

Integrating Technical Standards into ET Curricula to Meet ABET standards and Industry Needs

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Abstract

With technical standards affecting nearly every aspect of our daily lives, from computers to the components and materials used in car engines, it is critical that undergraduate students are educated on the importance of standards and provided with opportunities to locate and apply relevant technical standards to real world situations. In addition, with ABET accreditation requiring students to have a “basic understanding and familiarity with,” and experience “using” codes and standards, faculty need to consider how such material can be naturally integrated into the curriculum.

At Purdue University, education about codes and standards has been integrated into the mechanical engineering technology (MET) curriculum for decades with significant success. This paper discusses how standards are incorporated into mechanical design and quality control courses, as well as strategies for integrating standards into more courses in an MET curriculum. In addition, a discussion of standards resources that are freely available is included. Finally, a call to action for industry is presented, explaining the need and potential areas where industry can increase involvement in teaching students about technical standards.

Introduction

Despite standards affecting most facets of a company, as well as most products and machines we use on a daily basis, standards are often under-appreciated and thus under-taught at many educational institutions. Even though both ABET, an accrediting body of engineering and engineering technology programs [1], [2], and employers have indicated the need for students to know more about standards before entering the workforce [3], the topic is not always incorporated into curricula [4]. One reason is that many faculty believe that “adding anything to already jam-packed curriculum is dismissed as virtually impossible” [5]. At Purdue University however, faculty have risen to the challenge and developed a curriculum that provides a multitude of projects for which students must utilize technical standards. The following discussion highlights two such experiences, as well as, methods for incorporating standards into the classroom. Additionally, the authors share examples of products that students develop to demonstrate their standards competence, resources that are available to other educators and industry members to teach students or new hires about technical standards, and make a call to industry to support the standards education efforts of local educators to ensure students are adequately prepared prior to entering the workforce.

Relevance for Undergraduate Education

The ABET criteria for accrediting engineering and engineering technology programs reflect the importance of standards competence for students. Specifically, both the ABET Engineering Accreditation Commission (EAC) and Engineering Technology Accreditation Commission (ETAC) accreditation criteria give significant consideration to the topic of standards. 2018-19 EAC criterion 5d states, “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” [1]. Also, the 2018-19 ETAC criteria state student outcomes of “an ability to conduct standard tests and measurements” (3.c) and an “an ability to...identify and use appropriate technical literature” (3.f) [2]. Additionally, the ETAC MET program criteria states “basic familiarity and use of industry codes, specifications, and standards,” (e) and the EET program criteria, the “application of...engineering standards” (a) [2]. Both the EAC and ETAC criteria recently underwent proposed changes where the current language about standards was kept.

Curricular Integration

While there have been both surveys [3] and editorial pieces [6], [7] that indicate industry practitioners expect students to gain a working knowledge about standards, the actual level to which standards are integrated into the curriculum seems to be lacking [4]. In order to bridge the gap and assist both educators and industry professionals in educating students and new employees about how standards are used in their professional careers, faculty from both the mechanical engineering technology (MET) program and Purdue University Libraries partnered to integrate standards into curricula [8]. Additionally, they developed a series of introductory, openly available modules (funded by the National Institute of Standards and Technology (NIST), award # 70NANB16H261) and exercises, known as the “Standards are Everywhere” materials, to educate students how to locate, navigate, and apply standards to practical projects [9], [10]. While geared toward the engineering and technology discipline, the introductory standards materials are appropriate for a variety of courses.

Often standards are either integrated as a standalone topic or not connected to the remaining course content, or faculty fail to highlight the fact that the data charts, graphs, or processes that are utilized in a course many times come directly from a technical standard. This lack of knowledge about standards became abundantly clear when surveying students enrolled in MET 102, Production Design and Specification. [8]. Despite being sophomores and juniors and having completed courses in materials and statics as prerequisites, students report (see Figure 1) having little to no experience with technical standards before taking the course. Therefore, with standards influencing nearly all aspects of a good mechanical design, including the materials, drive system components, array of fasteners, and the fits and tolerances one should apply between mating parts, introducing a project into a mechanical design course that provides both breadth and depth to standards is valuable.

