Standards Education: An Industry, Government, University Partnership

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Abstract: Standards education for universities was established as a priority in the National Standards Strategy (NSS) in 2000 and continues as a priority in the updated United States Standards Strategy (USSS) in 2006. To support standards education and outreach, , the American National Standards Institute (ANSI) established a Committee on Education (CoE) with one of its charges to assist engineering and technology programs in standards education. This effort built on the ABET requirement for engineering major design experience "incorporating appropriate engineering standards and multiple realist constraints." The purpose of this paper is to provide a report and update of the ANSI CoE's activities and plans for standards education and outreach to universities and suggest ways that faculty members can become more involved in and benefit from this effort.

Key words: accreditation, design, engineering standards

Introduction

The ABET Criteria for Engineering programs require students to incorporate engineering standards in the culminating design experience; recent changes continue this requirement [1]. The United States National Standards Strategy (NSS) called for increased efforts to educate future leaders in engineering, business and public policy on the value and importance of standards[2]. The NSS was developed by a diverse group of government and private sector representatives from industry, government, trade and professional societies, and consumer organizations. To support the NSS, the American National Standards Institute (ANSI) established a Committee on Education (CoE) with one of its charges to support and assist engineering and technology programs in standards education. This effort built on the ABET requirement for engineering programs and NSS objective 11.

The United States Standards Strategy (USSS) was recently released and it calls for expanded and strengthened efforts to assist university and college programs in their efforts to educate students on standards and conformity assessment [3]. The USSS is essentially an update of the NSS.

The ANSI CoE has been assisted in its work by a number of US standards developers including ASTM International (ASTM) , the American Society of Mechanical Engineers (ASME), the Institute of Electrical and Electronic Engineers (IEEE), the American Society of Civil Engineers (ASCE), Underwriters Laboratories (UL) and others. This effort has also had broad participation and support from federal agencies, particularly the National Institute of Standards and Technology (NIST).

The purpose of this paper is to provide a report and update of the ANSI CoE's activities and plans for standards education and outreach to universities and suggest ways that faculty members can become more involved in and benefit from this effort.

Accreditation requirements

Although the context for education in the NSS and now in the USSS is much broader than engineering and technology, the CoE has focused its efforts so far on engineering and technology because of the ABET requirement for engineering programs. The CoE has worked closely with the Canadian Standards Association (CSA) over the last several years and, as a result, became aware of very similar, albeit stronger, requirements in the Canadian Accreditation Criteria [4].

Criterion 4 of the ABET Criteria for Accrediting Engineering Programs requires students to incorporate engineering standards and multiple realistic constraints in the culminating major design experience. Criterion 3 requires that students consider realistic constraints from a suggested list of eight that includes environmental, health and safety – which are commonly the subject of standards, codes and technical regulations that influence design, manufacturing, construction or use.

One of the goals of the current Canadian Standards Strategy (CSS) is to "Research and make recommendations on the development and application of a 'Standards & Conformity Assessment Education Module' for use by technical colleges and universities"[5]. In the CSS it is noted that issues such as security and sustainable development are encouraging efforts to improve processes to support and encourage innovative solutions. The CSS contains a mix of research, communication, and cooperative activities that are intended to address both new and ongoing standards issues.

The Canadian Engineering Accreditation Commission Criteria requires in Criterion 2 that engineering programs develop "communication skills and an understanding of the environmental, cultural, economic and social impacts of engineering on society and of the concepts of sustainable development." This is very similar to the comparable ABET criterion. Criterion 2.2.7 requires that appropriate exposure to the "concepts of sustainable development" be an integral component of all engineering curricula. This is stronger than the ABET requirement which only requires that sustainability be considered as a possible design constraint. With respect

to standards, Criterion 2.2.3 notes that constraints that affect design may be "governed by standards or legislation to varying degrees depending on the discipline." This is more explicit than the comparable ABET requirement in Criterion 4.

In the Canadian questionnaire for evaluation of programs guidance Section 2A.10, programs must describe how factors such as codes and standards and the value and impact of standardization are included in the engineering design experience [6]. Further, programs must indicate how the application of relevant standards and design codes is integrated into project work and design theory. Section 2A.23 deals with industrial relations and asks programs to describe any participation in "multi-stakeholder forums for the development of technical standards, codes, regulations or guidelines." Programs must provide, as part of the sections dealing with faculty information, information on memberships in standards developing organizations and on participation on standards development committees. There are no comparable specific requests in the ABET self-study guidance [7]

Canadian engineering colleges are asked to provide information relating to staff participation in standards development work at the national or international level. With respect to libraries, information on the location of sets of Canadian and foreign standards and design codes is requested along with information on other library resources. Here again there is no similar request in the ABET guidance.

