



The State of the Use of Standards in Engineering and Technology Education

Dr. Ahmed S. Khan, DeVry University, Addison, IL

Dr. Ahmed S. Khan is a Senior Professor in the College of Engineering and Information Sciences at DeVry University, Addison, Illinois. Dr. Khan has more than thirty years of experience in research, instruction, curricula design, development, evaluation, implementation and program accreditation, management and supervision.

Dr. Khan received an MSEE from Michigan Technological University, an MBA from Keller Graduate School of Management., and his Ph.D. from Colorado State University. His research interests are in the areas of Nanotechnology, Fiber Optic Communications, Faculty Development, Application of Telecommunications Technologies in Distance Education, and Social and Ethical Implications of Technology. He teaches Wireless Engineering, Network Engineering, Fiber Optic Communications, Science Technology and Society (STS), and Project Management. He also advises students on their senior design projects. He is the author of many educational papers and presentations. He has authored/coauthored the following books:

- Nanotechnology: Ethical and Social Implications (2012)
- Technology and Society: Issues for the 21st Century and Beyond 3E, (2008)
- The Telecommunications Fact Book and Illustrated Dictionary 2E (2006)
- Fiber Optic Communication: An Applied Approach, Prentice Hall, N.J.(2002)
- Technology and Society: A Bridge to the 21st Century (2002)
- Technology and Society: Crossroads to the 21st Century (1996)
- Technology and Society: A Spectrum of Issues for the 21st Century (1994)
- The Telecommunications Fact Book and Illustrated Dictionary (1992)

Dr. Khan is a senior member of the Institute of Electrical and Electronics Engineering (IEEE), and a member of American Society of Engineering Education (ASEE), and has been listed in Who's Who among America's Teachers. Dr. Khan also serves as a program evaluator for the Accreditation Board for Engineering and Technology (ABET).

Prof. Aminul Karim, DeVry University, Downers Grove, IL

Amin Karim is a visiting professor at the college of engineering and information science at DeVry University. Prior to this position, he served as the national director of the college of technology and Health Sciences at DeVry. He is a past Chair of the Electronics and Computer Engineering Technology Department Heads Association of the American Society for Engineering Education and served as a TAC of ABET evaluator for engineering technology programs. He is a member of the Standards Education Committee for IEEE.

Ms. Jennifer A McClain, IEEE

Jennifer McClain has been with the IEEE for over fifteen years. She spent eight years with the IEEE Standards Association aiding working groups with the standards development process, editing standards and as the Managing Editor of the Standards Information Network, publishing handbooks and guides to help with the implementation and understanding of standards. She is currently the Program Manager for Standards Education in the IEEE Educational Activities Department. Ms. McClain holds a B.A. from Western Michigan University, Kalamazoo, MI.

The State of the Use of Standards in Engineering and Technology Education

Abstract

During the past several decades, the economy of each nation has been significantly affected by globalization and technology. Government regulations and private sector standards affect a majority of world trade. Countries have been working together to establish international standards in almost every field. As a result, workers in all sectors need to have an understanding of standards. Engineering and technology students must not only possess an understanding of engineering standards and applicable government codes, but also learn to apply them in designing, developing, testing and servicing products, processes and systems. ABET's criteria for engineering and technology education require students to learn and apply standards in their class projects.

This paper is a follow-up of a 2006-2009 NSF initiative awarded to IEEE to help develop tutorials and case study modules for students and encourage standards education at college campuses. It presents the findings of a faculty/institution survey conducted through Electrical Engineering and ETD listservs representing the major engineering and technology disciplines during fall 2012. The intent of the survey was to gauge the status of use of standards and regulations in engineering and technology coursework and to identify benchmark practices. In light of survey findings, recommendations are made to standards development organizations, industry and academia to help enhance the use of standards in engineering and technology curricula.

Introduction

Who are the national and international stakeholders of Standards?

In today's global economy, the importance of the formal study of standards has been highlighted by the new demands of international trade. A number of national and international organizations provide guidance for developing and implementing standards to ensure product safety, such as

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Materials (ASTM)
- Association of Electrical, Electronic and Information Technology, Germany (VDE)
- Canadian Standards Association (CSA)
- European Commission of the European Union (CE)
- Federal Communications Commission (FCC)

- Institute of Electrical and Electronics Engineers (IEEE)
- National Transportation Safety Board (NTSB)
- Underwriters Laboratories (UL)
- US Food and Drug Administration (FDA)

At the national level, the ABET Criteria for Engineering programs also require students to incorporate engineering standards in their design experience¹. The National Standards Strategy for the United States (NSS) demands increasing the endeavors to educate future leadership in engineering, business and public policy, on the role, value and importance of standards.²

At the international level, Prof. Shiro Kurihara has proposed a Three-Wave Model for the spread of international Standardization³. The first wave is driven by scientists, engineers, and technologists; during this phase standards for technologies, products, manufacturing processes, and services are defined. The second wave started approximately two decades ago because of the application of network and digital technologies in communications.

The main stakeholders in this phase are the corporate and business leaders who are interested in the development of standards and procedures for interoperable technologies to facilitate world trade. This phase takes approximately five years and is not suitable for products with shorter lifecycles. The third wave is driven by government and consumers and typically involves standards for services and for product maintenance to improve customer safety and satisfaction. This phase has necessitated the development of global standards and regulations in other areas, such as accounting, law, health, environment and safety. The three waves are interrelated, and input from each phase is fed back to the other phases leading to continuous improvement. In summary, the role of standards is: (i) significantly expanding since the creation of the Internet and the World Trade Organization (WTO), (ii) leading to an increased impact on business and society, and (iii) creating many more stakeholders.⁴

What are the standards skillsets that all graduates must know?

In 2003, a group of industry engineers and educators formed Standards in Education Task Force within IEEE to find the knowledge and skillset in standards that engineers and technologists must acquire before graduation. The process included faculty and student surveys to identify the current state of standards education. The task force made the following recommendation:⁴

1. Engineering and technology graduates should receive a comprehensive introduction on standards. This includes information on how standards are developed, how they impact the development of product, process, or service and how they benefit a country's economy.
2. Graduates should be familiar with key standards organizations in their disciplines and study standards or regulations in the context of an engineering case study.
3. Graduates should be able to identify and apply relevant standards in solving the expectations of an engineering design.

The IEEE task force also coordinated the development of educational materials to help engineering and technology programs incorporate standards education.

What are the fundamental dynamics of standards?

Harding (2011) observes that students need to develop an understanding of the interplay of three fundamental dynamics of standards: Technology, Economics, and Politics. In this regard students need to learn:

- a. How standards play a part in their career;
- b. How to think critically about standards development and technology solutions;
- c. About the pace of standards development in terms of technical change;
- d. How standards help drive innovation;
- e. How standards development process provides good technical solutions;
- f. Why standards are flexible.

