2004. "Gray literature: Resources for Locating Unpublished Research." *College and Research Libraries News* 65, no. 3 (March): 125–128. This article lists directories, government, industry, and other sources for finding scientific and technical literature.

Virtual Technical Reports Center. University of Maryland Libraries: http://lib.guides.umd.edu/techreports. This site provides perhaps the most exhaustive listing of sources for technical reports on the web. Entries are listed alphabetically by authoring organization.

Patents

Patents and patent applications are another important type of primary literature for engineers. Chapter 20 of this book extensively covers patent research.

Secondary Sources

Technical standards and specifications, handbooks, and subject-specific encyclopedias comprise the majority of secondary literature sources in ILI for engineering students. Each of these offers quick reference abilities for solving particular problems or answering specific questions.

Standards

Standards most often consulted are those published by ANSI, ASTM, and IEEE. Often it is the case that standardization organizations will adopt standards issued by other organizations, so overlap is expected. Most current standards are available by individual purchase (electronic and/or print), but an institutional license will be more cost-effective for the library and useful to engineering students who need to access large amounts of standards. Each of the top three offer multiple purchase options.

American National Standards Institute (ANSI). http://ansi.org/. Current ANSI standards are available for purchase individually through their e-store (http://webstore.ansi.org/). Site licensing for restricted institutional use is also available. ANSI and ISO collaborate on a University Outreach Program that grants free access to a large collection of standards to participating academic programs (not libraries; see http://www.ansi.org/education_trainings/university_outreach.aspx?menuid=9).

ASTM International (formerly American Society for Testing and Materials). http://www.astm.org/. Offers the print series *Annual Book of ASTM Standards* (http://www.astm.org/BOOKSTORE/BOS/index.html) and the ASTM Standards and Engineering Digital Library (http://www.astm.org/DIGITAL_LIBRARY/index.shtml).

IEEE (formerly Institute of Electrical and Electronics Engineers). http://www.ieee.org/. Current IEEE standards are available in three ways: for purchase individually through the IEEE standards store (http://www.techstreet.com/ieeegate.html), through IEEE Xplore Digital Library (http://www.ieee.org/publications_standards/publications/xplore), or freely through IEEE's Get Program (http://standards.ieee.org/about/get/index.html; some restrictions apply).

IHS Standards Store. http://global.ihs.com/. This site offers the most exhaustive directory of technical standards in every field of engineering.

Handbooks and Encyclopedias

Handbooks offer quick access to data and formulas often not found on the open web, but are increasingly found on the web through e-book vendors such as eBrary and e-Book Collection, and through publishers' site licensing options. Handbooks are quite numerous and updated editions of many titles are published regularly. Since libraries often have a mix of older and newer print editions, it may be more practical to license an aggregator that provides access to the most current editions, as well as the widest scope of subject coverage. The following are just a few of the most widely consulted handbooks and handbook aggregators.

ASM Handbooks. http://products.asminternational.org/hbk/index.jsp. Each handbook presents data on specific subsets of materials, testing, or treatments. The set includes a comprehensive index. In addition to the print volumes, an online subscription is available for institutional use.

CRCnetBASE Engineering Collection. http://www.crcnetbase.com/page/engineering_ebooks. This is an online platform for the widely popular CRC Press handbooks series.

Knovel. http://why.knovel.com/solution/content.html. The Knovel platform hosts a large selection of handbooks and other reference materials from high-quality publishers. Knovel allows researchers to manipulate tables and graphs using data found in the references.

McGraw-Hill's AccessScience Encyclopedia of Science and Technology Online (http://www.accessscience.com/index.aspx) and *McGraw-Hill Concise Encyclopedia of Science and Technology* (New York: McGraw-Hill, 2009) are leading go-to references for finding introductory information on a large variety of engineering and technology topics. *AccessScience* includes many handbooks and encyclopedias, along with multimedia content not available in the print editions.