Standards

At the national and international level: With what standards should students be familiar and how can this be accomplished? Based on information from the Massachusetts Institute of Technology (MIT) library web site, mechanical engineering students are first directed to search the national standards network to determine if there is an American National Standard (ANS). However, a standard becomes an ANS only if the standards developing organization (SDO) is accredited by ANSI and submits the standard to ANSI for approval as an ANS. Consequently, not all standards students could be working with are ANSs. However, it is not unreasonable, following the Canadians, to expect that all students would have access through their library to all ANSs relevant to their field.

Access to International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) standards appears to be very limited for most students although some information on ISO and IEC processes is available on their web sites. Again, it is reasonable to expect that students should have access to relevant ISO and IEC standards and ANSI has recently started a pilot program to make ISO standards available to university programs across the range listed in the NSS and now the USSS.

A useful resource for students and faculty members looking for information on standards is the National Standards Network (NSSN) that can be accessed at http://www.nssn.org/. Although NSSN originally stood for the national standards system network, the NSSN is now much broader in scope and is a good starting point for students to research international standards as well. Another place to search for standards is the Information Handling Services (IHS) site http://store.ihs.com/specsstore/controller?event=HOME. Most

engineering libraries should be able to assist students and faculty members in searching for standards and some will have the resources for them to obtain standards electronically to support student projects.

Based on sample materials on the National Council of Examiners for Engineering and Surveying (NCEES) web site, there are no questions on standards on the Fundamentals of Engineering (FE) exam. The only practice questions on the FE exam deal with ethics. At the Professional Engineer (PE) level, there appears to be some questions dealing with codes and standards on the mechanical and electrical engineering examinations. For the civil engineering exam a list of design standards is given which must be used to answer questions in the structural and transportation areas. Also the NCEES is studying developing new practice oriented examinations that would likely have questions dealing with codes and standards.

In addition to the ABET general engineering criteria, there are program criteria that are the responsibility of the professional societies. Program criteria may only deal with curricula and faculty issues and none of the current program criteria appear to have standards requirements that go beyond the general criteria requirement [7].

One of the other responsibilities of the professional societies is to provide support and guidance for program evaluators. For example, ASCE has a commentary on the ABET general criteria and suggests things evaluators should look for on campus to ensure that students are using appropriate engineering standards in design [8].

The USSS looks at broader issues than engineering design, particularly the role of standards and conformity assessment in global commerce and in ensuring the competitiveness of U.S. industry. Standards developing organizations have a strong interest in training the professionals needed in standards development work. In addition, the USSS is looking for SDOs to provide educational opportunities worldwide to facilitate participation in U.S.-based standards activities. Further, the World Trade Organization's (WTO) Technical Barrier to Trade Agreement (TBTA) expects countries to participate in standards activities important to its industry and the USSS calls for organized education activities to ensure broader more effective participation in standards processes and higher quality standards [9]. There is also recognition in the USSS that there is also a need to educate the public on the benefits of standardization.

Incorporating standards in a student design project

The ABET requirement for engineering standards is in Criterion 4 and specifically calls for the use of standards in design. The Canadian requirement is broader although it is also focused around design.

Relevant standards should be consulted early in the design process and since it is reasonable to assume many companies will want their products to be accepted in the global market, students could be expected to look to see if their product is likely to be covered by a

European Union (EU) Directive [10]. According to the most recent report by the U.S. Trade Representative, the EU continues to be the U.S.'s largest trading partner and, as such, is a large market for US goods and services.

The National Institute of Standards and Technology (NIST) has a number of publications that students can use to learn about EU Directives that could affect design projects. NIST Special Publication (SP) 951 gives an overview of the European process [11]. A table is included which shows the product fields affected by the new approach. Some areas covered by directives include: medical devices, construction products, machinery and low voltage equipment.

A series of reports are available dealing with directives in different sectors which students could consult for details specific to their project area. These documents provide more detail than NIST SP 951 but are linked to this document. An example is the guide to the machinery directive [12]. The EU's essential requirements deal with health, safety, and the environment and this NIST report includes a discussion of health and safety issues specific to machinery. A discussion of the machinery directive would be a good way for students to gain an understanding of some of the considerations in Criterion 3 and Criterion 4 as they relate to the design of machinery. The directive can be accessed at the EU legislation website [13].