What are the needs of undergraduate and graduate students?

Harding (2011) further notes that the state of standards education at the university level is diverse. There are different needs at the undergraduate and graduate levels:

- a. Undergraduate students require a basic level of understanding that standards and standards organizations exist.
- b. Students can use standards at the project level.
- c. Graduate students use standards related to specific fields of interest.
- d. Graduate students can explore the standards development process and the intersection with business interests.

What are practical factors that hinder the inclusion of standards in the curricula?

Some of the practical factors which hinder the inclusion of standards to the curricula are:⁵

- a. Institutions are overwhelmed by the quantity of currently required materials;
- b. Professors believe that they do not know enough about standards to teach the subject effectively or assess student work;
- c. Required materials for teaching standards do not exist.

Harding (2011) observes that in addition to these, there is also a philosophical barrier, i.e., university education focuses on teaching the fundamental concepts and theories of engineering, and many professors believe that standards do not fit well in the foundation courses.

What is the state and status of Standards education in academia?

To gauge the state and status of standards education in academia, a faculty survey was conducted through Electrical Engineering and ETD listservs. The ETD listserv has a membership of more

than 3800 faculty members. The following is a summary of results and recommendations based on faculty input and feedback.

Survey Results

Question 1: Do you teach standards and regulations in your curricula?

Out of 149 respondents, 71% said yes and 29% replied no.

Question 2: Do students in your senior design course incorporate industrial standards and regulations in their senior design projects?

Sixty-six percent of respondents said yes and thirty-four percent answered no.

Question 3: Which organizational resources are available for your students to access standards documents? (check all that apply)

One hundred forty-nine respondents answered and 2 respondents choose not answer this question (see Figure 1).

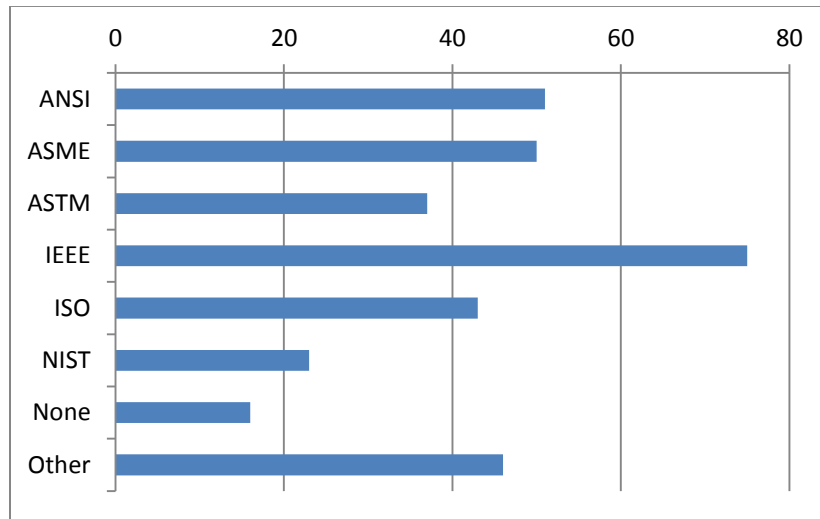


Figure 1. Types of Organizational resources available for students to access standards documents.

Question 4: What are the impediments to teaching and learning about technical standards? (check all that apply)

One hundred forty-two respondents answered this question (see figure 2) and 9 respondents skipped this questions. The responses in terms of their percentages are listed below:

- Lack of text books that provide the fundamentals and examples of application of technical standards (62%)
- Cost of access to technical standards documents (56%)
- Lack of faculty expertise on application of standards (49%)
- Lack of access to technical standards documents (42%)
- The “other” (21%) responses include: limited time, too many standards to teach, lack of faculty time, standards are continuously changing, standards use complex language, and lack of standards knowledge by faculty and administrators.

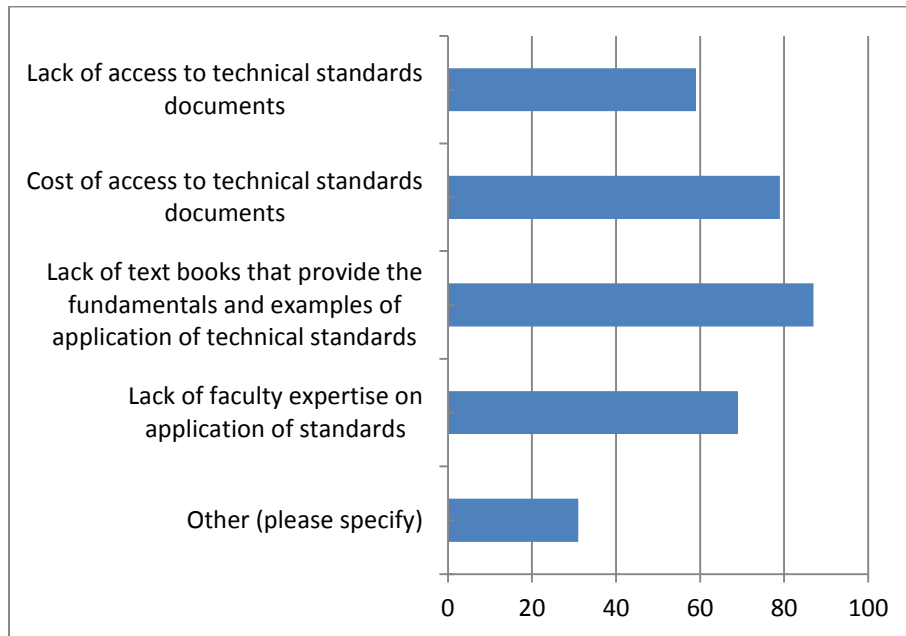


Figure 2: Response distribution of impediments to teaching and learning of standards.

Question 5: How can standard development organizations (SDOs) such as the IEEE, ASME, ASTM, and others help in mitigating the impediments to teaching and learning about standards?

A summary of all responses is presented in Appendix A.

Question 6: Which textbooks or reference books or resources are being used to teach standards in your curricula?

A summary of all responses is presented in Appendix B.

Question 7: Do you have any recommendations/suggestions for improving the teaching of standards and regulations in engineering and technology curricula?

A summary of all responses is presented in Appendix C.

Question 8: What is your department affiliation?

One hundred fifty-one respondents answered this question. Figure 3 shows respondents' departmental affiliation. The other categories contain areas representing Civil engineering, Agricultural engineering, Manufacturing engineering, Construction engineering, Chemical engineering, Industrial engineering, and Aviation.

