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Standards are Everywhere: A Freely Available Introductory Online Educational Program on Standardization for Product Development

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Introduction

The collaboration between the Purdue Libraries and the Purdue Polytechnic Institute on standards education goes back to the 1980s.[1] With a shared goal of preparing students for success after graduation, the Libraries and (then) Department of Mechanical Engineering Technology (MET) devised activities and instruction to show students that they will need to be able to find information 'beyond the textbook' to solve the problems they will face in the workplace. They will need specific information that relates to their particular circumstance, whether it is a material property, production technique, or an industry standard.

In recent years, the Libraries and Polytechnic have incorporated basic information literacy skills—such as the abilities to seek, evaluate, apply, and document information—into a first-year *Introduction to Design Thinking* course, which is required of all majors. This leaves more time later in the curriculum to focus on building skills with specialized resources such as industry standards. Surveys of students[2] identified that they needed to use standards as an important part of their co-op experiences, and that they learned about standards from interactions with their academic librarians. A survey of employers[3] similarly found that they believed engineers need to understand the "fundamentals of standards development and knowledge to find and apply standards prior to employment."

ABET accreditation criteria also highlight the need for students to achieve facility with standards, with the Engineering Technology Accreditation Commission

(Continued from page 1)

(ETAC)[4] requiring the student outcomes of "an ability to conduct standard tests and measurements" (3.c), "an ability to… identify and use appropriate technical literature" (3.f), and the Mechanical Engineering Technology criteria requiring "basic familiarity and use of industry codes, specifications, and standards," (e) and Electrical Engineering Technology, the "application of…engineering standards" (a). The new ABET Engineering Accreditation Criteria (EAC)[5] accreditation student outcomes are more general, but include "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability" (3.c). Many of these considerations are impacted or governed by standards.

The crux of the collaboration between libraries and engineering technology disciplines surrounds the complementary disciplinary expertise of finding and evaluating information (libraries) with that of interpreting and applying that information (engineering technology). As we surveyed the landscape of available online tutorials, we noticed that there was a gap; there is little, if any, material that is not specific to a particular standards developing organization (SDO), institution, or discipline; targeted to undergraduate students; interactive; and includes information literacy components. Since there are many more engineering and engineering technology instructors than engineering librarians, we felt it was likely harder to find expertise in locating, evaluating, and organizing standards, the forte of librarians, in the typical classroom. Thus, we felt a treatment of standards from an information perspective would be most beneficial contribution to the standards education community. As highly modular objects, the tutorial components can be easily dropped into any course as a supplementary resource or targeted to provide context for specific activities.

In order to allow more time in the classroom for active learning, we sought to create online instructional objects that students could interact with before their activities in the classroom. We also wanted to make the resources available to anyone else interested in using them, including 'feeder institutions' to Purdue programs, so that students will be prepared to use standards in their advanced courses on our campus. With the generous support of NIST's Standards Services Curricula Development Cooperative Agreement Program (#70NANB16H261), we were able to create these resources and make them available across campus and to a global audience.

Our NIST-funded project consists of three components: a set of animated online tutorials which students can view as needed or directed by their instructors; a collection of case studies of 'standards in action' commissioned from students to show the importance and utilization of standards from a student viewpoint; and microcredentials (badges) to acknowledge student achievement in standards knowledge and application. All of these materials can be accessed from our project website at http://guides.lib.purdue.edu/NIST_standards.

These materials are aimed at the novice student, perhaps in their first or second year of undergraduate study, when they are just exploring the discipline but have little technical expertise. The tutorials can be used as a stand-alone overview of standards, answering the questions such as what is a standard, how are they developed, how are they used, and what is the structure of a standard (i.e., how do you read a standard?)

Educational Material Development

With over thirty years combined experience teaching standards-related material to students, we believed we had a framework for understanding the core competencies students need to be successful professionally when working with standards. However, to ensure that our ideas aligned with other members of the community, we interviewed five additional faculty, from the disciplines of engineering, engineering technology, and library and information science, to uncover what standards concepts they noticed their students struggled with; what was most important that students needed to know; and what additional topics beyond our initial framework we needed to incorporate into an introductory standards program. These conversations confirmed the core goals of our project while giving us extra ideas to refine our content. We also want to acknowledge two good introductory texts that informed our curriculum development: Thompson's *A Guide to Standards* (SES) and Hunter's *Standards, Conformity Assessment, and Accreditation for Engineers* (CRC Press).

Tutorials

We decided that the core student outcomes could be encapsulated into four tutorials: *Overview of Standards for Product Design*; *Anatomy of a Standard*; *Discovering and Locating Standards*, and *Standards in Everyday Objects* (see Figure 1). The entire tutorial program takes about forty-five minutes to view, approximately the length of one class lecture. Once students have viewed the tutorial, they should be ready to engage in activities or deeper discussions in the classroom about standards.

Each module begins by listing the learning outcomes students are expected to achieve. Engaging, animated content leads the viewer through the main concepts, and embedded quizzes check for understanding.