Prior to taking MET 102, how would you describe your knowledge/understanding about technical standards?

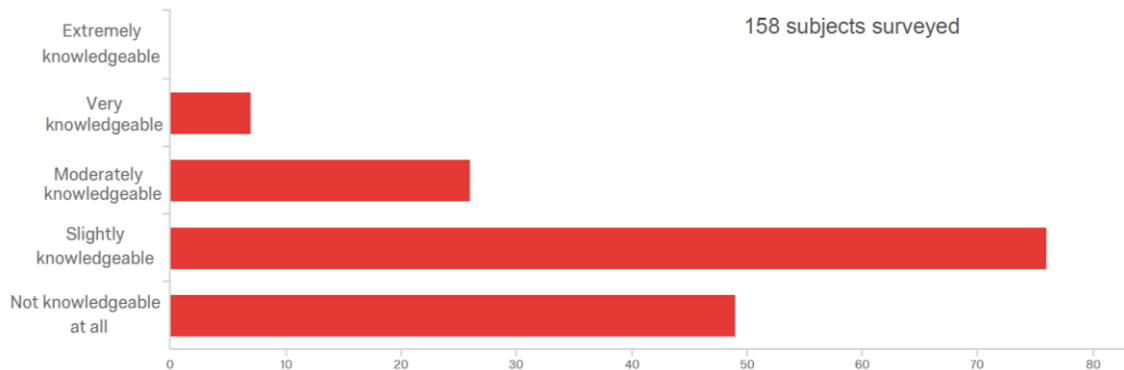


Figure 1. Student understanding of standards before taking MET 102.

Much like other technical topics, approaching the introduction and integration of standards into the curriculum from a scaffolding methodology aids in training students to become comfortable and independent in using the material throughout their educational career. In MET 102, students are introduced to standards throughout the first design project, which involves modeling an arbor press. Students actively utilize standards associated with spur and rack gear design, knurling and dimensioning and tolerance to develop models and drawings that meet engineering specifications. In tandem with the arbor press, students undertake an independent research project known as “standards for common everyday items” in which they conduct independent research to find two standards that drive the design, manufacturing, or testing of three commonplace items. Additionally, they develop a miniature case study explaining the relevance of how the technical content of one of the two standards per item pertains to the aforementioned areas. Upon completion of these projects, students then move on to developing more complex mechanical designs that require the use of multiple drive systems. For each of these projects students are expected to utilize their understanding of technical standards to find and apply any necessary technical specification to the design of each component used in their machines.

With the continued emphasis of how standards apply to various mechanical components, the implementation of the “standards for common everyday items” project, and having a segment for each project where student must utilize technical standards to successfully complete the project, students are able to hone critical skills necessary to being successful in the profession. The design projects build the student’s knowledge and understanding of how to locate and discern relevant technical information from within the standard and apply it to the design problem at hand. They utilize the equations, charts, and graphs to ensure that each project is designed to the proper specification. In addition, students hone their skills on using proper technical terminology, technical writing skills, as well as search and navigation strategies on various standards databases. As shown in Figure 2, upon completing the various exercises in MET 102, the same 158 students surveyed, report having a much greater understanding of technical standards students.

How would you describe your knowledge/understanding of technical standards after completing the standards project?

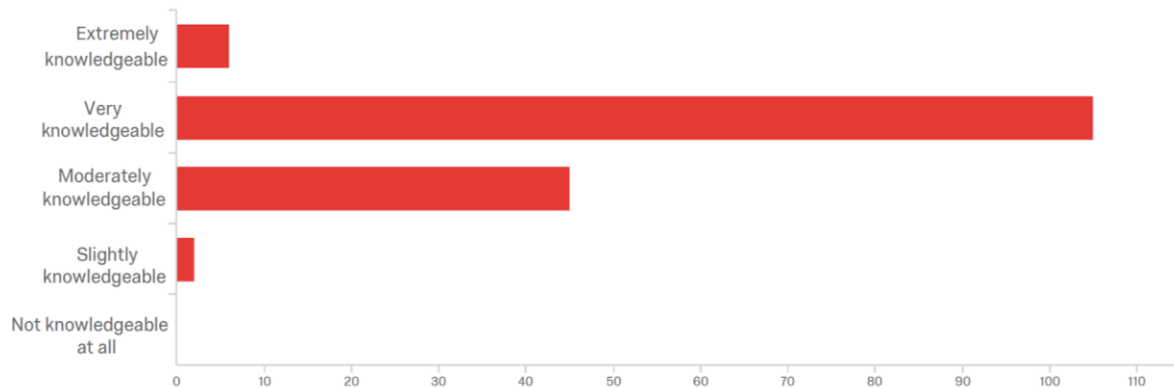


Figure 2. Survey of MET 102 students' knowledge about standards.