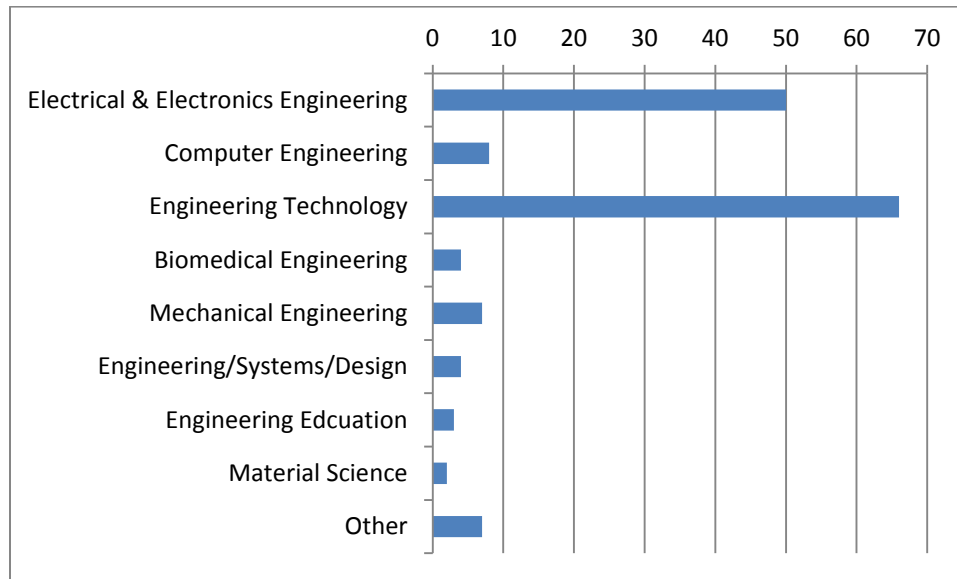


Figure 3 : Departmental affiliation of respondents.

Question 9. What is your email address (optional)?

Sixty-one respondents provided their e-mail address, and 90 respondents choose to skip this question.

What are the Implications for Practice /Recommendation?

Based on the survey results and participants' feedback, the following recommendations are made for enhancing the teaching and learning of standards into the curricula and senior design projects.

1. The standards development organizations can help academia to better incorporate standards education in the curricula by:
 - a. Making standards available online to students and faculty at no cost.
 - b. Conducting standards education training programs for faculty.
 - c. Developing and disseminating standards education materials that can be incorporated into existing courses. Materials may include tutorials, case studies, webinar lectures by industry professionals on the basics of standards, and instruction on how to read and use a standard.
 - d. Developing and disseminating ancillary materials that provide guidance for faculty on incorporating standards education and evaluating output of student in standards education-related activities.
 - e. Sponsoring educational contests and events to encourage hands-on application of standards in student work.

2. Academia and industry should collaborate for:
 - a. Sponsoring authors to write/revise textbooks on standards and/or chapters on standards in textbooks for various engineering disciplines.
 - b. Developing examples of how to use standards in various foundation and senior design courses.
 - c. Conducting workshops and industry seminars on standards education for students and faculty.
 - d. Providing advisers to guide students on their senior projects based on standards.
 - e. Developing standards-based elective courses for undergraduate and graduate programs.
 - f. Providing internship opportunities for students in standards development organizations.

Conclusion

This paper highlighted the state and status of standards education in engineering and technology curricula by discussing the faculty survey conducted through Electrical Engineering and ETD listservs. It also made recommendations for improving the teaching and learning of standards in the engineering and technology programs vis a vis collaboration of academia and industry.

References

- [1] Accreditation Board for Engineering and Technology, Inc (ABET), *Criteria for Accrediting Engineering Programs*, available online, retrieved December 28, 2012. <http://www.abet.org>.
- [2] ANSI National Standards Strategy for the United States, available online, retrieved December 28, 2012, http://www.ansi.org/standards_activities/nss/nss.aspx?menuid=3 .
- [3] Kurihara, Shiro. “*Foundations and Future Prospects for Standards Studies: Multidisciplinary Approach.*” International Journal of IT Standards and Standardization Research, Vol. 6, No. 2, July-August 2008.
- [4] Karim, Amin., and McClain, Jennifer. (2009). Standards Education in Technology Programs, 2009 ASEE Conference proceedings, available online , retrieved December 28, 2012, http://search.asee.org/search/fetch;jsessionid=1w7s93s84xile?url=file%3A%2F%2Flocalhost%2F%3A%2Fsearch%2Fconference%2F19%2FAC%25202009Full370.pdf&index=conference_papers&space=129746797203605791716676178&type=application%2Fpdf&charset=
- [5] Harding, Bruce (2011). *Lessons from Professors: What the IEEE learned from Global University Outreach*, presented at ICES 2011 Workshop, June 27-29 at Hangzhou, China. Available at http://www.ieee.org/education_careers/education/standards/educators_resource_library.html.

Appendix A
Responses to Question 5

Question 5: How can standard development organizations (SDOs) such as the IEEE, ASME, ASTM, and others help in mitigating the impediments to teaching and learning about standards?

The following is a summary of 106 responses; 45 respondents choose not answer this question:

		50 responses per page
1.	Provide a "primer" on standards.	Sun, Dec 2, 2012 1:54 PM
2.	Provide low cost access to standards.	Mon, Nov 12, 2012 8:39 PM
3.	provide info to universities	Thu, Nov 8, 2012 8:27 PM
4.	Less of an issue in the software world	Wed, Nov 7, 2012 8:05 AM
5.	Access - Access - Access	Mon, Nov 5, 2012 11:01 AM
6.	Providing interpretation of standards via examples	Mon, Nov 5, 2012 10:36 AM
7.	Make standards available to students and faculty on no-cost or minimum-cost basis.	Mon, Nov 5, 2012 9:27 AM
8.	Provide them free of charge, or at least at a reduced cost, to educational institutions, similar to what software companies do.	Mon, Nov 5, 2012 8:13 AM
9.	Make it easier for novices (e.g. student teams) to determine the relevant standards.	Mon, Nov 5, 2012 7:57 AM
10.	Make standards available to university libraries at lower cost; allow students to obtain a few standards at little or no cost for class use	Mon, Nov 5, 2012 7:39 AM

