AC 2010-939: STANDARDS FOR NEW EDUCATORS: GUIDE TO ABET OUTCOMES AND STANDARDS AVAILABILITY IN LIBRARIES

Charlotte Erdmann, Purdue University

Standards for New Educators: Guide to ABET Outcomes and Standards Availability in Libraries

Abstract

Engineering educators worked with standards in industrial and research careers. Many faculty members use standards in their research and teaching. Awareness of standards may develop in a variety of ways including reading and writing dissertations, journal articles, conference papers, and handbooks. References to standards are also prevalent in bibliographic databases, and campus websites. Faculty members often expose students to standards in laboratory exercises throughout their college careers. These subtle opportunities are documented in the paper.

ABET criterion and outcomes used to evaluate engineering and engineering technology programs now emphasize the use of standards, especially in the design process. This is a new challenge for the engineering educator. Given that new engineering educators teach their students about standards, it is necessary to become familiar with available information that may help students as well as typical best practices for academic libraries. Acquiring access to standards is the first step in using standards. The next step is to acquire skill and learn how to critically read and apply them.

The literature review includes definitions and two book recommendations as well as best practices papers outlining the library's role in standards collections. The literature survey describes these papers including practices related to building collections, survey results, and local database creation.. Two surveys of "top engineering schools" and 35 university libraries that are members of the Association for Research Libraries (ARL) are discussed.

The paper also includes standards education materials that may be helpful as engineering educators teach students the basics. A historic case study on hose couplings is a good starting place. Case studies are a solid way to introduce standards. Accuracy is very important in case studies. It is more work to research a historical example but it unravels the truth. Typical descriptions of historical standards are incomplete. Casual references that feed inaccuracy to the next generation of engineers do no one any favors. Brief modern day examples are also presented and standards are used by faculty, staff, and students.

There is a strong need for more educational materials. Standards organizations have prepared some materials but the materials vary in quality. Materials from several standards educational organizations and major standards development organizations are included.

[This departs from previous incomplete versions of the abstract.].

Introduction

New engineering educators begin their academic careers with varied experiences. Their primary focus is becoming successful teachers and researchers. Publications and funded research are typically evidence of these activities. Obtaining quality information to acquire expertise in these areas is necessary. Typically, educators use journals and conference papers in their writing. This paper focuses on standards, which are one of a whole suite of materials available to faculty and students.

ABET accreditation impacts the curriculum, program outcomes, and facilities in undergraduate and graduate education. ABET identifies standards as materials that students should learn how to use. The paper discusses specific ABET curriculum requirements and outcome criterion. The author also prepares a list of questions for consideration as an educator implements a standards instruction program.

Many graduate students, engineers, and faculty members use standards in their day-to-day work. Depending on one's specialty and research area, standards may be familiar new educators. The author reviews statistics from many sources showing the prevalence of standards in the field of engineering. There are many examples of university faculty, staff, and students involved in national and international standards activities.

The paper also includes standards education materials that may be helpful as engineering educators teach students the basics of standards. There are also case studies that describe how faculty, staff, and studies use standards.

Literature Review

Two authors have written credible books that are significant in their coverage of standards. Robert D. Hunter (2009) [1] has written an up-to-date book with many diagrams, flowcharts, and discussions. There is a section on standards education with a bibliography. Albert Batik (1992)[2] offered an industrial perspective with brief examples of why standards exist and wrote brief case studies that need expanding. Both books are good overviews of the subject.

Subramanian[3] (1981) laid the ground work for standards information when he described standards as:

> … Fundamental to many aspects of modern life including science, technology, industry, commerce, health, and education. Standards and specifications are documents that stipulate or recommend: (1) minimum levels of performance and quality of goods and services, and (2) optimal conditions and procedures for operations in science, industry, and commerce, including production, evaluation, distribution, and utilization of materials, products, and services. Standards are established by general agreement among representatives of consumers, designers, manufacturers, distributors, and other concerned groups…
>
> In scientific research standards are essential to ensure reproducibility of research and accuracy and reliability of the results. In industrial and commercial practice, standards are essential (1) to prevent avoidable wastage of resources and manpower, (2) to enhance safety, speed, and productivity, (3) to ensure uniformity, reliability, and excellence of product quality, (4) to achieve overall efficiency and economy.

Subramanyan states that the topic covers a “variety of documents including standards, specifications, codes of practice, recommendations, guidelines, nomenclature and terminology, and so on.” A document may also be a “composite” of these.

Linda Musser (1990)[4] wrote a straight forward overview of “Standards Collections for Academic Libraries” including why a library should collect standards and described ways to build the collection while Taylor (1999) does a similar project but gets into a description of individual ordering through document delivery services, standing order services, and maintaining the collection.

Bonnie A. Osif[5] (2006) edited an up-to-date guide to Using the Engineering Literature that reviewed engineering disciplines and gave guidance on all forms of engineering information. The book also contains chapters for each engineering discipline that are written by engineering librarians. Piety and Piety[6] (2006) wrote an excellent description of standards for all fields of engineering in the chapter on General Engineering. Most chapters also include standards resources and descriptions of organizations that create standards for that subject area. Standards and specifications are created by “companies, technical associations and professional societies, government agencies, national standards bodies, and international standards agencies.” Harding and McPherson (2009) [7] describe the present sphere of standards organizations in his ASEE paper.

Two surveys describe the libraries’ best practices for standards. The original plan to do a survey did not appear necessary after finding these two surveys. Both surveys cover large academic libraries. Brian S. Mathews (2006)[8] wrote about “top engineering schools” while Lorraine F. Pellack (2004)[9]did a survey of 34 libraries that are members of the prestigious Association for Research Libraries (ARL). In 2003, Pellack’s survey indicated that there are many libraries doing special ordering with format half of the libraries buying print while the others purchased eleclectronic format. Most libraries subscribed to some standards organizations electronically but many received paper format. Pellack reported that half of the managers preferred electronic format for their subscriptions while the same number of preferred standards in print format. Clients experienced some success with Interlibrary Loan but many libraries did not loan standards through ILL. While both surveys are helpful for giving ideal “best practices,” the subscription collections are not representative of smaller institutions that serve only undergraduate students. Both offer interesting insights with some libraries creating research guides while other institutions not providing this important service to their clients. Pellack’s servey of ARL libraries discussed problems that libraries experienced supplying standards. Those surveyed reported that money has been a major concern. Librarians may benefit from reading these surveys so they understand this important subject better.