Scholarly and Professional Databases

Academic Search Complete. EBSCO: http://www.ebscohost.com/academic/academic-search-complete. While not specifically an engineering database, Academic Search Complete includes substantial engineering content.

ASCE Library. American Society of Civil Engineers: http://ascelibrary.org/. The ASCE Library provides full-text access to every publication of the American Society of Civil Engineers, including journals and conference papers, back to 1995.

Engineering Village. Elsevier: http:// www.engineeringvillage2.org/. The Engineering Village platform is perhaps the most comprehensive collection of scholarly engineering content available. At its core lie the Inspec and Compendex index and abstract databases, but various modules may be added to expand its content to patents, technical reports, conference proceedings, reference collections, and more. On its own, Engineering Village includes no full-text articles, but linking to a library's full-text holdings can be established.

IEEEXplore. IEEE: http://ieeexplore.ieee.org/Xplore/guesthome.jsp. Considered the most relevant and trusted source of scholarly information in computing and electrical engineering. IEEEXplore provides full-text access to all IEEE journal articles, current IEEE standards, conference papers, and e-books published by IEEE.

Conclusion

As indicated by the two sets of educational standards discussed in this chapter (i.e., the "Information Literacy Standards for Science and Engineering/Technology" and the *Criteria for Accrediting Engineering Technology Programs*), graduates require more than a basic knowledge of how to use a library. They will be expected to understand the complexities of the information life cycle—how information is produced, shared, retrieved, and used.

Engineering programs are experiencing an influx of new students, an increased demand to meet institutional assessment goals in order to prove their value, and an ever-expanding scope of interdisciplinary curriculum demands. It should not be surprising to librarians that there is little support among faculty to add yet another requirement—information literacy—to their core curriculum. Although there is a lot of current professional literature addressing these issues, it is not clear how the academic community will respond to emerging needs. It is the librarian's duty to pursue opportunities for integrating information literacy into the curriculum, for which relevant educational standards provide a road map.

References

ABET. 2009. *Criteria for Accrediting Engineering Technology Programs: Effective for Evaluations during the 2010–2011 Accreditation Cycle*. ABET, Inc. http://www.abet.org/accreditation-criteria-policies-documents/.

ACRL (Association of College and Research Libraries). 2000. "Information Literacy Competency Standards for Higher Education." American Library Association. www.ala.org/ala/mgrps/divs/acrl/standards/informationliteracycompetency.cfm. Document ID: 185693.

———. 2012a. "Characteristics of Programs of Information Literacy That Illustrate Best Practices: A Guideline." American Library Association. Revised January. http://www.ala.org/ala/mgrps/divs/acrl/standards/characteristics.cfm.

———. 2012b. "Information Literacy Standards for Science and Engineering/Technology." American Library Association. Accessed November 5. http://www.ala.org/ala/mgrps/divs/acrl/standards/infolitscitech.cfm.

Edzan, N. N. 2007. "Tracing Information Literacy of Computer Science Undergraduates: A Content Analysis of Students' Academic Exercise." *Malaysian Journal of Library and Information Science* 12, no. 1: 97–109.

Furno, Christine, and Daphne Flanagan. 2008. "Information Literacy: Getting the Most from Your 60 Minutes." *Reference Services Review* 36, no. 3: 264–271.

Mann, Michael E., Raymond S. Bradley, and Malcolm K. Hughes. 1998. "Global-Scale Temperature Patterns and Climate Forcing Over the Past Six Centuries." *Nature* 392, no. 23: 779–787.

Neely, Teresa Y. 2006. *Information Literacy Assessment: Standards-Based Tools and Assignments*. Chicago: American Library Association.

Van Cleave, Kendra. 2008. "The Self-Study as an Information Literacy Program Assessment Tool." *College and Undergraduate Libraries* 15, no. 4: 414–431.

Zhang, Yingting. 2012. "Comparison of Select Reference Management Tools." *Medical Reference Services Quarterly* 31, no. 1: 45–60. doi:10.1080/02763869.2012.641841.