11.	Make standards more affordable to educational institutions and available in electronic format	Mon, Nov 5, 2012 7:22 AM
12.	free viewable documents to those in academia	Mon, Nov 5, 2012 6:21 AM
13.	Student access would help them in the long run. Like farmers planting seeds.	Mon, Nov 5, 2012 4:29 AM
14.	Students should know about standards and where to find out about standards. BUT every SDO would want their standards to be the one discussed.	Sun, Nov 4, 2012 9:45 AM
15.	Make standards easy to find with condensed summaries at the top.	Sun, Nov 4, 2012 3:03 AM
16.	By giving faculty members examples of how to use standards in their courses. For example, what standards might apply to a typical machine design course?	Sat, Nov 3, 2012 2:12 PM
17.	a short list of 3-5 sentences of each standard, what it is for, how it is used, etc.	Sat, Nov 3, 2012 1:37 PM
18.	Please provide resources to help faculty teach about standards and regulations (across multiple engineering disciplines).	Sat, Nov 3, 2012 8:28 AM
19.	Offer Seminars/workshops to Faculty	Fri, Nov 2, 2012 12:01 PM
20.	Can provide desk copies to professors.	Thu, Nov 1, 2012 2:56 PM
21.	Make more widely accessible to students	Thu, Nov 1, 2012 3:18 AM
22.	SDOs can suggest books and periodicals that publish or list technical standards.	Wed, Oct 31, 2012 3:18 PM
23.	Offer free student licenses that "time out" like the software companies provide for students (i.e. AutoCAD, Solidworks, etc.).	Wed, Oct 31, 2012

		1:09 PM
24.	Make applicable standards available for FREE when used in the classroom.	Wed, Oct 31, 2012 1:08 PM
25.	Inexpensive electronic access for students (at least for summary material) or access through library subscriptions. If they are already spending hundreds of dollars on textbooks, adding on significant costs for standards or standards references is a problem	Wed, Oct 31, 2012 12:37 PM
26.	Their standards should be put on the website of IEEE or other organizations so that students could have access for their capstone projects.	Wed, Oct 31, 2012 10:42 AM
27.	Using ASTM 42 as a model. Educators are taking part in developing standards for Additive Manufacturing and educational competencies are derived from the standard and integrated into instruction.	Wed, Oct 31, 2012 10:37 AM
28.	Standards on line and free	Wed, Oct 31, 2012 10:18 AM
29.	Develop abridged versions containing only the commonly used standards.	Wed, Oct 31, 2012 10:09 AM
30.	USA Engineering Education ~ Should have "STEM" as a required core course	Wed, Oct 31, 2012 9:40 AM
31.	Add to curriculum	Wed, Oct 31, 2012 9:22 AM
32.	Allow students free access to a limited number of standards	Wed, Oct 31, 2012 8:30 AM
33.	Provide technical standards for educational purposes at a reduced cost to the students	Wed, Oct 31, 2012 8:14 AM
34.	Standards need to be more readily available to students and less costly to acquire. Additionally, examples of the standards in use need to be provided for case study utilization and critique.	Wed, Oct 31, 2012 8:07 AM
35.	Discounts for students taking a college class.	Wed, Oct 31, 2012 7:47 AM

36.	By providing training to faculty and by making the Standards easily accessible to faculty and students.	Wed, Oct 31, 2012 7:46 AM
37.	Drop the requirement in ABET. It's not something that belongs in the undergrad curriculum. This is not a difficult concept and should be learned on the job as needed.	Wed, Oct 31, 2012 7:45 AM
38.	Provide educationally discounted electronic documents for use on a network.	Wed, Oct 31, 2012 7:42 AM
39.	Make standards available for free to students and faculty.	Wed, Oct 31, 2012 7:36 AM
40.	Create an introduction or educational sample (Student Version) of the standards in digital form at low cost or no cost.	Wed, Oct 31, 2012 7:30 AM
41.	Since the problem of teaching standards is undefined, how can we ask for solutions?	Wed, Oct 31, 2012 7:09 AM
42.	Offer technical seminars targeted to faculty members, explaining the role and advantages in using standards as a complementary teaching resource.	Wed, Oct 31, 2012 7:05 AM
43.	Keep doing what they are doing.	Wed, Oct 31, 2012 6:58 AM
44.	Work with publishers to encourage authors to add related standards to the textbook.	Wed, Oct 31, 2012 6:54 AM
45.	Free or low-cost educational copies, preferably electronic (for searchability) Writing in plain language Annotated versions giving examples, elaboration, and/or summaries	Mon, Oct 29, 2012 1:25 PM
46.	Broad/free access.	Mon, Oct 29, 2012 9:36 AM
47.	communicate the location of communicate new information	Sun, Oct 28, 2012 11:56 AM
48.	Cost to educational institutions could be considered	Fri, Oct 26, 2012 8:39

		AM
49.	Standards should be made freely available to all academic institutions.	Fri, Oct 26, 2012 8:34 AM
50.	Find a mechanism to release parts of standards at a reduced price.	Wed, Oct 24, 2012 9:31 AM
51.	Facilitate the access to at least the latest draft of the working document (before it becomes a standard). This way it would be possible to use an "almost standard" document in the classroom, without incurring in any cost.	Wed, Oct 24, 2012 8:14 AM
52.	To lower the price or to do a special price for teaching purposes.	Wed, Oct 24, 2012 7:53 AM
53.	Providing standards or parts of them free to students and faculty	Wed, Oct 24, 2012 7:43 AM
54.	provide limited low-cost access to the standards for students, faculty, or at least textbook authors who want to incorporate standards content in their books	Wed, Oct 24, 2012 4:09 AM
55.	Example lessons on how to incorporate standards into design projects.	Tue, Oct 23, 2012 1:59 PM
56.	Creating a web resource with the summary of these standards instead of the full blown standard	Tue, Oct 23, 2012 1:27 PM
57.	Provide standards to universities free of charge.	Tue, Oct 23, 2012 9:44 AM
58.	provide them free to university professors conducting research and/or teaching courses.	Tue, Oct 23, 2012 2:54 AM
59.	Free access to published standards for use in academic endeavors and lower cost permission fees for authors employing standards in their textbooks.	Mon, Oct 22, 2012 5:50 PM
60.	Provide a digest for standard development and how they can be utilized.	Mon, Oct 22, 2012 4:12 PM