Norma J. Dowell(2004) [10]and John Matylonek and Maren Peasley (2001)[11] highlighted their worthwhile print ANSI collections as they prepared databases to help clients discover available standards . They have created two separate databases that make it easier to access their local at Iowa State University and Oregon State University. Major fields including titles, standard numbers, and sponsoring organizations. These databases are particularly helpful for subscriptions to print standards. Dowell’s database is patterned from a database at the University of Washington. Databases at Iowa State University and University of Washington are still operating while John Matylonek's database at Oregon State University is no longer available. Similar databases are currently available at the University of Michigan and Purdue University

Awareness of Standards

Faculty, staff, and students have experience with standards from designing products, procuring materials, reading journal articles and conference papers, searching library-licensed bibliographic databases or campus websites, and completing research for their doctoral degrees. The sources do not contain the actual standards but they do describe the use of standards. None of these methods replace the actual use of standards.

The author searched the acronyms for American Association of State Highway and Transportation Officials (AASHTO), American National Standards Institute (ANSI), American Society for Testing and Materials (ASTM), and the phrase "IEEE standard" in a variety of sources. Hundreds of standards organizations are prevalent in the United States. The sample searches are representative of the organizations.

Full-Text Dissertations from Dissertations and Theses Databases

Many graduate students do research for their dissertations and theses using standards. The author searched four standards organizations in two databases, Dissertations and Theses (PQDT), distributed by Proquest and the free SCIRUS ETD Search created by the Networked Digital Library of Theses and Dissertations which contains many electronic theses and dissertations (ETDs) that are made available by United States and international universities. Figure 1 outlines the Number of Full-Text Dissertations Found with references to standards in two databases.

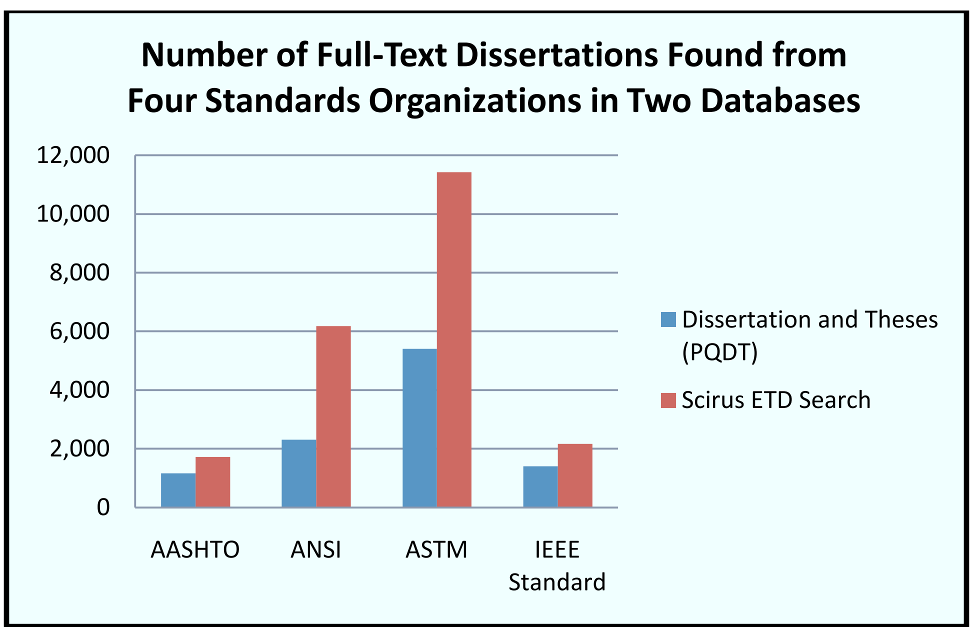


Figure 1:- Number of Full-Text Dissertations Found from Four Standards Organizations in Two Dissertations Databases

The number of dissertations and theses which discuss standards is impressive in both databases. ASTM is the most prevalent. There may be some inaccuracies when the acronym has more than one meaning. For example, Anci appeared as an author's first name in SCIRUS. Given the international emphasis of SCIRUS, it is good to see that U.S. standards are used in international theses and dissertations.

The library licensed Dissertations and Theses (PQTD) database starts in 1861 but abstracts and full-text searching are not available for a significant portion of the 2.1 million record database. Full-text searching is available for most if not all of the publications in SCIRUS. Making theses and dissertations available electronically is a growing movement in academic libraries for the last 15 years.

Full-Text Journals, Conference Papers, and Books

A search of three full-text digital libraries from three publishers gives a glimpse of references to standards found in IEEE Xplore, Elsevier's ScienceDirect and SpringerLink. The ability to search publications' content is the common element while the coverage, especially subjects and years are not the same. It is logical to expect dissimilar results based on these differences. Table 1 shows standards found in Full-Text Publisher Collections.

Full-Text Collection	IEEE Xplore	ScienceDirect, (Elsevier)	SpringerLink (Springer)
AASHTO	159	1,427	262
ANSI	26,742	26,051	5, 334
ASTM	9,800	85,717	14,320
IEEE Standard	24,996	3,824	2,850
Totals	61,697	117,019	17,432

Table 1: Standards in Full-Text Publisher Collections, also known as Digital Libraries

Access to the full-text content of these publishers is paid by library subscriptions. Elsevier and Springer are commercial publishers while IEEE is a society publisher.

Library Research Databases

Research databases contain references to journal articles and conference papers and are paid by library subscriptions. Searchable fields include titles, abstracts, subject words, sources, authors, and author affiliations but not the full-text. The years covered by these sources are much more extensive than digital libraries or web search engines. Table 2 shows the number of standards discussed in five research databases .

Bibliographic Database	Applied Science & Technology Abstracts	COMPENDEX	INSPEC	Materials Research Database/w METADEX	Web of Science plus Conference Proceedings
AASHTO	362	1,820	135	619	1,039
ANSI	1,361	10,175	11,464	1,598	2,486
ASTM	6,938	7,015	36,889	31,177	7,987
IEEE Standard	182	2,747	1,223	295	809

Table 2: Discussion of Standards in Six Library Research Databases

These bibliographic databases are representative of the available sources for students and researchers. Space did not permit the inclusion of all relevant specialized databases.

