# AC 2009-1168: INCORPORATING STANDARDS INTO ENGINEERING AND ENGINEERING TECHNOLOGY CURRICULA: IT'S A MATTER OF PUBLIC POLICY

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# Incorporating standards into engineering and engineering technology curriculum: It's a matter of public policy

**Abstract**
Standards are those rarely noticed background rules and procedures which make products and processes successfully function in society. Standards can be technical, procedural or societal, and affect everything from automobiles, to accounting practices, to much of what we carry in our pockets or purses, to the way we read this electronic page. Standards are so pervasive that during our daily routine we may interact hundreds of times with products of standardization.

Still, as important as standards are, the topic is often approached with as much enthusiasm as that of watching grass grow. Worse, knowledge of standards, their use and development may actually be completely overlooked throughout the educational process. Why does this disinterest exist? How can it be remedied? ABET (the Accreditation Board for Engineering and Technology) for one, has begun the process in establishing basic requirements for standards education spanning both engineering and engineering technology.

This paper discusses how such criteria can be addressed and standards incorporated into classrooms and across disciplines, to help battle disinterest and graduates' dearth of standards knowledge. It includes educational techniques, strategies and sources of case studies that may be directly employed in classrooms. It goes further in offering insight into the standards development process and the rationale for involvement. It also touches on future trends in standards development. Involvement in the process can further individual professional development, as well as helping establish valuable contacts with industry and standards leaders, both nationally and internationally.

**Introduction**
Standards have been an integral part of United States public policy since long before the terms 'public policy' or even 'standard' were coined. In the early 18th Century, John Quincy Adams wrote about 'standard' weights and measures:

> "Weights and measures may be ranked among the necessaries of life to every individual of human society. They enter into the economical arrangements and daily concerns of every family. They are necessary to every occupation of human industry; to the distribution and security of every species of property; to every transaction of trade and commerce; to the labors of the husbandman; to the ingenuity of the artificer; to the studies of the philosopher; to the researches of the antiquarian; to the navigation of the mariner, and the marches of the soldier; to all the exchanges of peace, and all the operations of war. The knowledge of them, as in established use, is among the first elements of education, and is often learned by those who learn nothing else, not even to read and write. This knowledge is riveted in the memory by the habitual application of it to the employments of men throughout life."[1]

However with the passing of time and new technology advances, the interpretation of standards has evolved. Donald L. Evans, Secretary of Commerce in 2004 wrote:

> "The international language of commerce is standards. Adherence to agreed upon product or service specifications underpins international commerce, enabling

> trillions of dollars of goods to flow across borders, regardless of the spoken language of any business parties. The common acceptance of standards is fundamental to the success of robust, fair and free trade. Without standards, it would be difficult to imagine the tremendous volume and complexity of international trade."[2]

Engineering and technology educators bring varying degrees of industrial experience to their academic position. Based on that experience, their evolving scholarship interests and their continuing professional development, faculty go about their jobs preparing future practitioners, often in graduate school, as mirrors of their own interests. In doing so some faculty write their textbooks, some use others' books while a few also use industrial handbooks as primary or suggested texts.

Our products as engineering educators are practitioners with newly minted degrees, who often find themselves required to locate technical and non-technical information from a variety of sources. More often than not, their first choice is the internet, an engineering handbook or perhaps a textbook retained from college. Few faculty and even fewer students realize the origins of much of the technical information they find in these publications — industry standards, which are both relevant and time-sensitive. Standards in fact represent the ultimate source material for much of the technical knowledge and procedures in our textbooks, handbooks and in what we teach. Yet are we stressing the importance of standards as the very core of an increasingly global engineering environment, one in which our students will work? Perhaps more importantly are we providing our graduates with the knowledge of not only standards but the processes of standards development? After all, 'baby boomers' are the predominate generation of standards developers today. But the oldest 'boomers' are now beginning to retire.[3] Is the 'millennial'[4] generation (sometimes called Generation Y) ready to take up the responsibility for standards development best for their companies' business and technical goals?

A study in 2004 by the Center for Global Standards Analysis at Catholic University found that of the 2500 colleges and universities in the United States there are only four courses nationwide, all at graduate level, dedicated to the study of standards and process of standardization. Of those one was in an engineering technology program, two were in business (management) programs and one was in an information technology program.[5]

Standards drive industry by forming the bridge between business and customers. And yet,

> *"Standards generally go unnoticed. They are mostly quiet, unseen forces, such as specifications, regulations and protocols, that ensure that things work properly, interactively, and responsibly. How standards come about is a mystery to most people should they even ponder the question."*
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> *Global Standards: Building Blocks for the Future*
> Office of Technology Assessment, Congressional Report, March 1992

However almost all industry standards, be they domestic, another country's national standards, or international standards, are reaffirmed or revised at least every five years. So unless our textbooks or handbooks are brand new, they rarely reference current industry standards.