61.	Post the standards online at no cost. Make it readily available	Mon, Oct 22, 2012 3:31 PM
62.	creating simple (student oriented) brochures etc. about the GENERAL idea and the standard. Using IEEE without knowing the basics is like chasing your tail	Mon, Oct 22, 2012 1:10 PM
63.	I note IEEE's availability of standard 802 on-line as a very useful tool	Mon, Oct 22, 2012 1:05 PM
64.	Make standards available to educational institutions at no cost	Mon, Oct 22, 2012 12:36 PM
65.	Teaching standards requires methods to kindle students interest as standards can be somewhat boring to students. A mechanism to collect and share creative ideas and teaching examples would be quite useful in promoting use of standards in the classroom.	Mon, Oct 22, 2012 12:35 PM
66.	MANY more WAYS than currently	Mon, Oct 22, 2012 11:02 AM
67.	Need	Mon, Oct 22, 2012 10:59 AM
68.	Create tutorials and case studies	Mon, Oct 22, 2012 10:50 AM
69.	I don't know about those groups but ASCE and AASHTO are very supportive.	Mon, Oct 22, 2012 10:48 AM
70.	provide discount copies to teaching libraries?	Mon, Oct 22, 2012 10:16 AM
71.	Develop instructional reference books	Mon, Oct 22, 2012 10:12 AM
72.	Academic pricing or free	Mon, Oct 22, 2012 9:39 AM
73.	Perhaps develop an example of how the standards can be integrated into a typical curriculum that teaches Software Engineering or the like...	Mon, Oct 22, 2012

		9:34 AM
74.	provide open access to standards from *.edu addresses	Mon, Oct 22, 2012 9:31 AM
75.	Provide Student Priced standards or cheap site license for on-line standards	Mon, Oct 22, 2012 8:40 AM
76.	they don't care.	Mon, Oct 22, 2012 8:38 AM
77.	code summaries that target a particular industry	Mon, Oct 22, 2012 8:35 AM
78.	Make them more available for students?	Mon, Oct 22, 2012 8:24 AM
79.	Provide easier access for faculty and to provide online self-paced training modules.	Mon, Oct 22, 2012 8:21 AM
80.	Student Versions, Inclusion in textbooks, Compilations of like standards (Ex. concrete, steel, glass)	Mon, Oct 22, 2012 8:21 AM
81.	Make them available free to educational institutions	Mon, Oct 22, 2012 8:11 AM
82.	Most standards are too complicated to teach in a traditional course. the only way for the students to learn the standard is when they have to study the standard as part of a capstone design	Mon, Oct 22, 2012 8:01 AM
83.	SOME ORGANIZATIONS PROVIDE FREE MEMBERSHIP TO FACULTY AND STUDENTS WHICH HELPS SIGNIFICANTLY OBTAINING LAST STANDARDS.	Mon, Oct 22, 2012 7:59 AM
84.	Make sample material available through digital media at low or no cost. This could be an 'educational' version of the standard to help students find material and be made aware of the standards.	Mon, Oct 22, 2012 7:56 AM
85.	Make Stds available to education at a lower cost.	Mon, Oct 22, 2012 7:55 AM
86.	Too many symbols being used in the technical levels where the math can be just as	Mon, Oct

	easily incorporated without a lot of their use.	22, 2012 7:53 AM
87.	better access to cost effective information	Mon, Oct 22, 2012 7:47 AM
88.	Having some special dissemination agreement for educational purposes and increase the public documentation about them	Mon, Oct 22, 2012 7:46 AM
89.	Make Standards available to the students at a greatly reduced cost	Mon, Oct 22, 2012 7:42 AM
90.	teaching CAD is difficult, when students see examples throughout books that are not drawn to ANSI standards; Very difficult for students to understand geometric tolerances when the mating component isn't shown.	Mon, Oct 22, 2012 7:37 AM
91.	Unknown	Mon, Oct 22, 2012 7:31 AM
92.	Provide them at no cost to universities.	Mon, Oct 22, 2012 7:28 AM
93.	Allow academic institutions free access	Mon, Oct 22, 2012 7:27 AM
94.	Access to technical standard for educational purposes should be free as long access is limited to students and faculty.	Mon, Oct 22, 2012 7:26 AM
95.	Better search engine focus on each SDO	Mon, Oct 22, 2012 7:25 AM
96.	Develop a video presentation on standards so that faculty can use.	Mon, Oct 22, 2012 7:24 AM
97.	Let the standards access be free for faculty to use in their course.	Mon, Oct 22, 2012 7:21 AM
98.	Provide wider, but limited, access to students and faculty members.	Mon, Oct 22, 2012 7:21 AM

99.	Make standards available for academic use at a reduced or zero cost.	Mon, Oct 22, 2012 7:18 AM
100.	Provide online-only access for educational use; or provide limited standards free instead of a full suite.	Mon, Oct 22, 2012 7:17 AM
<div style="border: 1px solid black; padding: 2px; display: inline-block;">50 responses per page</div> 3		
101.	SDOs can provide workshops, materials, and other teaching assistance to faculty.	Mon, Oct 22, 2012 7:14 AM
102.	Make material easier to find.	Mon, Oct 22, 2012 7:13 AM
103.	Make them available for no cost to school libraries.	Mon, Oct 22, 2012 7:12 AM
104.	They do pretty good job of this.	Mon, Oct 22, 2012 7:10 AM
105.	free standards	Mon, Oct 22, 2012 7:04 AM
106.	Make standards documents more easily and less expensively available to students.	Mon, Oct 22, 2012 6:53 AM

Appendix B
Responses to Question 6

6. Which textbooks or reference books or resources are being used to teach standards in your curricula?

Ninety-four respondents answered this question and fifty-four respondents choose not to answer this question. The following is a list of responses.

			50 responses per page 
1.	None	Sun, Dec 2, 2012 1:54 PM	
2.	none currently - would value having one.	Tue, Nov 13, 2012 9:09 AM	
3.	ASTM resources.	Mon, Nov 12, 2012 8:39 PM	
4.	Get these standards from a web search	Thu, Nov 8, 2012 8:27 PM	
5.	None but we refer to the SEI CMMI	Wed, Nov 7, 2012 8:05 AM	
6.	None	Mon, Nov 5, 2012 3:41 PM	
7.	none	Mon, Nov 5, 2012 11:01 AM	
8.	NEC 2011, AWS	Mon, Nov 5, 2012 10:36 AM	
9.	n/a	Mon, Nov 5, 2012 8:13 AM	
10.	None; I had a guest speaker come to class through the ASTM outreach program	Mon, Nov 5, 2012 7:39 AM	
11.	Use only self-generated materials	Mon, Nov 5, 2012	

		7:22 AM
12.	websites for standards	Mon, Nov 5, 2012 6:21 AM
13.	Library resources and word of mouth only	Mon, Nov 5, 2012 4:29 AM
14.	Varies with each project, but PVP is covered the most.	Sun, Nov 4, 2012 9:45 AM
15.	Online IEEE and ISO materials.	Sun, Nov 4, 2012 3:03 AM
16.	none	Sat, Nov 3, 2012 1:37 PM
17.	N/A - I would welcome suggestions of good books to use! I do send students to our (somewhat out of date) ASTM manuals in the library - but a textbook/book chapter that discusses standards would be very useful.	Sat, Nov 3, 2012 8:28 AM
18.	None specific. Use different sources but try to focus on those relevant in a course.	Thu, Nov 1, 2012 2:56 PM
19.	IEEE references	Thu, Nov 1, 2012 3:18 AM
20.	IEEE Xplore	Wed, Oct 31, 2012 4:55 PM
21.	Most of the technical standards students research are from sources found in websites such as RF Cafe and others.	Wed, Oct 31, 2012 3:18 PM
22.	Fundamentals of GDT by Krulikowski and Technical Drawing 101 with AutoCAD by Smith and Ramirez are both based on ASME Y14.5-2009 standard and are very helpful. However, the cost of an educational site license of this software is too steep.	Wed, Oct 31, 2012 1:09 PM
23.	We use a national electrical code reference book (it is locked in a colleagues office at the moment). The IEEE standards usually have fairly good educational material in them.	Wed, Oct 31, 2012 12:37 PM

24.		NO	Wed, Oct 31, 2012 10:42 AM
25.		ASTM Publications	Wed, Oct 31, 2012 10:37 AM
26.		Various	Wed, Oct 31, 2012 10:18 AM
27.	Machinery's Handbook; Print Reading for Engineering & Manufacturing Technology by Madsen & Madsen; Technical Drawing with Engineering Graphics by Giesecke et al		Wed, Oct 31, 2012 10:09 AM
28.	MostText-books are obsolete ... !! Each faculty/ Professionals should develop content and curricula to select Text-books and /or resources.		Wed, Oct 31, 2012 9:40 AM
29.	Incorporated in the textbooks on materials and welding - not separate texts		Wed, Oct 31, 2012 8:30 AM
30.	We require the students to purchase the respective technical standards plus a textbook (if applicable).		Wed, Oct 31, 2012 8:14 AM
31.	Several standards are printed in the software engineering books I use.		Wed, Oct 31, 2012 8:07 AM
32.	Fundamentals of Geometric Dimensioning and Tolerancing, 3rd ed.		Wed, Oct 31, 2012 7:47 AM
33.	No textbook I have seen does a good job. We mostly use notes.		Wed, Oct 31, 2012 7:45 AM
34.	ASME documents metrology type text books, and Machinery's Handbook.		Wed, Oct 31, 2012 7:42 AM
35.		IEEE 802 family of standards	Wed, Oct 31, 2012 7:36 AM
36.		NEC, NFPA & IEEE Color Book Series	Wed, Oct 31, 2012

		7:30 AM
37.	None.	Wed, Oct 31, 2012 7:09 AM
38.	IEEE color books	Wed, Oct 31, 2012 7:05 AM
39.	Dr. Maan Jawad's textbooks on pressure vessels and plates and shells.	Wed, Oct 31, 2012 6:58 AM
40.	Handbook for telecommunication	Wed, Oct 31, 2012 6:54 AM
41.	IPC J-STD-001D	Mon, Oct 29, 2012 1:25 PM
42.	ieee publications	Sun, Oct 28, 2012 11:56 AM
43.	Not textbooks but references available on campus	Fri, Oct 26, 2012 8:39 AM
44.	My own personal textbook, which I wrote partially motivated by the fact that the texts I saw don't incorporate design codes and standards.	Fri, Oct 26, 2012 8:34 AM
45.	NEC code book. Others as needed for Senior Projects (capstone experience).	Wed, Oct 24, 2012 9:31 AM
46.	Published Standards. My own texts and teaching resources.	Wed, Oct 24, 2012 7:53 AM
47.	Some standards directly	Wed, Oct 24, 2012 7:43 AM
48.	Machinery's Handbook; ASTM standards (available through library site license); sample MSDS (available online); various other open-access online resources that "interpret" the content of specific standards such as UL-94	Wed, Oct 24, 2012 4:09 AM

49.	Only a few Internet references, at the moment.	Tue, Oct 23, 2012 1:59 PM
50.	None only web resources	Tue, Oct 23, 2012 1:27 PM
51.	Metals Handbook	Tue, Oct 23, 2012 9:44 AM
52.	Standards are integrated within two of my books: Machine Elements in Mechanical Design and Applied Fluid Mechanics, by Robert L. Mott	Mon, Oct 22, 2012 5:50 PM
53.	N/A	Mon, Oct 22, 2012 4:12 PM
54.	Use of Journals	Mon, Oct 22, 2012 3:31 PM
55.	manufactures literature, websites	Mon, Oct 22, 2012 1:10 PM
56.	none	Mon, Oct 22, 2012 1:05 PM
57.	Engineering Materials Properties and Selection, Budinski, 9e Machinist Handbook	Mon, Oct 22, 2012 12:35 PM
58.	IEEE,	Mon, Oct 22, 2012 11:02 AM
59.	N/A	Mon, Oct 22, 2012 10:59 AM
60.	The list is too long to type in.	Mon, Oct 22, 2012 10:48 AM
61.	I had to write my own classroom handouts	Mon, Oct 22, 2012 10:16 AM

62.	The standards themselves	Mon, Oct 22, 2012 10:12 AM
63.	none	Mon, Oct 22, 2012 9:57 AM
64.	n/a	Mon, Oct 22, 2012 9:39 AM
65.	web info	Mon, Oct 22, 2012 9:31 AM
66.	ANSI Drafting Standards	Mon, Oct 22, 2012 9:23 AM
67.	ASME Y14.5	Mon, Oct 22, 2012 8:40 AM
68.	Technical documentations of various companies.	Mon, Oct 22, 2012 8:38 AM
69.	selected pieces of the national electric code.	Mon, Oct 22, 2012 8:35 AM
70.	Not taught currently.	Mon, Oct 22, 2012 8:21 AM
71.	"Basic Construction Materials" by T.W. Marotta, 7th ed. had a wonderful selection of ASTM standards. Obviously someone at ASTM decided Marotta couldn't do this anymore so the 8th edition doesn't have it. Now students go to the library and make copies of the standards they need	Mon, Oct 22, 2012 8:21 AM
72.	We don't teach standards because they are used only to develop specific applications	Mon, Oct 22, 2012 8:01 AM
73.	SAME STANDARD	Mon, Oct 22, 2012 7:59 AM
74.	National Electric Code, IEEE Color Book Series	Mon, Oct 22, 2012