Case Study Database

In order to make standards relevant to students, we wanted to provide examples of 'standards in action,' told through the voices and seen through the eyes of students. We created a database to house case studies (https://apps.lib.purdue.edu/standards/) illustrating how standards are used, and/or what role they play in everyday settings. Anyone is free to contribute case studies to the database (they are reviewed before being made public), and we commissioned a handful of students to seed the database with case studies. As students in our courses complete assignments in subsequent years, exemplary examples will be invited to contribute their case studies to the database. This will give them a credential acknowledging the quality of their work for future employers, as well as educational/inspirational materials for their peers.

Badges

We kept the badging component of the project simple. We created two badges, demonstrating 'developing' and 'proficient' levels of achievement for students, as encapsulated in their ability to complete an integrative project locating and analyzing standards. The Technical Standards Explorer badge (www.openpassport.org/Badge/techstandardsexplorer/) charges students to "locate and access standards from appropriate sources, describe the role of standards in product design, and classify a standard as either design, performance, or testing (or a combination)." The Technical Standards
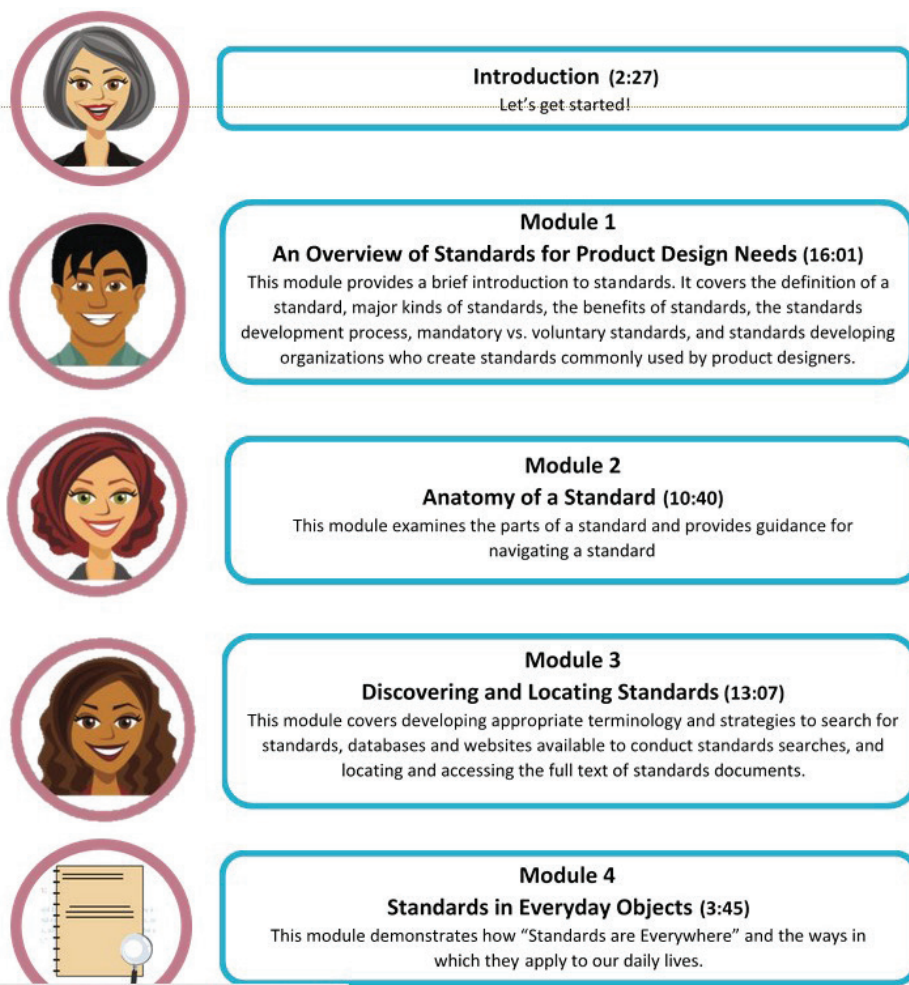

Figure 1: Standards are Everywhere tutorial modules (http://guides.lib.purdue.edu/NIST_standards)

Integrator badge (www.openpassport.org/Badge/techstandardsintegrator/) further challenges students to "extract pertinent information from a standard, apply knowledge from a standard to a practical situation, and compose a formal, structured document using appropriate referencing and citation styles."

In each case, the standards badges, compliant with the Open Badge Initiative (OBI), allow students to display their achievements in their vitae or portfolios, while linking directly to the work they submitted to earn the badge. Thus, a potential employer can independently evaluate a student's abilities, directly from the original work.

Deployment
Workshops

Once we developed the pilot tutorial, we gathered feedback for improvement from engineering and technology instructors and librarians in a variety of venues. We presented a 'flipped classroom' workshop at the 2017 ASEE annual conference[6] and another one at Purdue to a local audience of Polytechnic faculty, wherein participants explored the tutorials online before the workshop. In total, forty-five instructors and librarians from thirty-one institutions have attended our workshops. During the workshop we conducted four activities, one for each module, to reinforce or explore further concepts from that module. For example, we gave participants an 'everyday object' (e.g. smoke detector, keyboard) to analyze to determine what kinds of standards might govern its construction, performance, and/or testing. We then asked them to locate relevant standards and compare among themselves to see which ones were most relevant and why. We also gave them a scenario whose solution could be informed by standards, and had them analyze and

extract relevant information from some sample standards. The workshop, which is also linked from the project website (http://guides.lib.purdue.edu/NIST_standards), thus gave participants experience not just working with the content of the tutorial, but also how to use it as a springboard for further discussion/exploration.