There are NIST guides for medical devices, the low voltage directive, and other sector-specific issues as well as more general guides dealing with issues such as product liability and product safety. All of these documents are available for downloading from the NIST site. These sector guides could be used to provide background for the design experiences in mechanical, electrical and biomedical engineering, and in general be illustrative if not applicable, guides for all areas. They provide a framework that could be useful in developing design constraints that are called for in Criterion 3 and in meeting the requirements for consideration of engineering design in the major design experience called for in Criterion 4.

General education aspects of standards

Standards and technical regulations already play a major role in defining health, safety and environmental considerations nationally and internationally and these influences on design and manufacturing are growing. Students should have a general understanding of how standards are developed, and how standards can become part of regulations and thus become mandatory requirements – technical regulations.

European Union policy is to define an approach for achieving desired outcomes - health, safety and environment - and then direct the European standards organizations to write appropriate standards where international standards do not already exist, and ultimately to require designers to design and manufacture products to meet those standards. Although products do not have to be designed

according to specific standards, doing so carries the presumption of conformity to the directive which is a requirement to market a product in the EU. Thus there is a strong incentive to actually design and manufacture to the appropriate standards. Clearly there is enlightened self-interest in writing standards that promote regional economic advantage while at the same time raising the bar for health, safety and the environment. From an international business perspective, the strategic implications of standards are increasing. For example, the EU has a framework directive for eco-design of end-use equipment. The objective is a directive that harmonizes requirements concerning the design of end-use equipment to ensure the free movement of these products within the EU and to reduce their impact on the environment. The proposed directive would apparently merge initiatives dealing with design of electrical and electronic equipment and energy and efficiency requirements[14]

Sun Microsystems is concerned about a directive that would affect design of products they market in the EU. Their position is that these objectives of the EU would be better accomplished by working in an international standards-setting context and working more closely with industry[15]. In the Information Technology area, where standards and products evolve rapidly and the U.S. market is clearly global, the incentives for understanding such policy issues are clear.

These brief examples are given to suggest that exploring some of these "soft" issues in engineering design courses could contribute to the general education component of a curriculum. These experiences could also be structured to provide evidence for achievement of outcomes 3(h) and 3(j).

Professional societies

Some of the engineering societies with ABET program responsibilities are also major standards developers. They have materials that can be used to provide basic background on standards and standardization processes for students as well as for training professionals for standards work.

The IEEE-Standards Association (IEEE-SA) is the leading developer of global industry standards in a broad-range of industries, including Power and Energy, Biomedical and Healthcare, Information Technology, Telecommunications, Transportation, Nanotechnology, and Information Assurance. According to its web site, ASME currently maintains 600 codes and standards dealing with mechanical devices. ASCE has committees which develop standards in a variety of civil engineering fields. All of these organizations have standards that are used internationally.

ASME has an introductory publication that describes its standards processes [16]. This publication is general enough to be a good introduction for all engineering students. ASME notes that over two hundred standards developing organizations are accredited by ANSI which means they abide by the principles of transparency, balance of interest, and due process in developing their standards. It is further noted that the members of standards committees are typically engineers knowledgeable in the technical aspects of the

standard and notes that participants must agree to adhere to the ASME Policy on Conflict of Interest and the Engineer's Code of Ethics.

The Institute of Electrical and Electronic Engineers is a major international standards developer and has been reviewing what graduates in electrical and computer engineering should know about standards. As part of this review, the electrical and computer engineering and engineering technology education communities reported their needs for knowledge and skills in the application of standards to engineering and engineering technology design and development in a survey conducted by the IEEE joint Standards Association and Educational Activities Board's Standards in Education Task Force in the late spring of 2004. The results of that survey motivated development of on-line learning modules to provide a foundation to the use of standards in design and development by students and their faculty mentors in electrical and computer engineering and engineering technology. The IEEE portal can be accessed at http://www.ieee.org/portal/cms_docs/education/setf/index.html.

Activities of other partners

Many trade organizations are major standards developing organizations and many have materials that can be used to provide sector-specific information on standards. For example, INCITS – the International Committee for Information Technology Standards – develops voluntary consensus standards in the area of information technology. As one example, they develop and maintain programming standards with C++ - an example with which many students would be familiar. INCITS provides their standards at a low cost to students and faculty members for educational purposes. American Petroleum Institute (API) standards are used globally by the petroleum industry and API provides free access to oil and gas standards for petroleum engineering students and faculty.

The federal government is a major user of standards and in the past has been a major standards developer. A number of federal agencies have significant standards activities that can be good sources of specialized information for students. For example, the Department of Energy has an introduction to standards which includes a great deal of general information as well information specific to energy [17]. NIST coordinates federal agency standards activities and is also is a source of basic information on standards [18].