			7:56 AM
75.		Boylestad	Mon, Oct 22, 2012 7:53 AM
76.	i mostly use items from my 18 years as an engineer prior to teaching in academics... real life scenarios are so much more practical, and applicable, than most of the theoretical textbook items.		Mon, Oct 22, 2012 7:47 AM
77.		URL links	Mon, Oct 22, 2012 7:46 AM
78.		ACI Concrete Code AISC Steel Code ASHRAE Standard 189.1-2011	Mon, Oct 22, 2012 7:42 AM
79.		machinery's handbook, ISO9000 standards	Mon, Oct 22, 2012 7:37 AM
80.		None	Mon, Oct 22, 2012 7:31 AM
81.		None.	Mon, Oct 22, 2012 7:28 AM
82.	The instructor for our structures courses is a practicing professional engineer and has access to the IBC.		Mon, Oct 22, 2012 7:26 AM
83.		Library reference books on ASME and ASTM	Mon, Oct 22, 2012 7:25 AM
84.		None	Mon, Oct 22, 2012 7:24 AM
85.		FDA, AAMI, IEEE	Mon, Oct 22, 2012 7:21 AM
86.		none that I am aware of	Mon, Oct 22, 2012 7:21 AM
87.		None	Mon, Oct

			22, 2012 7:18 AM
88.	ASCE 7-10 ASHRAE 90.1		Mon, Oct 22, 2012 7:17 AM
89.	NEC, IEEE 'color' books		Mon, Oct 22, 2012 7:14 AM
90.	None		Mon, Oct 22, 2012 7:13 AM
91.	Perspectives on Engineering		Mon, Oct 22, 2012 7:12 AM
92.	We use the sources on the internet.		Mon, Oct 22, 2012 7:10 AM
93.	n/a		Mon, Oct 22, 2012 7:04 AM
94.	ASME & 14.5 Standards		Mon, Oct 22, 2012 6:53 AM

Appendix C
Responses to Question 7

7. Do you have any recommendations/suggestions for improving the teaching of standards and regulations in engineering and technology curricula?

Eighty-three respondents answered this question and sixty-eight respondents choose not to answer this question. The following is a list of responses.

		50 responses per page
1.	A problem: if standards are introduced as a distinct topic, what do we take out?	Sun, Dec 2, 2012 1:54 PM
2.	if we had someone on the faculty who had actually practiced the application of standards who was willing to lecture on this topic it would be very helpful	Tue, Nov 13, 2012 9:09 AM
3.	Require students to conduct a standards search for applicable standards for their capstone projects.	Mon, Nov 12, 2012 8:39 PM
4.	Just provide abbreviated documentation	Thu, Nov 8, 2012 8:27 PM
5.	Poll your sponsoring companies to see which standards are most important to them	Wed, Nov 7, 2012 8:05 AM
6.	No	Mon, Nov 5, 2012 3:41 PM
7.	Access - Access - Access	Mon, Nov 5, 2012 11:01 AM
8.	Stress presenting real applications using standards and good textbooks	Mon, Nov 5, 2012 10:36 AM

9.	Provide workshops on use of standards in design at local campuses.	Mon, Nov 5, 2012 9:27 AM
10.	Incorporate standards more fully in design textbooks.	Mon, Nov 5, 2012 8:13 AM
11.	Outreach programs (such as the one offered by ASTM) are a good way to get access to guest speakers involved in developing and using standards to	Mon, Nov 5, 2012 7:39 AM
12.	assignments which require students to search for relevant standards for specific applications. These can be short assignments and be much targeted in nature.	Mon, Nov 5, 2012 7:22 AM
13.	text book dedicated to standards with resources and many examples in a CD	Mon, Nov 5, 2012 6:21 AM
14.	Owners develop teaching modules.	Mon, Nov 5, 2012 4:29 AM
15.	Standards are like CAD programs - every company complains they you don't teach such and such in your school. You can't teach them all especially in mechanical engineering.	Sun, Nov 4, 2012 9:45 AM
16.	Make the inclusion of relevant standards mandatory for capstone design courses/projects.	Sun, Nov 4, 2012 3:03 AM
17.	Having examples of components that can be designed to a standard and then built and tested.	Sat, Nov 3, 2012 2:12 PM
18.	I just have to learn more, so that I can help my students more	Sat, Nov 3, 2012 1:37 PM
19.	Do you have any video clips I could show in the classroom about the use of standards? Perhaps some real-world design examples to discuss? Do you have people on staff who I could bring in by Skype to discuss the use and importance of standards?	Sat, Nov 3, 2012 8:28 AM

20.	1. Introducing a course on STDs 2. Using Case studies in a course before capstone project course	Fri, Nov 2, 2012 12:01 PM
21.	Think SI units should be the base and aggressively taught. Specifics can be tailored to courses and discipline.	Thu, Nov 1, 2012 2:56 PM
22.	Make accessibility more prevalent	Thu, Nov 1, 2012 3:18 AM
23.	Teaching more design techniques motivates students to seek technical standards in circuit component selection and circuit construction.	Wed, Oct 31, 2012 3:18 PM
24.	Our program adopted ASME Y14.5-2009 for the creation of mechanical engineering drawings. Teachers in every course are required to use this standard so it has become the departmental standard for teaching dimensioning and tolerancing. We have seen that students whose portfolios reflect an understanding of this standard fair well in job interviews especially among organizations that also employ standards.	Wed, Oct 31, 2012 1:09 PM
25.	Make them more part of the syllabus requirements. ABET should ensure this happens.	Wed, Oct 31, 2012 1:08 PM
26.	The applicability of standards in ECE courses varies by sub discipline within ECE. It is easier in the area I work in (power) than it is others. Some Ethernet standards also see use.	Wed, Oct 31, 2012 12:37 PM
27.	Collaboration with industry	Wed, Oct 31, 2012 10:42 AM
28.	Make it as interactive as possible, Have students go out into their own environment and collect standards that are found in the product information all around them. Structured as a standards scavenger hunt, the standards collected can then be used for exploration and discovery as related to other technical course content.	Wed, Oct 31, 2012 10:37 AM
29.	We need to transform our Engineering/ TECH curriculum ~ to be competitive with India, China and Latin America.	Wed, Oct 31, 2012 9:40 AM
30.	The use of standards and regulations should be incorporated into every program.	Wed, Oct 31, 2012 8:14 AM
31.	There should be more emphasis placed upon this at the accreditation level. Technical societies also need to make the standards more readily available for student / faculty	Wed, Oct 31, 2012