Here is a brief description of the database examples:

- Applied Science & Technology Abstracts (formerly Industrial Arts Index), journals only,1913-date
- COMPENDEX (Engineering Index), journals and conferences, 1884-date
- INSPEC (Physics Abstracts, Electrical and Electronics Abstracts, and Computer and Control Abstracts), journals and conferences, 1898-date
- Materials Research Database with METADEX (Metals Abstracts), journals and conferences,1966-date
- Web of Science, a multi-disciplinary science index, which is better known as Science Citation Index, 1900-date. Conference Proceedings, 1990-date. The references to older years have been added recently.

These databases and many others have been the foundation of engineering and science research since 1884. Given a topic that has historic roots, it is necessary to use the ones that cover the years that are needed. Searching multiple databases is also recommended.

Campus Websites

The author did a Google® search of standards from the four organizations using seven university educational sites. The author chose private and public universities with research reputations. Size of engineering programs varied with most having over 3000 students. Table 3 shows the results:

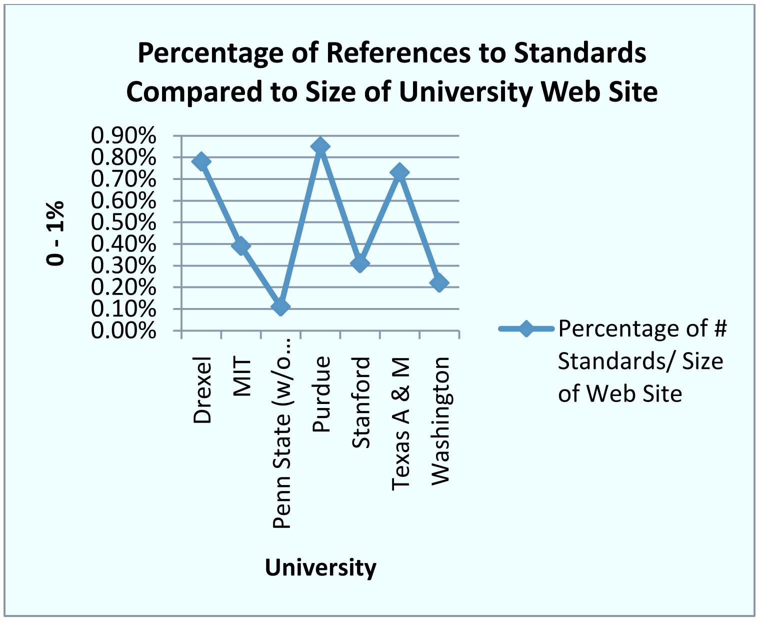
University	Drexel	MIT	Penn State (without CiteSeerX)	Purdue	Stanford	Texas A & M	Univ. of Wash.
AASHTO	84	92	226	667	78	870	221
ANSI	253	7,380	1,600	1,650	5,810	1,410	1,220
ASTM	371	1,830	920	1,280	1,790	1,580	682
IEEE Standard	79	1,060	500	121	1,100	190	100
Total Hits for Four Organizations	787	10,362	3,246	3,718	8,778	4,050	2,223
Google Results site:edu	101,000	2,650,000	3,366,000	477,000	2,840,000	557,000	1,010,000

Table 3: Google Search Results for References to Standards on University Websites

The total hits from the four standards organization ranged from 787 to 10,362. The number of search results for each university's website influenced the retrieval since the size of these websites ranged from 101,000 to 3,366,000. Search strategies have been adjusted for Pennsylvania State University's site since the original standard hits appeared very high because 45,000 came from CiteSeerX beta, Scientific Literature Digital Library and Search Engine.

The author also reviewed the university website results and compared it to the number of references to standards retrieved. More standards have been found for universities with larger websites, especially at Massachusetts Institute of Technology and Stanford University. The author could not determine any other explanation. The domain for psu.edu represents all campuses of the Penn State University system.

Figure 2 shows the Percentage of References to Standards Compared to the Size of the University Website.



=

Figure 2: Percentage of References to Standards Compared to Size of University Website

Universities across the country are involved in standards. Those with larger web sites may include more information on their public websites while others use Blackboard or other means of communicating with students. The standards activity at Penn State probably originates from the University Park campus but the totals represent all campuses. As a result the percentage is lower than is expected.

Transition from Standards Awareness to Standards Use

Whether a new engineering educator is aware of standards or uses standards in daily work, the new ABET criteria now encourages more inclusion of standards in undergraduate education. The requirements are vague but curriculum and program outcomes are expected. Facility support for information infrastructure are also mentioned.

Further reading of instructions for ABET accreditation is encouraged understand the new requirements. Faculty who have worked with accreditation at local institutions may offer guidance on documentation and visitation team expectations.

ABET and Standards

Three aspects of the ABETs' Criteria for Accrediting Engineering Program (2009)[12] and Criteria for Accrediting Engineering Technology Programs (2009)[13] impact standards education and information literacy. These include

- Criterion 5: Curriculum;
- Criterion 7: Facilities.
- Criterion 3: General Criterion of Program Outcomes

There are many additional materials that discuss the ABET accreditation process on ABET's website. This brief discussion is a selected description.

Curriculum

ABET Criterion 5 gives a broader context for the Curriculum of the two separate programs. There are only a few aspects of standards and technical literature that specifically apply to the programs. Table # shows curriculum related information for both programs.

Program	Criterion 5
Engineering	"Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints."
Engineering Technology	"The communications content must develop the ability of graduates to: c) Utilize the appropriate technical literature and use it as a principle means of staying current in their chosen technology."

Table 5 ABET Criteria 5: Curriculum for Engineering and Engineering Technology

Information Infrastructure

Standards are among the materials contained in the "information infrastructure" that "support scholarly activities" and "educational objectives" as outlined in Criterion 7's description of "Facilities, computer and information infrastructure." The Engineering Program is vague while the Engineering Technology Program is more specific. The criteria for the two programs are described in Table 6.

Program	Criterion 7
Engineering	"Computing and information infrastructures must be in place to support the scholarly activities of the students and faculty and the educational objectives of the program and institution.
Engineering Technology	"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."

Table 6: ABET Criterion for Facilities, Computers and Information Infrastructure

Program Outcomes

The General Criteria of Program Outcomes (Criteria 3) have similar themes for both programs. Determining the appropriate outcomes for standards education is a judgment call. A first reading of the outcomes does not lead an educator or librarian to make quick decisions regarding appropriate outcomes. Depending on the type of course and the assignment, the outcomes may be different. The author recommends that the educator review the outcomes to determine appropriate choices. Readers are encouraged to read the outcomes in Appendix B: Criteria for Accrediting Engineering Programs (2009)[14] Criterion 3: General Criterion of Program Outcomes and Criteria for Accrediting Engineering Technology Programs (2009)[15] Criterion 3: General Criteria of Program Outcomes.

ABET evaluation often lists information literacy as a life-long learning outcome. A further discussion of the outcomes will be discussed in another paper by Harding and Erdmann (2010) [16] in this session.

Several specific program criteria in Engineering Technology identify outcomes for acquiring expertise with industry standards, regulations, codes, specifications and testing as well as safety, health, and environmental considerations. Harding and McPherson (2009) [17] detailed the standards-related criteria for programs in their public policy paper. These Engineering Technology Programs include aeronautics, architectural engineering, chemical engineering, civil engineering, construction, drafting/design engineering, mechanical technology, instrumentation and control systems, marine engineering, nuclear engineering, and surveying/geomatics.

Questions for Educator's Consideration for Implementing Standards Education in ABET Outcomes

1. An individual educator may not be able impact a whole curriculum. The whole college or school/department needs to determine how standards education should be integrated into the curriculum. An individual educator maybe working with a class that has relevant topics related to standards. This should be a starting point to work with colleagues in this class and make strides working with other colleagues with other classes. The author has prepared this list of questions to consider for discussion. It is not a definitive list.

2. How should standards be introduced to students?
    a. What background do the students already have?
    b. What learning should they acquire?
    c. Should the student learn about standards in one course?
    d. Should the student learn about standards in several courses?
        i. If so, what are the current classes that teach students about standards?
        ii. If none, what are the most appropriate courses?
    e. At what level(s), should be student receive instruction?
    f. Should the students work alone or in teams?

3. What are students supposed to learn?
    a. Are students studying a single standard?
    b. Are students studying a group of standards?
    c. How should students learn to find the standards that exist for a given topic?
    d. How should students apply standards to capstone classes

4. What type(s) of assignment are the student completing?
    a. Does an assignment involve design?

b. Does an assignment involve laboratory work?
c. Does an assignment involve research?
d. What is already being done in course(s) that should benefit from standards education
e. What is the assignment?
f. What standards apply to these assignments?

5. What materials are currently available to teach standards?
    a. Books
    b. Websites?
    c. Teaching aids, e.g. PowerPoint slides?
    d. Chapter in textbook, is it accurate?
    e. Case study, is it accurate?

6. How can the library help faculty and students to delivery instruction and the necessary standards?
    a. What does the library have available that may help?
    b. Does the library have a research or subject page on standards?
    c. Has the instructor checked with the library to see if the standards are available?
        i. If not, are there funds available to purchase the standards?
    d. Is the professor familiar with the policies and procedures to acquire standards?
    e. Can the library staff help with teaching the students, i.e. information literacy
        i. Searching skills?
        ii. Documenting skills?
        iii. Critical thinking skills
        iv. Evaluation
        v. Next steps? Are there related materials that students should learn about at the same time? For example, product catalogs?

7. What outcomes do you want the student to acquire from this assignment?

8. How can standards organizations or granting agencies facilitate the preparation of instructional materials to assist the educator and the library staff?

9. How can standards organizations facilitate the acquisition of standards when/ if the costs are beyond the budgets of libraries?

Standards and Libraries

Engineering educators and librarians work together to make standards available for teaching and research needs. Most libraries include standards in their collections. Libraries do not have a formula that recommends buying the same standards for every educational institution that offers an engineering degree. Every institution is unique. The disciplines, curriculums, varieties of research, and size of the university influence needs for all types of materials, including standards.

Smaller universities do not have the funds to support materials budget on the same scale as larger universities. *******

The author has worked at two academic institutions over her thirty year career. Both institutions had strong undergraduate programs. With the new ABET requirements for standards in engineering design and specific outcomes expected for engineering technology programs, the ABET requirements may create more standards demand. Collections that supports research as well as undergraduate and graduate education are necessary.

Each discipline needs standards from unique organizations. These organizations' standards are typical:

- International Code Council. International Building Code for Civil Engineering and Construction
- Society of Automotive Engineers standards for Aviation and Mechanical Engineering
- American Society for Testing and Materials for many disciplines

Whether one needs a selected or complete collection depends on needs. Research programs and budgets are also the major influences. Standards also vary in price. As a result, this complicates the ability of the library or educator to purchase titles from their budgets.

Deciphering Standards

Library staff members are available to help the library users who may confuse standards with other publication types, especially conference papers and technical reports:

- ASME PTC 23-2003 Atmospheric water cooling equipment (Standard)
- ASME 94-GT-535 Wake Recovery Performance Benefit in a High-Speed Axial Compressor (Conference Paper)
- ASME PVP-Vol. 406 "Waterjet Development," High Pressure Technology (Conference Paper)
- ASME BPVC-V-2007 BPVC Section V-Nondestructive Examination
- NIST-SP-903 Directory of U.S. Private Sector Product Certification Programs (Technical Report/Government Document)

Librarians also help with the questions, does the library have "ASME PTC 23-2003 Atmospheric water cooling equipment?" They are also available to help with information literacy training programs, especially identification in appropriate databases, location, and purchase of materia**ls.**

Communication

It is important that educators and librarians communicate specific needs. Methods to inform users about currently available standards and services are also necessary. This is a two-way process. Needless purchases by engineering educators and university employees have occurred for standards that the library owns. Interlibrary Loan is a viable option for a limited number of standards. Since many are not cataloged or are out-of-date, availability is a factor.

Mechanisms explaining the library's purchase policies and procedures to facilitate the ordering process for quick turnaround. This may involve a website description of services and contact information so that questions may be answered.