**A primer on technical standards**

For brevity, business and societal standards will not be covered. In that context, just what are standards, and more specifically, technical standards typically applied to engineering and allied fields? The American Society of Mechanical Engineers (ASME) the oldest standards developing organization (SDO) in the United States defines the term standard as, "A set of technical definitions and guidelines developed so that items can be manufactured uniformly and provide for safety and interchangeability." The Society further defines a code as, "A standard which has been adopted by governmental bodies, either local, state, or federal, or which is cited in a contractual agreement, and which has the force of law."[6] ASTM International (formerly The American Society for Testing and Materials), the largest SDO in the United States, defines a standard more generally as "A common language that promotes the flow of goods between buyer and seller and protects the general welfare."[7] Other SDOs may use slightly different words, but effectively say much the same thing.

In the United States the standards development system is a highly diverse market-driven operation directed by consensus of stakeholders who are ideally from both private and public sectors. However standards could technically be company-based, deriving consensus among employees. They could be consortia-based standards, deriving consensus among a small group of like-minded organizations, whose goals perhaps are beyond the resources of any one of the members. Standards could be industry-based, deriving consensus from among many companies within an association. Standards could also be government-driven and written by consensus within an agency. However government standards are now less common as more and more private sector standards are adopted by reference as mandatory.

The mandatory nature of this phenomenon came about as a result of the National Technology Transfer and Advancement Act (NTTAA) of 1995 (Public Law 104-113) stating that government agencies must reference public sector standards where practical rather than develop overlapping government standards, and furthermore it mandates that government agencies must actively participate in public sector voluntary consensus standards development. NIST (The National Institute for Standards and Technology) is responsible for assuring government compliance with the NTTAA.

To that end, United States standards to be designated as American National Standards fall under the broad national public policy goals of the *United States Standards Strategy* (USSS).[8] Approved December 2005, the USSS specifically "establishes a framework that can be used by all interested parties to further advance trade issues in the global marketplace, enhance consumer health and safety, meet stakeholder needs and, as appropriate, advance US viewpoints in the regional and international arena."[9] Effectively the USSS unites the nation's SDOs under a common certifying body, The American National Standards Institute (ANSI), a non-profit private federation which also serves as the national voice of the US standardization and conformity assessment system, including programs such as ISO 9000 (quality) and ISO 14000 (environmental) management systems. Internationally ANSI serves as the US representative body to the International Organization for Standardization (ISO), the International Electrotechnical Commission (IEC) and a host of multinational regional organization in Europe, Asia, Oceania and the Americas. This system ensures that consensus-driven stakeholders lead the development of standards, not the US government – commonly referred to as a bottom-up approach. This approach is unique among national standardizing bodies. For example the British Standards Institute (BSI), the Deutsches Institut für Normung (DIN) – The German Institute for Standardization, and most other national standardizing bodies are government funded and government-driven in a top-down approach. In essence the governments determine what is to be standardized.

**The call to action for engineering and technology educators**

With hundreds of United States SDOs needing experts and leadership and only four courses about standardization existing in the entire US higher education system, from where are the thousands of near-future 'experts' to come?

**Observations**

Academics, many of whom joined their faculty straight out of graduate school or immediately following a post-doctoral appointment have little or no knowledge of practitioner standards. Many have never seen a standard or based their instruction on the requirements of standards. Often faculty do not understand the fact that virtually every device they touch or technique they employ is based on standards. As evidenced by the dearth of courses on standardization, many educators do not teach about the infrastructure of standardization. Even if active in a professional society such as IEEE (Institute of Electrical and Electronics Engineers) or ASME or ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers), few members have any knowledge of the codes and standards side of their organization.

It is no wonder that practitioners, having been taught by these academics, often erroneously assume standards are only developed by large corporations or the government. Few understand their discipline's relationship to standards, nor the system of normative referencing across standards. Many view standards as hampering innovation and not very user-friendly.