	usage. I'd also like to see more "best practices" presentations at teaching conferences / workshops.	8:07 AM
32.	Provide an incentive by getting students certified in standards.	Wed, Oct 31, 2012 7:47 AM
33.	Yes, include Standards in the curricula and syllabi	Wed, Oct 31, 2012 7:46 AM
34.	no	Wed, Oct 31, 2012 7:45 AM
35.	Helps to have industry input -- such as advisory boards.	Wed, Oct 31, 2012 7:42 AM
36.	More projects based courses because the standards are most important when implementing something that MUST work..	Wed, Oct 31, 2012 7:36 AM
37.	See comments in item 5 above	Wed, Oct 31, 2012 7:30 AM
38.	We need to create the connections between teaching standards and teaching other course material, likely through project-based pedagogy.	Wed, Oct 31, 2012 7:09 AM
39.	Include recommendations related to teaching standards and regulations in program accreditation requirements	Wed, Oct 31, 2012 7:05 AM
40.	Stop making all decisions on the basis of enrollment.	Wed, Oct 31, 2012 6:58 AM
41.	It was answered in question 5.	Wed, Oct 31, 2012 6:54 AM
42.	- Develop learning activities to explicitly improve reading comprehension with non-fiction, especially technical material. Chris Tovani's books are an excellent resource, full of exercises and best practices. - Explicitly teach students to evaluate standards, in order to expose the hidden assumptions they often make about criteria for goodness. Students should be able to judge why the standards choose the tradeoffs that they do, and to assess whether a standard is appropriate for a situation -- or whether it is overkill, or possibly inadequate.	Mon, Oct 29, 2012 1:25 PM

	- Students benefit from developing their own quality assurance and quality control processes, based on standards, and defending their reasoning. This helps them clarify their thinking, identify their assumptions, notice causal relationships, and evaluate potential contradictions in the standards -- and also in the relationships between technical standards, ethical/moral standards, environmental standards, community standards, etc.	
43.	no	Sun, Oct 28, 2012 11:56 AM
44.	None	Fri, Oct 26, 2012 8:39 AM
45.	Hire faculty with industry work experience instead of those with only academic credentials.	Fri, Oct 26, 2012 8:34 AM
46.	To create an open repository with teaching resources that are being used to teach standards.	Wed, Oct 24, 2012 7:53 AM
47.	Perhaps establish a repository and reference process for those resources that interpret standards for users. If faculty can't afford to access the actual standard, they could use help in verifying its general content.	Wed, Oct 24, 2012 4:09 AM
48.	More examples.	Tue, Oct 23, 2012 1:59 PM
49.	yes, the creation of s summary web tool of the standards	Tue, Oct 23, 2012 1:27 PM
50.	Broad-based initiatives to promulgate standards usage among engineering and technology faculty members.	Mon, Oct 22, 2012 5:50 PM
51.	probably as part of general engineering course	Mon, Oct 22, 2012 4:12 PM
52.	Make it readily available online at no cost	Mon, Oct 22, 2012 3:31 PM
53.	the freshman today need more basic background classes. Nobody fixes there car so they don't know what a screw or a screwdriver is but the ALL want to be engineers cause that what people say we need (STEM programs)	Mon, Oct 22, 2012 1:10 PM

54.		See above	Mon, Oct 22, 2012 12:35 PM
55.		None	Mon, Oct 22, 2012 10:59 AM
56.		No, most textbooks refer to them and use them.	Mon, Oct 22, 2012 10:48 AM
57.		Our design projects emphasize creativity rather than compliance with standards. Neither faculty nor students think technical standards are important enough to require in undergraduate studies.	Mon, Oct 22, 2012 10:01 AM
58.		faculty training	Mon, Oct 22, 2012 9:57 AM
59.		we typically have student teams develop inter-group interface standards that all teams must respect, as part of the design process. So even if we are not using actual industry standards, we are following the standard processes for negotiating and agreeing on standards.	Mon, Oct 22, 2012 9:31 AM
60.		First, we should use the standardized notations. Secondly, we need to stress and explain the importance of standards and difficulties of their development and implementation.	Mon, Oct 22, 2012 8:38 AM
61.		It is difficult to train an engineer in a 120-hr curriculum when 60-hrs are taken up with history, government, phis. ed. and other subjects that are taught in high school. I do believe engineering students should have a well-rounded education but not at the expense of the technical subjects in engineering and other sciences.	Mon, Oct 22, 2012 8:35 AM
62.		I hadn't thought about a location, but a good spot would be to include the information in the capstone course. We have just added it to our two-year program.	Mon, Oct 22, 2012 8:21 AM
63.		Incorporate standards presentations into classes, especially labs. Require oral presentations on standards	Mon, Oct 22, 2012 8:21 AM
64.		Make information for standards more accessible and easier to understand	Mon, Oct 22, 2012 8:01 AM
65.		SDO MUST COLLABORATE WITH FACULTY. A GOO EXAMPLE IS AISC,	Mon, Oct

	WHICH HAS A VERY GOOD UNIVERSITY PROGRAM		22, 2012 7:59 AM
66.		See item 5 above	Mon, Oct 22, 2012 7:56 AM
67.		See #5.	Mon, Oct 22, 2012 7:53 AM
68.		--	Mon, Oct 22, 2012 7:46 AM
69.	Try to have authors incorporate Standards and Code into their textbooks and problems		Mon, Oct 22, 2012 7:42 AM
70.	more assemblies so students can see the interrelationship between parts.		Mon, Oct 22, 2012 7:37 AM
71.		None	Mon, Oct 22, 2012 7:31 AM
72.		Include units in the Intro to Fundamentals course.	Mon, Oct 22, 2012 7:28 AM
73.	Capstone courses are a natural place for consideration of standards and should include use of relevant standards.		Mon, Oct 22, 2012 7:26 AM
74.		No	Mon, Oct 22, 2012 7:25 AM
75.		As indicated above a video will be useful	Mon, Oct 22, 2012 7:24 AM
76.	Need to determine which standards are most important to the local employers and either have access to these standards through the Library or through the course.		Mon, Oct 22, 2012 7:21 AM
77.	I think there is a big difference between standards, which are largely voluntary agreements to assist with compatibility, and regulations, where are like code requirements. Giving a better idea about how and why standards are created, and similarly, how and why regulations are created, would be helpful.		Mon, Oct 22, 2012 7:21 AM

78.	Standards need to be made available as open source documents or at zero cost to be able to include them in the curriculum.	Mon, Oct 22, 2012 7:18 AM
79.	Make sure the instructors have used them in their careers to perform actual professional engineering designs so that they know how they get implemented and how good or bad some of them are.	Mon, Oct 22, 2012 7:17 AM
80.	No.	Mon, Oct 22, 2012 7:13 AM
81.	Introduce the concepts of standards, make a project/homework a reference search, and introduce technical specifications which incorporate standards references.	Mon, Oct 22, 2012 7:12 AM
82.	Sell off the technical college to a company who cares	Mon, Oct 22, 2012 7:08 AM
83.	no	