Subject Guides and Databases

One of the survey questions was asked related to subject guides for standards. This is becoming a common trend now. Here are an example: University of Minnesota's Selected Resources for: Standards.[18]"

Many libraries have created guides discussing databases to identify standards and standard series in all formats. Given the complicated nature of how standards are acquired, a guide that helps the client is an asset. It certainly helps when this guide can be a one-stop location for all relevant information including services.

Databases to Identify Standards

Many print and electronic standards are identified using free or subscription databases. Some libraries depend on commercial databases that are continually updated while others use free databases from ANSI, standards organizations, and document delivery services..

Web search engines are also widely used by faculty and students and are helpful for identifying known standards. Google and Yahoo may quickly send one to an organization or commercial service. It is recommended that one uses caution when buying standards since the library may have access to them.

There are many sources that are available to verify standards. Three subscription databases are shown as examples:

- IHS Standards Expert (Specifications and Standards) provides an index to a large number of standards. Some libraries have full-text access to standards from a limited number of organizations.
- ILI Standards Infobase contains very good coverage of U.S. and international standards including detailed information and equivalent standards from other countries. Some libraries have an electronic order program through ILI.
- IEEE Xplorer, i.e. IEEE/IET Electronic Library contains IEEE and IET (formerly IEE) journals and conferences as well as IEEE standards. Standards can also be purchased selectively.

Free search databases are also available.
- NSSE from the ANSI website.
- Standards organizations' websites. For example, International Organization for Standardization < http://www.iso.org>
- Standards delivery suppliers including
    - IHS Store (formerly Global Engineering Documents)
    - TechStreet

ANSI also maintains a list of acronyms[19] for standards organizations that can be helpful for an overview. ISO also maintains ISONET[20] online directory for its associate, national and international members. This is very good place for locating national standards organizations their websites.

This is not an all-inclusive list but gives people a starting point

Purchase of Standards

The current trends are for libraries to subscribe to frequently used standards and purchase others selectively. Subscriptions formats include print, CD-ROM, or online. Subscriptions give the users the advantage of always knowing that standards from a specific organization are available. One-time purchases may be print or downloaded pdf to meet a specific need quickly.

The types of standards ordered on one-time purchases vary. It is not uncommon to order standards from International Organization for Standardization (ISO), Aerospace Industries Association (AIA), and European Commission (Eurocodes). These are ordered from reliable document delivery services or standards organizations who offer quick turnaround time.

Libraries follow the procedures established by their acquisitions and business offices. Some libraries use deposit accounts or credit cards for rush orders. For others, library staff members order using a purchase order. Electronic standards subscriptions are usually paid annually. Some print subscriptions, e.g. ASCE standards are invoiced as they are shipped. These are called standing orders.

Cataloging of Standards and Database Creation

Creating records for the library catalog is typically done in smaller libraries but may not be done in larger libraries since established catalog records from shared sources, such as OCLC are not available. Alternate locally prepared databases are often made available for large print collections of standards, e.g. American National Standards Institute (ANSI).

Here are examples of prepared standards databases at universities:

- University of Washington
- Iowa State University
- University of Michigan
- Purdue University

Most libraries catalog selected titles that are regularly received in print. Collections of standards from organizations are usually done as a series but individual standards within a collection are not cataloged. Here are two examples:

- International Building Code
- ACI Manual of Concrete Practice

Both titles are catalogued but the ACI Manual is done as a series and the standards within it are not cataloged..

Databases to Identify Standards

Many print and electronic standards are identified using free or subscription databases. Some libraries depend on commercial databases that are continually updated while others use free databases from ANSI, standards organizations, and document delivery services. Web search engines are also widely used by faculty and students and are helpful for identifying known standards. Google® and Yahoo® may quickly send one to an organization or commercial service. It is recommended that one uses caution when buying standards since the library may have access to them.

There are many sources that are available to verify standards. These are not an all-inclusive list but gives people a starting point. Three subscription databases are shown as examples:

- IHS Standards Expert (Specifications and Standards) provides an index to a large number of standards. Some libraries have full-text access to standards from a limited number of organizations.
- ILI Standards Infobase contains very good coverage of U.S. and international standards including detailed information and equivalent standards from other countries. Some libraries have an electronic order program through ILI.
- IEEE Xplorer, i.e. IEEE/IET Electronic Library contains IEEE and IET (formerly IEE) journals and conferences as well as IEEE standards. Standards can also be purchased selectively.

Free search databases are also available:.

- NSSN from the ANSI website: http://www.nssn.org

- Standards organizations' websites. For example, International Organization for Standardization http://www.iso.org
- Standards delivery suppliers including
  - IHS Standards Store (formerly Global Engineering Documents): http://global.ihs.com/
  - Techstreet: http://www.techstreet.com

Educational Materials

Students used standards in laboratory experiments, cooperative education, and design products. Based on the ABET curriculum and outcomes criterion, it is appropriate that students get more exposure to standards. New engineering educators working with classes for the first time may want assistance. The author recommends several ways of approaching this task. These include using published materials, case studies that explain why standards are needed, and prepared materials from major societies that are available on the web.

There are a limited number of case studies that are well prepared and well- documented. There is a big need for credible educational materials. Case study examples on society and government websites are sometimes incomplete and inaccurate. Students need to understand why standards matter and the impact that standards have. Accurate case studies may give students are "real world" examples. A discussion of the ethical dilemmas involved is appropriate as well.

Hose Coupling Problems at the Great Fires Case Study

Proposals for national hose coupling standards of the 19th and 20th century have been described in detail since 1873. The earliest dates are usual missed from the present day accounts. Cochrane (1966)[21] as well as many other authors typically discussed the beginning of the activities to create a hose coupling standard as beginning in 1904 after the Great Fire in Baltimore when fire companies from the region's major cities arrived to help fight the great "conflagration" in February. Most could not attach their hose couplings to Baltimore fire hydrants because "common uniform threads" for the couplings did not exist at the time. As a result of this fire, 1,526 buildings in 70 city blocks burned to the ground.

Staff at the National Bureau of Standards did a study in 1904 and found that more than 600 different couplings existed at that time and standards activities moved more quickly to solve the problem. These are the facts that are typically reported. Cochrane who wrote the history of the National Bureau of Standards does mention a few more details and names. Albert S. Merrill is the person responsible for the large coupling study but no published account of the study has been found by this paper's author. Cochrane dismissed earlier efforts to create a standard as being ineffective. In 1904, the NBS had its own minor fire on their campus and could not attach hoses.

A better telling of the story has been done in S.W. Stratton (1914)[22] report about the beginning of standards efforts in 1873 at the Convention of Fire Engineers. They met for the first time in

Baltimore following the Great Boston Fire of 1872 where hose coupling problems contributed to the loss of property and life in another “conflagration.” The Boston fire has been reported as a similar scale to Baltimore’s fire. In that first convention of the fire engineers, James Hill of Cleveland offered a detailed resolution that began the standard efforts. The resolution passed. In 1876, the organization now called the National Association of Fire Engineers received a lengthy report and passed another resolution. Activities continued and members completed more reports. C.A. Landy of Elmira, NY produced a comprehensive report in 1891 detailing the large number of couplings that had been available then. Members of the National Fire Protection Association, American Water Works Association, and the American Society of Mechanical Engineers got involved. Several standards received approval between 1891 and 1914. Getting states and community fire departments to accept the standards took at lot more time. Into the 1920s, many departments did not conform to the new standards.

Some source documents are available and made interesting reading. Hathi Trust and Google® Books have been helpful online sources for obtaining many materials before 1923. The Commissioners Appointed to Investigate the Great Fire (1873)[23] prepared a Report of the Commissioners Appointed to Investigate the Cause and Management of the Great Fire in Boston. It tells a complicated story of the great difficulties that the fire department and the city experienced. Reading the reports of Landy and Merrill could be enlightening but no library has been identified that holds either report. Further research is planned to determine if sources are available. Griswold[24 25 26 27] wrote four journal articles/conference papers that give a commentary of the time from 1912-1922. Griswold in one of his publications mentioned that there had been problems with couplings in the Great Chicago Fire of 1871. The author is researching more sources to verify these facts. Based on this experience, I suggest that all case studies be checked carefully for the accuracy of their accounts.

Educational Materials from Standards Organizations

Many organizations have been involved in the standards education movement. It still needs more momentum in the academic community. The Strategic Value of Standards Education(2008),[28] a global survey conducted by the Center for Global Standards Analysis, is a report that is getting a lot of press and should serve as a motivation to increase educational efforts. An international organization that is making standards education a priority is the International Cooperation for Education and Standardization (ICES). [29] Workshops have been held since 2006 and presentations are available on the ICES website.

Most standards organizations offer some case studies, web tutorials, videos, and PowerPoint presentations as well as fee-based training meant for practicing engineers. Many case studies are very incomplete. For academic needs, some also offer classroom services. Given the large amount of information on organization websites, it is not possible to describe all relevant information in this short space. Here are several examples:

- ANSI’s StandardsLearn.org[30] offers short courses, case studies, an acronym directory, and an education database to other organizations. Most links are active but the author found a few dead links. ANSI advocates standards education at colleges and universities. It is trying to work with selected educational institutions and standards organizations to promote standards education. It has a University Outreach Program[31] and offers services for classroom teaching.

- ASME created a 20-page pamphlet on its Codes and Standards[32] with examples, several short articles, case studies, and basic educational materials for students. ASME celebrated the 125th anniversary of codes and standards. The June 2009 of Mechanical Engineering[33] has several relevant articles. There is also a 125th anniversary[34] website which shows video clips from volunteers and staff that serve on standards committees.
- ASTM International Campus[35] is a comprehensive website with audience tabs and many learning opportunities for faculty and students alike. It offers five modules of educational resources using PowerPoint slides. It also offers full-text standards at low cost for course packs. The author recommends checking with the campus library to determine present subscriptions.
- IEEE[36] also offers a web-based standards education program. It is calling for volunteers and is expanding its website to include more materials, case studies, and student application papers. There has been considerable improvement in the last few months.

The author reviewed several encyclopedias and handbooks. Some are very thorough. For example, Kirk-Othmer Encyclopedia of Chemical Technology contains quality articles on standards. Some are long and others are short. J. H. Westbrook(2000)[37] wrote an extensive article on "Materials Standards and Specifications." It is one of 934 articles on standards in early 2010.

Case Studies of Faculty Involvement with Standards

Faculty, staff, and students at universities are involved in many aspects of standards. Another way to educate students is to share with them the stories that involve the creation, review, and use of standards. There are many examples available. Since people are currently working, it may be possible to do interviews with people.

Floating Point Arithmetic and Computers

Professor William Kahan, a computer science professor at the University of California, Berkeley has spent more than 30 years contributing to the IEEE 754 standard on floating point arithmetic. Kahan (1981)[38] and Kahan(2005) [39] are two of his eleven publications on the topic. The introduction to the second article gives perspectives on the problems that earlier computer users encountered.

> In the past 20 years, IEEE 754: Standard for Binary Floating-Point Arithmetic (http://grouperieee.org/groups/754/) has revolutionized the portability and reliability of programs that use binary floating-point arithmetic. Gone are the days when one could routinely run into situations where 18 divided by 3 gives a result other than 6…

The standard was first adopted in 1985 and revised in 2008. There is also an interesting interview with Kahan that was done by Charles Severance in 1998. The Kahan-Severance[40] interview transcript is available on the web.

Faculty as Proposers, Committee Members, and Critiques

New standards activities are also common. Many faculty members are involved in proposing standards, serving on committees as well as critiquing proposed standards.

- William Field, an Agricultural & Biological Engineering Professor and his colleagues proposed a new SAE standard for "Access Systems on Off-Road Machinery for Agricultural and Other Workers with Disabilities.[41]" in 2009.
- Perry D. Roland who works with the Libraries at the University of Virginia has been on a group that approved IEEE Recommended Practice for Defining a Commonly Acceptable Musical Application Using XML[42] in 2008. Baggi, the committee chair is from the University for Applied Science Southern Switzerland.
- Faculty and staff critiqued the ANSI INCITS 359-2004, Standard on Role Based Access Control and identified "a number of technical errors and limitations of the standard and suggested how they [the problems] can be addressed…[43]"

Faculty Research on Damage to Pentagon and Destruction of World Trade Center

Standards are also regularly discussed in significant research publications. Many faculty members also use standards in their research publications:

- Mete Sozen, a distinguished professor at Purdue University served as an expert on the review team investigating the structural damage to the Pentagon following the 9/11 crash... He was one of the authors of the final report.[44] Standards mentioned in the report include those from the American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), American Society for Testing and Materials (ASTM), and Eurocode (European Committee for Standardization).
- Eurocode construction codes have been used for many journal articles and reports related to the design of buildings, other civil engineering works and concrete products. An example is two authors who published an article[45] on the collapse of the World Trade Center. The authors state that "Eurocode 3 is used to estimate the changes in modulus of elasticity and yield strength of steel with temperature, and to provide an axial load capacity estimate for core columns."

University Procurement and Purchasing

University personnel also use standards, specifications, and government regulations purchasing and procurement in day-to-day operations. The examples included the specifications for a new boiler and concrete paving.

- A university specifies its need for a new Natural Gas Fired Package Boiler[46] and requests that bids must meet standards from 36 different standards organizations. Examples included those from the Boiler and Pressure Vessel Code of the American Society of Mechanical Engineers (ASME) and the International Building Code (IBC).
- Another university presents a similar document for a Concrete Paving[47] project. Standards cited incorporated those from ACI, ASTM, AASHTO, and City of Seattle and Washington State Department of Transportation (DOT) standard specifications.

Conclusion

IThis paper covers the needs of new engineering educators for standards information. It gives a brief view of the ways libraries help educators meet ABET criteria and outcomes.

Appendix A:

Criteria for Accrediting Engineering Programs

Criterion 3: General Criterion of Program Outcomes

Engineering's Criterion 3. Program Outcomes have similar themes as their program "must demonstrate that their students attain the following outcomes:"

a. An ability of apply knowledge of mathematics, science, and engineering
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. An ability to function on multidisciplinary teams
e. An ability to identify, formulate, and solve engineering problems
f. An understanding of professional and ethical responsibility
g. An ability to communicate effectively
h. The broad education necessary to understand the impact of engineering solutions in a global economic, environmental, and societal context
i. A recognition of the need for, and an ability to engage in life-long learning
j. A knowledge of contemporary issues
k. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Criteria for Accrediting Engineering Technology Programs

Criterion 3: General Criterion of Program Outcomes

In Criterion 3, the Engineering Technology criterion requires that each program must demonstrate that graduates have the following outcomes:

a. An appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines

b. An ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology.
c. An ability to conduct, analyze and interpret experiments, and apply experimental results to improve processes.
d. An ability to apply creativity in the design of systems, components, or processes appropriate to program educational objectives
e. An ability to function effectively on team
f. An ability to identify, analyze and solve technical problems.
g. An ability to communicate effectively.
h. A recognition of the need for, and an ability to engage in life-long learning
i. An ability to understand professional, ethical and social responsibilities
j. A respect for diversity and knowledge of contemporary professional, societal and global issues.
k. A commitment to quality, timeliness, and continuous improvement

---

[1] Hunter, Robert D. (2009). Standards, Conformity Assessment, and Accreditation for Engineers. Boca Raton, FL: CRC Press.
[2] Batik, Albert L. (1992).The Engineering Standard: A Most Useful Tool. Ashland, OH: BookMaster/El Rancho.
[3] Subramanyam, K. (1981). Scientific and Technical Information Resources. New York: M. Dekker. .
[4] Musser, Linda R. "Standards Collection for Academic Libraries." Vol. 10(3): 59-71.
[5] Osif, Bonnie. A., ed. (2006)Using the Engineering Literature. New York: Routledge, Taylor & Francis Group.
[6] Piety, Jean Z, Piety, John (2006). "General Engineering Resources." In Using the Engineering Literature, edited by Osif, Bonnie A. New York: Routledge, Taylor & Francis Group. Pages 25-31.
[7] Harding, Bruce and McPherson, Paul (2009). "Íncorporating Standards into Engineering and Engineering Technology Curricula: It's a Matter of Public Policy." ASEE Annual Conference Proceedings AC 2009-1168. 8 pages.
[8] Mathews, Brian.(2006). "The Role of Industry Standards: An Overview of the Top Engineering Schools" Libraries." Issues in Science and Technologies Libraries. Spring. 9 pages..
[9] Pellack, Lorraine J. "Industry Standards in ARL Libraries: Electronic and On-Demand. Collection Building 24(1): 20-28.
[10] Dowell, Norma J. "ANSI Standards" Creating a Local, Searchable Database." Collection Building Vol. 24(1): 29-34.
[11] Matylonek, John C. and Peasley, Maren (2001). "A Web Database to Manage and Organize ANSI Standards Collections." Issues in Science and Technology Librarianship. Summer. 7 pages.
[12]ABET Engineering Accreditation Commission. (2009) Criteria for Accrediting Engineering Programs: Effective for Evaluations During the 2010-2011 Accreditation Cycle. Incorporates all changes approved by the ABET Board of Directors as of October 31, 2009. Baltimore: ABET, Inc.
[13] ABET Engineering Accreditation Commission. (2009) Criteria for Accrediting Engineering Technology Programs: Effective for Evaluations During the 2010-2011 Accreditation Cycle. Incorporates all changes approved by the ABET Board of Directors as of October 31, 2009. Baltimore: ABET, Inc.
[14]ABET Engineering Accreditation Commission. (2009) Criteria for Accrediting Engineering Programs: Effective for Evaluations During the 2010-2011 Accreditation Cycle. Incorporates all changes approved by the ABET Board of Directors as of October 31, 2009. Baltimore: ABET, Inc.
[15] ABET Engineering Accreditation Commission. (2009) Criteria for Accrediting Engineering Technology Programs: Effective for Evaluations During the 2010-2011 Accreditation Cycle. Incorporates all changes approved by the ABET Board of Directors as of October 31, 2009. Baltimore: ABET, Inc.
[16] Harding, Bruce and Erdmann, Charlotte (2010 In Press) "Leveraging the Internet and Limited On-Campus Resources to Teach Information Literacy Skills to Future Engineering Practicitioners." ASEE Annual Conference Proceedings. 15 pages.

[17] Harding, Bruce and McPherson, Paul (2009). “Incorporating Standards into Engineering and Engineering Technology Curricula: It’s a Matter of Public Policy.” ASEE Annual Conference Proceedings AC 2009-1168. 8 pages.