The Standards Engineering Society (SES) promotes the use of standards and standardization. Although its focus is on the standards professional, all of the presentations from its annual conference and award winning papers from the World Standards Day paper competition, are on its website and can be downloaded [19]. Students and faculty members will find a wealth of information on standards and conformity assessment on the SES website.

ANSI's role

ANSI is a federation of companies, organization, government, consumer interests and educational institutions. ANSI is not a standards developer but instead administers and coordinates the U.S. voluntary standards and conformity system. In response to the NSS Objective 11, ANSI established an *ad hoc* education committee with representation from industry, government and academe to address outreach to the public and university faculty members. In support of the NSS and to implement university outreach activities, ANSI developed a standards education portal available at www.StandardsLearn.org. A free introduction to standards e-learning course, *Why Standards Matter*, was developed as well as a course on U.S. standards development, both of which are available through the portal. Students and faculty members in many disciplines, not just in engineering, have found both courses a useful introduction to standards. ANSI e-learning courses could be used as background for a lecture on standards in the capstone design course or students could be directed to complete the course on their own - an exercise in life-long learning. The course on U.S. standards development has a special module for faculty members and students using an example of an engineering technology student.

Workshops were conducted at the fall 2004 and spring 2005 ASEE Mid-Atlantic meetings where representatives from industry, government and academia provided insight into the world of voluntary standards and techniques for incorporating standards and conformity assessment-related topics in university curricula. Examples of current standardization issues – such as sustainable development; manufacturing and design issues; health and safety requirements; economic, social and political considerations – were discussed from the perspective of teaching design in engineering and technology programs.

Feedback from these workshops emphasized the need to find ways to make actual standards more accessible to faculty and students for educational purposes. A partial response to this is the ANSI pilot program to make ISO and IEC standards available and progress on these efforts and identification of other and possibly better ways to make standards accessible for educational purposes are under study by the ANSI CoE.

A workshop is being organized for the 2006 ASEE Annual meeting in Chicago. This workshop is cosponsored by the ASEE Civil Engineering Division and will provide more examples of just how to incorporate standards in capstone design courses.

ANSI CoE strategies

At its meeting in February 2006, the CoE discussed the USSS and what the CoE could and should do to aid in implementation. Objective ten of the USSS deals with education and it is ambitious - ***Establish standards education as a high priority within the United States private, public and academic sector.***

One of the specific tactical initiatives under ten is to "Develop or significantly enhance standards education programs that address the needs of specific groups within the United States. These programs must reflect the multidisciplinary environment in which standards development takes place and address national and international standards development procedures; the relationship between private and public sector standards; the environment, health, safety, sustainability, international trade, public policy, competition, legal, economic benefits, and strategic considerations; and how to balance the interests of stakeholders." This list clearly overlaps with the constraints listed in ABET Criterion 3. However, the challenge remains how best to make this connection for programs in engineering and technology and then assist them in incorporating standards in their programs. The CoE has a task committee that is developing some specific initiatives again initially targeting engineering and technology programs. The current planning is building on the extensive engineering outreach effort being conducted by the CSA.

Another tactical initiative in the USSS is to "Develop a national database of standardization case histories. The database should be jointly managed by the American National Standards Institute and the U.S. Department of Commerce." Plans at this point are to identify resources to study the feasibility of developing such a database.

Outreach to engineering educators through ASEE meetings will continue to be a priority. The committee intends to use what it has learned with the engineering and technology community to broaden its outreach to other areas such as business and consumer science.

Summary

The ABET Criteria for Engineering programs require students to incorporate engineering standards in the culminating design experience; this requirement is explicit in Criterion 4 but it is also implied in Criterion 3 in the list of suggested constraints that include health and safety and environmental issues. Health, safety and environmental considerations are commonly the subject of mandatory standards or technical regulations affecting design. The Canadian Engineering Accreditation Criteria have similar expectations for students to use codes and standards in design but also include expectations that library resources will ensure access to appropriate standards and that faculty members participate in standards work.

The United States Standards Strategy calls for more education on the importance of standards. There are already extensive resources available on most aspects of standards with much of it freely available on the web. The challenge is to make standards learning resources more visible and useful to faculty and students possibly through a common web portal. As suggested in the introduction, the

education objective of the NSS and now the USSS and the requirements in the ABET Criteria that imply or require, respectively, standards remains a window of opportunity for the standards and engineering education communities to work together.

ANSI and the authors would welcome input from engineering educators on specific needs and thoughts on how to make standards a high priority in engineering education.

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