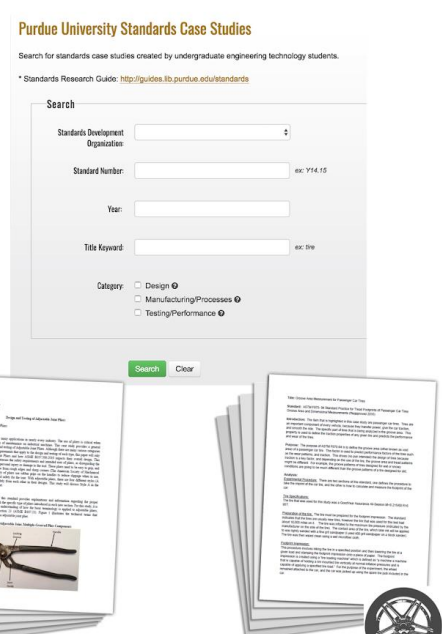
With MET 102 being the only required mechanical design course in the major, it has become important to find additional, upper level, courses where standards can be implemented and their importance in industry be reiterated. Two such courses are MET 451, Quality for Manufacturing and the School of Engineering Technology senior capstone course. Although not a required course, students enrolled in MET 451 utilize an array of technical standards, including ASME Y14.43, *Dimensioning and Tolerancing Principles for Gages and Fixtures*, to support the design and manufacturing of fixtures for a part inspection project. In addition, students utilize ANSI/ASME Y14.5-2009 to help interpret a multitude of dimensions and tolerances on mechanical drawings. Students also learn about Quality Management standards, including ISO 9001 and TS 16949, and the requirements that companies must adhere to in order to receive certification. Finally, students must complete a “Quality in Industry” term paper where they interview an engineer and learn how standards play a critical role in ensuring both manufacturing and quality control procedures within their company. Students enrolled in the senior capstone course must take standards into consideration as they design new jigs, fixtures, or products for industry partners. Students often have to ask the company mentor for a list of standards the product must conform to, or if the fixture must meet or perform any standard test procedure. It is then up to the students to decipher what technical content is relevant to their specific apparatus.

The approach at Purdue University has not been to significantly change any course, but rather utilize existing projects that have historically relied on information from technical standards and encourage faculty to not only highlight the fact that the technical information being used to complete the projects are pulled from technical standards but to show students the actual standard and explain the importance of the standard. In addition, by adding components that reinforce the use of standards throughout course projects, students grow in their information literacy abilities to find standards but also gain a more diverse understanding of how technical standards apply to almost every aspect of their discipline.

Student Products to Demonstrate Competency

Upon completion of the courses previously discussed, students also gain the benefit of having several academic products that can be shared with potential employers to demonstrate their competency with technical standards. From MET 102, students have a technical report outlining the impact of standards on common everyday items, along with several mechanical designs that adhere to a variety of technical standards. Beginning in the fall of 2018, students also now have the opportunity to submit their work to an online educational badge system, developed by Michael Fosmire from Purdue Libraries, where instructors evaluate the work and award a competency badge for high quality work that truly demonstrates the student understands how standards pertain to the design, manufacturing, or testing of an object. As depicted in Figure 3, students have the opportunity to earn two badges, the *Standards Explorer* badge for the work completed in MET 102 and the *Standards Integrator* badge if they develop a more in-depth case study on one item that demonstrates a deeper dive and application of the technical content within a standard. With the award of the *Integrator* badge, the student's work can be added to the open access case study database. These badges, which can distinguish the student from their peers, can then be shared via social media to notify employers that the student has excelled in the area of standards. Even as a new system, approximately 70 students have already submitted their work to earn the *Explorer* badge in fall 2018.