[18] Jeffryes, Jon. (2009) Selected Resources for: Standards. Minneapolis: University of Minnesota Libraries. < http://www.lib.umn.edu/subjects/rqs/359> Accessed 1/8/2009.

[19] StandardsLearn.org (2010). Acronyms in Standards and Conformity Assessment. New York: ANSI. <http://www.standardslearn.org/acronyms.aspx> Accessed 1/9/2010.

[20] International Organization for Standardizaton (2010). ISONET Directory. <http://www.wssn.net/WSSN/RefDocs/isonetdir/index.html> Accessed 1/8/2009.

[21] Cochrane, Rexmond C. (1966) Measures for Progress: A History of the National Bureau of Standards. Washington, D.C., National Bureau of Standards, U.S. Department of Commerce. Miscellaneous Publication no. 275. Pages 84-86.

[22] Stratton, S.W., director (1914) National Standard Hose Couplings and Fitting for Public Fire Service. Circular of the Bureau of Standards no. 50. Department of Commerce. Washington: Government Printing Office.

[23] Commissioners to Investigate the Great Fire (1873). Report of the Commissioners Appointed to Investigate the Cause and Management of the Great Fire in Boston. Boston, Rockwell & Churchill.

[24] Griswold, F.M. (1912) ”Progress in the Adoption of the National Standard Hose Couplings and Hydrant Fitting for Public Fire Service.”Quarterly of the National Fire Protection Association v.6:1, pages 22-29.

[25] Griswold, F.M.(1921) “The Great Boston Fire of 1872.” The Quarterly 15 no.1, pages 9-19..

[26] Griswold, F.M. (1913) “National Standard Hose Couplings and Hydrant Fittings of Public Fire Service.” Journal of the American Society of Mechanical Engineers.

[2727] Griswold, F.M. (1922) Progress in Hose Coupling Standardization.” Quarterly of the National Fire Protection Journal 15:3.

[28]Purcell, Donald E., ed. (August 2008) The Strategic Value of Standards Education. Washington, D.C. : Center for Global Standards Analysis, Catholic University. http://www.ieee.org/portal/cms_docs_iportals/iportals/education/standards/Centers_Global_Survey_Report_%28August_2008%29.pdf Accessed 1/8/20010.

[29] ICES (2010). International Cooperation for Education about Standardization: News and Events. Delft, Netherlands: ICES. <http://www.standards-education.org/> Accessed 1/8/2009.

[30]American National Standards Institute (2009). Welcome to StandardsLearn.org! New York: StandardsLearn.org Administration, American National Standards Institute. http://StandardsLearn.org

[31] ANSI Education and Training (2009) University Outreach Program. New York: American National Standards Institute. http://www.ansi.org/education_trainings/university_outreach.aspx?menuid=9 Accessed 1/8/09

[32] ASME International (2009?). ASME Codes and Standards: Examples for Use for Mechanical Engineering Students. New York: ASME International. Accessed 1/1/2009.

[33] ASME International (June 2009). “ASME Codes and Standards: Celebrating 125 Years: Special Issues.” Mechanical Engineering 131:6. http://cs125.asme.org/magazine.php Accessed 1/8/2009

[34] ASME International. Celebrating 125 Years of Service: ASME Interviews. New York: ASME International. http://go.asme.org/CS125 Accessed 1/8/2009.

[35] ASTM International (2010). ASTM International Campus. University of Washington http://www.lib.washington.edu/Engineering/standards/web.html

[36] IEEE. Standards Education. IEEE. <http://www.ieee.org/web/education/standards/index.html> Accessed 1/8/2010.

[37] Westbrook, J.H. (2000) “Materials Standards and Specifications,” vol.15, Pages 33-67. In Kirk-Othmer Encyclopedia of Chemical Technology, 4th ed .New York: John Wiley & Sons.

[38]Kahan, W. (1981) Why Do We Need A Floating Point Arithmetic Standard? <http://www.eecs.berkeley.edu/~wkahan/ieee754status/why-ieee.pdf> 49 pages

[39]Kahan, William (2005). “An Open Question to Developers of Numerical Software.” Computer 35(5): 91-94.

[40]Severance, Charles. (1998) An Interview with the Old Man of Floating Point: Reminiscences elicited from William Kahan, by Charles Severance. <http://www.eecs.berkeley.edu/~wkahan/ieee754status/754story.html> Updated 02/20/1998. Retrieved 01/06/2009.

[41]Yoder, Aaron M., Field, William E., and Gail, DeBoy R. (2009) "A Proposed SAE Standard on Access Systems for Off-Road Machinery for Agricultural and Other Workers with Disabilities." ASABE Paper 09029. 2009 ASABE Annual International Meeting, Grand Sierra Resort and Casino, Reno, Nevada.

[42]IEEE Recommended Practice for Defining a Commonly Acceptable Musical Application Using XML (2008). IEEE Std 1599. New York: IEEE Computer Society.

[43]Li, Ninghui, Byun, Ji-Won, Bertino, Elisa. [2006?]. A Critique of the ANSI Standard on Role Based Access Control. [West Lafayette, IN]: X University, CERIAS. <http://www.cs.purdue.edu/homes/ninghui/papers/aboutRBACStandard.pdf> Retrieved 10/06/2010.

[44]Pentagon Building Performance Study Team (January 2003). The Pentagon Building Performance Report. Reston, VA: American Society for Civil Engineers.

[45]Irfanoglu, Ayhan and Hoffmann, Christoph M. (2008). "An Engineering Perspective of the Collapse of WTC-I."Journal of Performance of Constructed Facilities 22 (1): 62-67..

[46]Purdue University (2009). Detailed Specifications for Wade Utility Plant: Purchase, Supply & Install for One 200,000 Pounds Per Hour Natural Gas Fired Package Boiler 7. Overlook Park, KS: Lutz, Daily, & Brain, LLC. http://www.purdue.edu/purchasing/pdf/Boiler_7_As_Issued_7-31-09.pdf Updated 7/31/09. Retrieved 1/06/10.

[47]Section 32 13 13 Concrete Paving. [Seattle]: Specifications Standards for University of Washington, Job Order Contracting 202936 ZGF Partnership.
http://www.cpo.washington.edu/DOCMAN/WEB_FTP/DOCMANFTP/32%2013%2013%20-%20Concrete%20Paving.pdf