Comments from the workshops were fed back into development of the tutorial to clarify certain points in the content and suggestions for applications of the tutorial to different course environments.

MET 102: Production Design and Specifications

Mechanical Engineering Technology 102 is a required course in the MET undergraduate program at Purdue University taken by around 300 students per year, typically at the sophomore and junior level. One of the learning outcomes of MET 102 is for students to be able to locate and use relevant technical standards to develop mechanical designs. It is this class where the School of Engineering Technology at Purdue ensures compliance with ABET accreditation requirements for MET students.

For the past few years, two of the authors, Prof. Paul McPherson (course instructor) and Prof. Margaret Phillips (engineering librarian), have partnered to integrate an "everyday objects" assignment into MET 102 to introduce students to the topic of technical standards.[7] The assignment requires students to explore how technical standards relate to a set of common objects such as headphones, a toaster, or a light bulb. Students investigate and report on how technical standards impact the design, performance, or testing of their various objects. In subsequent course assignments students are then expected to independently seek out and integrate relevant technical standards into their designs.

The first few times this lesson was deployed, students were introduced to the topic of technical standards through an in-class lecture. With the development of the tutorial module series, the lesson has been changed to a flipped classroom approach. This model requires students to complete the modules and a standards pre-assignment before coming to class and then has them dive deeper during class through a team-based active learning lesson focused on applying the content from the modules. This new approach has been piloted for two terms (fall 2017 and spring 2018). Our observations and a preliminary look at the results of the students' performance on the everyday objects assignment indicate this modified approach leads to improved student learning and higher quality final projects.

Next Steps

There are several activities which we will be conducting in the future to enhance the system:

- We will conduct a usability study with undergraduate engineering and engineering technology students this spring to determine whether the standards modules are easy to navigate, understand, and engaging to our target audience, and how we can improve the modules.
- We will be delivering another workshop, "Industry Standards for Everyone: Demystifying Technical Standards," promoting our standards educational materials at the 2018 Special Libraries Association (SLA) Annual Conference to be held June 9–13, 2018 in Baltimore Maryland.
- We plan to use the results of our usability study, feedback from participants of our three workshops (ASEE, Purdue, and SLA), and insights gained from deploying the materials in MET 102 to improve the content and delivery of our tutorial modules.
- Many participants in our workshops have indicated they plan to use our openly available materials in their own courses. We will conduct a follow-up survey in fall 2018 to investigate how widely and extensively the materials are being utilized.

Authors

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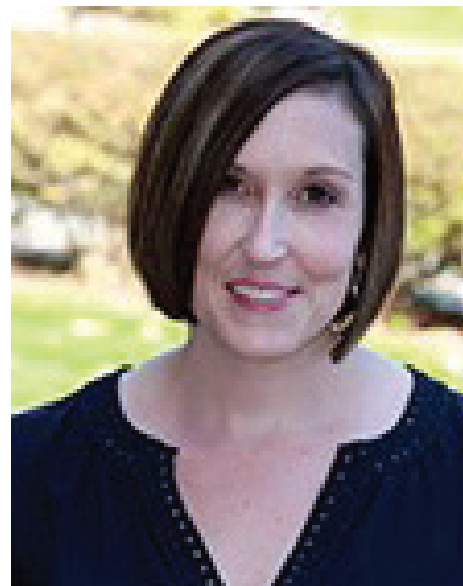
Paul McPherson (pmcphers@purdue.edu, ORCID: 0000-0002-1514-183X) is an Assistant Professor of Practice in the School of Engineering Technology at Purdue University. He is a co-PI of the *Standards are Everywhere* project. He teaches two courses that incorporate standardization student outcomes; the introductory Mechanical Engineering Technology course required of all majors, *Production Design and Specification*, as well as the advanced elective course *CAD in the Enterprise*. As an application engineer at Tri C Company, Professor McPherson gained experience utilizing standards for manufacturing and design purposes. He is a member of ISO/TC 10 *Technical Product Documentation* through the American Society of Mechanical Engineers (ASME) committee Y14, which is the US Technical Advisory Group (TAG) for ISO/TC 10.

Michael Fosmire (fosmire@purdue.edu, ORCID: 0000-0002-5138-8178) is a Professor of Library Science, Head of the Physical Sciences, Engineering, and Technology Division of the Purdue University Libraries, and a co-PI of the *Standards are Everywhere* project. Professor Fosmire has almost twenty years of experience investigating the use of information by students and professional scientists and engineers as well as effective instructional practices. He has developed online tutorials for working with scientific and technical information and a badge-based information literacy program to support first-year engineering technology students. He is the co-editor/author of *Integrating Information into the Engineering Design Process* (Purdue University Press).

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