Case Study Database



Badges Platform

To demonstrate your expertise with standards, you can complete either or both of these badges.



Standards Explorer is a Developing level badge, indicating mastery of basic principles of technical standards.



Standards Integrator is a Proficient level badge, indicating the ability to apply information from technical standards to make decisions.

Figure 3. Case study database and competency badges.

Furthermore, students that take MET 451 or the senior design course, graduate with additional knowledge and understanding of applying technical standards to practical, industry driven

projects. Students have a series of presentations and well documented projects that will highlight their use of technical standards to complete the course projects.

Additional Openly Available Resources

In addition to the “Standards are Everywhere” materials developed by faculty members in MET and the Purdue Libraries, there are other openly available resources educators and industry members can use for standards teaching and learning. NIST, through its *Standards Services Curricula Development Cooperative Agreement Program*, has funded projects to support the integration of standards content into undergraduate and graduate courses since 2012. Case studies and materials from this work are regularly published in *Standards Engineering*, the Journal of SES – the Society of Standards Professionals., and are available at this URL: <https://www.ses-standards.org/page/306>. Additionally, Phillips and Huber [11] provide web links and annotations for more openly available standards education resources.

Call for Industry Involvement

While the integration of technical standards into the curriculum by faculty has been successful, faculty are somewhat limited in being able to supply students with a diverse amount of practical examples of standards being implemented into industry. Students have indicated that one way to help make the curriculum more relatable and engaging would be to have practitioners share their experience utilizing standards in their respective industry and explain the benefits of having a solid foundation in the area prior to becoming a professional practitioner. Therefore, as a call to industry: if having graduates that understand what a standard is, how to locate the proper standard, and how to apply the technical content to a real world project, consider the following opportunities to get involved in the process of educating students:

1. If your company has a representative serving on an academic industrial advisory committee, have the representative highlight the need for more integration of technical standards into the curriculum, or at least making students aware.
2. If you collaborate with an educator to provide company tours, ensure that students have the opportunity to witness how your company adheres to technical standards, and thoroughly explain the importance of these standards to the overall operation of your company.
3. With many undergraduate courses being too large for a tour, work with educators to develop a series of videos that can be made available to students that explain the standards your company must adhere to, as well as the manufacturing or testing process that is driven by the standards.
4. Consider having a manager or company representative that serves on a standards development organization offer to serve as a guest speaker that highlights the use of technical standards within your industry, sharing tangible examples of their impact.

5. Consider providing financial support to local academic libraries and educators so that they can purchase individuals standards and subscribe to standards databases (which can be implemented into courses), as well as conduct research pertaining to standards education. In addition, actively work with the educators to identify areas where the integration of standards would naturally make sense.

Final Thoughts

With standards playing a vital role in all industries, it is important to have the education about standards be naturally integrated into curricula. Having students investigate how standards play a role in the design, manufacturing or testing of common everyday items as well as utilizing standards to complete mechanical design projects has proven to aid in their ability to be better prepared for professional careers. While the faculty at Purdue University have developed a series of open source, online resources for educators to actively use, the resources do not take away from the importance for industry involvement. With the aid of professional practitioners, faculty will have even more resources to help with the natural integration of the topic into their curriculum, as well as reinforcement to students as to why it is critical to learn about standards before entering the workforce.

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Biographical information

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As an Assistant Professor of Practice in the School of Engineering Technology at Purdue University, Paul teaches both mechanical design and quality control courses. Having recognized the importance of technical standards in industry, Paul has integrated technical standards into curricula for seven years. He is a co-Principal Investigator on a NIST funded project titled "Standards are Everywhere: An Information Literacy Approach to Standards Education."

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KYLE REITER

Currently, in his second year at Purdue University, Kyle Reiter is pursuing his master's degree in Engineering Technology and is a teaching assistant for MET 102 a design specification course. Kyle received a B.S. in Engineering Physics from the University of Colorado at Boulder. His current thesis research is using graphene as an encapsulation method for lead (II) based inorganic-organic halide solar cells.