**Is there hope at the end of the tunnel?**
ABET is beginning to add language about standards to both engineering and engineering technology criteria. However much of the wording is vague and arguably unenforceable. For example:

- In the program criteria for the baccalaureate of applied science programs (2008-09) and (2009-10) it states in curriculum criteria #6 "… graduates must be able to: identify and apply *applicable standards, regulations, and codes*;"[10]
- In the general criteria for engineering programs (2008-09) and (2009-10) it specifies that the curriculum is to include courses in which students can apply engineering standards, stating specifically, "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."[11]
- In the aeronautical engineering technology program criteria under outcomes, "… program must demonstrate that graduates can apply … b. Technical expertise in assembly and support processes, *industry standards,* regulations and documentation, and computer-aided engineering graphics with added technical depth in at least one of these areas.[12]
- In the drafting/design engineering technology (mechanical) criteria under outcomes, "Graduates of baccalaureate degree programs … must demonstrate … Competency in the application of *current codes and standards* … with open-ended design experiences that integrate materials, manufacturing, design analysis, or graphics. Understanding of concepts relating to the environmental and economic impacts of design must also be demonstrated."[13]
- In the instrumentation and control engineering technology program criteria under outcomes, "The program must demonstrate that graduates have the ability to: f. communicate the technical details of control systems using current techniques and *graphical standards."*[14]
- In the program criteria for surveying./geomatics engineering technology criteria under objectives, "An accreditable program in surveying/geomatics engineering technology will prepare graduates with the technical skills necessary to enter careers … and are prepared to design and select appropriate measurement systems, analyze positional accuracy in *conformance with appropriate standards,* …"[15]p

**Recommendations**
On a more direct level the ABET criteria must be clarified in both engineering and engineering technology. With more lucid criteria, standards textbooks and other learning material would follow. Some principles and practice exams require familiarity with standards while others do not. A consistent approach would be helpful. Expanded access to the standards themselves would greatly assist instructors in standards instruction; also for many institutions, standards are too expensive. New and applied instructional material, such as case studies, needs to be developed especially for faculty with little practitioner experience. As our students become practitioners in the global marketplace, we in the United States additionally need access to international standards and the national standards of other countries.

**Resources available now**
Introduction to standards and case studies are available at the following websites (some may require membership for access). Some are free or available at minimal cost. This is by no means

an exhaustive list. Visitors to these and other SDO websites should check thoroughly for case studies and free or inexpensive standards. Sometimes they are not well presented and may be difficult to find. If the organization is also a membership-driven organization as well (IEEE, ASME, ASHRAE, etc.) make sure to locate the codes and standards portion of the site. Often that aspect of an organization is less apparent than the membership side.

(ANSI) http://www.standardslearn.org (included is an application for free standards for classroom use).
(IEEE) http://www.ieee.org/web/education/home/index.html.
(ANSI) The United States Standard Strategy, http://www.us-standards-strategy.org.
(ASME) http://asme.org/Codes/.
(ASTM) http://astm.org.

**Conclusions**

Standards are a critical but often overlooked aspect of an engineering education, many times discovered only after graduation. Regardless, no practitioner can afford to ignore standards, domestically or internationally. It has been said that standards are the bridge between markets and technology and that whomever controls the bridge controls the future. As the late Peter Drucker, business theorist, noted," The best way to predict the future is to have a hand in shaping it." We as engineering and technology educators hold the future (our students) in our hands. We must strive to teach them how to become the experts of our public policy on standards.

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[1] John Quincy Adams. *Report on Weights and Measures by the Secretary of State* made to the US Senate on February 22, 1821.
[2] Donald L. Evans, Secretary of Commerce, from *Standards & Competitiveness: Coordinating for Results* (2004)
[3] *Economy faces bigger bust without Boomers,* Reuters, Jan 31, 2008
[4] Shapira, Ian (2008-07-06). "What Comes Next After Generation X?". *Education (The Washington Post):* pp. C01. http://www.washingtonpost.com/wp-dyn/content/article/2008/07/05/AR2008070501599.html. Retrieved on 19 July 2008.
[5] http://www.standardslearn.org/Standards_in_the_classroom.aspx. Retrieved on 5 February 2009.
[6] *Overview – ASME Codes & Standards, 2008* (unpublished)
[7] *ASTM Standards Process, 2008* (unpublished)
[8] www.us-standards-strategy.org
[9] http://www.ansi.org/standards_activities/nss/usss.aspx?menuid=3
[10] ABET Criteria for accrediting applied science programs (2008-09) and (2009-10), P. 19, Para 1, program criteria for baccalaureate level programs.
[11] ABET Criteria for accrediting engineering programs (2008-09) and (2009-10), p. 5.
[12] ABET Criteria for accrediting engineering technology programs (2008-09), aeronautical engineering technology, p. 11, Outcomes, Section B.

[13] ABET Program criteria for drafting/design engineering technology (mechanical), p. 19, Outcomes:

[14] ABET Program criteria for instrumentation and control systems engineering technology, p. 25, Outcomes:

[15] ABET Program criteria for surveying/geomatics engineering technology, p. 29, Objectives: