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Using Everyday Objects to Engage Students in Standards Education

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***Abstract*- This paper describes an innovative approach to standards education in an undergraduate mechanical engineering technology design course. The work is focused on making standards appeal to students by using "everyday objects" (e.g. toaster, ladder, grill, etc.) as catalysts to introduce the topic of standards in a way that connects to students' daily lives. The project involves instructor-librarian collaboration to incorporate information literacy and campus library resources into the standards curricula, so that students not only become familiar with standards resources, but also proficient at searching for and locating the documents. Preliminary results and observations indicate this is an effective approach to introduce the topic of technical standards in design courses.**

Keywords—standards education; information literacy; mechanical engineering technology; product design; library resources

I. INTRODUCTION

Standards are a vital source of information for product design. They provide guidelines for the design, manufacture, testing, and use of whole products, materials, and components. Knowledge of applicable standards is key to designing high quality products that are efficient, economical, and safe. Employers believe it is important for engineering and engineering technology graduates to be familiar with standards, as well as be able to locate and utilize the documents [1]. Despite evidence demonstrating a need for standards information literacy, many engineering and engineering technology programs do not incorporate standards into the curricula [2]. Additionally, there is a sense that many of the academic programs that do incorporate standards, only do so on a surface level. This paper describes an innovative approach to deeply embed standards education into an undergraduate engineering technology course that can be taken and modified to compliment nearly any engineering or engineering technology program.

At the authors' institution standards instruction has been integrated into a Mechanical Engineering Technology (MET) product design and specifications course for over 30 years [3-6]. The instruction has evolved from a treasure hunt activity, where students answered questions by locating information in a variety of resource types, including standards, to an approach that focuses explicitly on standards. In the revised approach students are introduced to other types of resources key for design work (journal articles, reference sources, etc.) in a required course taken earlier in the MET curriculum, TECH 120. This frees up class time for a more in-depth, focused approach to standards education. The new approach makes standards appealing and relevant to students' everyday lives by incorporating objects they commonly use.

II. BACKGROUND

MET 102, Production Design and Specifications, is a required course in the Mechanical Engineering Technology curriculum, generally taken in the second semester of students' sophomore year, or first semester of their junior year. During the academic year it is offered as a sixteen week course, and class size is typically limited to 25 students per section. It is occasionally offered in an accelerated format during summer sessions. Approximately 200 students per year are enrolled in the course. A learning outcome of MET 102 is that students are expected to utilize technical standards to aid in the development of sound mechanical designs.

In order to successfully integrate standards into this course, the faculty member has teamed with librarians who have professional expertise in engineering technical literature, including standards, and information literacy integration into courses. The librarians support the course by assisting with the development of instructional materials to help students search for, locate, and utilize standards. They also hold consultations with students to support their standards research outside of formal class time.

The Purdue Libraries have access to thousands of technical standards. Currently, the Libraries subscribe to the database IHS Standards Expert, which includes full-text access to standards from ASTM, American Association of State Highway and Transportation Officials (AASHTO), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), American Society of Mechanical Engineers (ASME), Association of Home Appliance Manufacturers (AHAM), International Code Council (ICC), International Civil Aviation Organization (ICAO) and National Fire Protection Association (NFPA). Additionally, the Libraries have access to electronic standards through many other databases, including ASCE Library, ASTM Digital Library, IEEE Xplore, and SAE Digital Library. The Libraries

also maintain a print standards collection where documents are discoverable through a publicly available database [7]. Standards that are not owned by the Libraries are purchased upon request for faculty members and students. Full details of the Libraries standards collections are available on a Standards Resources Libguide [8].

III. Literature Review

In 2000, the National Standards Strategy for the United States (NSS) was developed and identified standards education as a high priority [9]. The NSS has been renamed the United States Standards Strategy (USSS) and undergone three revisions, all while continuing to prioritize standards education in academics, industry, and government [10-12]. Additionally, employers want new engineering and technology graduates to be proficient in understanding standards development, and in finding and using standards, before they are hired [1]. A survey by Jeffreys and Lafferty demonstrated standards knowledge is important for engineering co-op students as well, as industry standards were reported as the most common type of literature needed to complete on-the-job tasks [13].

The importance of integrating standards into the curricula is prominent in the ABET Engineering Accreditation Commission (EAC) and Engineering Technology Accreditation Commission (ETAC) criteria for accrediting engineering and engineering technology programs [14-15]. In particular, the criteria for Mechanical Engineering Technology and Electrical/Electronic(s) Engineering Technology programs include the application of standards as part of their student outcomes [15].

Examples of engineering and engineering technology faculty members integrating standards into undergraduate design courses can be found in the literature [16-20], but often do not include incorporating standards in an information literacy context, emphasizing not only standards use, but also the development of student skills to know when standards are appropriate, as well as how to effectively search for and locate relevant documents. Of those that do take an information literacy approach, [3-6, 21-22] only Leachman and Pezeshki's [21] work solely focuses on standards, while the other examples include standards as one type of information resource introduced to students, along with many others (e.g. journal articles, reference sources, etc.) in the same instruction session.

While there is demonstrated integration of standards in some courses, Khan, Karim, and McLain's survey of faculty found that nearly 30% of engineering and technology programs do not teach standards and regulations, and that 34% of students do not incorporate standards into their senior design projects [2]. Additionally, their survey found that 49% of respondents reported "lack of faculty expertise" as an impediment to teaching about standards.

Our "everyday objects" instructional approach responds to calls for developing standards educational materials [2, 9-12] and showing students "how standards play a part in their lives" [23].

IV. Methods

The majority of students in MET 102 have not been formally introduced to technical standards prior to enrolling in the course. For this reason the instructor has implemented a scaffolding approach [24] to gradually build students awareness and knowledge of technical standards, as well as skills in locating and using the documents. With standards impacting the design, manufacturing, and testing of most items we interact with on a daily basis, and industry practitioners utilizing standards regularly, it is crucial that students have both a theoretical and practical understanding of technical standards. Table I provides a brief overview of this scaffolding approach, outlining how the course projects evolve to gradually increase the student's use of technical standards, leading them to become independent in researching and applying technical standards to practical design problems.

Table I. *Course Framework*

Course Layout		
Week	Assignment	Level of Expected Independence
1-2	Design and document a vise assembly	Low – Standards are provided to the students and instruction is given as to how the decipher and apply the pertinent content.
3-4	Standards and Everyday Objects	Moderate- With some instruction students are guided through the process of how to identify areas where standards apply and how to utilize library resources to search and locate standards.
5-15	Mechanical design projects based on open-ended design prompts	High- Students are expected to independently identify where standards apply to their designs and ensure that their designs conform to the necessary standards.

In addition to strategically structuring the projects in the course to build on each other, the instructor has selected Madsen and Madsen's *Engineering Drawing and Design* as the course text book, which highlights specific standards related to each topical area of the course [25]. For example, when covering welds or discussing gear selection and design, the corresponding chapters provide students with notes indicating the standards associated with each topic, such as the standard related to documenting welds, AWS A2.4 *Standard Symbols for Welding, Brazing and Nondestructive Examination*, and the standards associated with gear specifications, AGMA 2000-A88 and ASME Y14.7.1. To supplement these notes, Madsen and Madsen include specific examples for students to follow to assure their documentation adheres to the standards. This book provides a great form of reinforcement of how technical standards play a critical role in the design and documentation process.

A. Low Level Introduction to Standards

The first step in the scaffolding model is to get students thinking about how standards apply to the design of standard parts. Therefore, the first design assignment requires students to design various objects that incorporate a part with ACME thread and taper pins that must be designed to meet specifications found in technical standards for proper assembly. As an introduction to what a technical standard is and how to locate and apply the necessary information within the standard, the instructor provides a copy of both ASME B1.5-1997, that outlines the proper dimensions for the ACME thread profile, and ASME B18.8.2-2000, that specifies the size of the taper pin and the corresponding hole, while showing how to apply this information into a CAD model. When developing mechanical drawings to document their designs, students are provided with the standard ANSI/ASME Y14.5-2009 *Dimensioning and Tolerancing*, which is to be used as a reference guide for proper dimensioning styles and must be utilized throughout the duration of the course for each mechanical design.

The goal of this initial introduction to standards is to help students understand the importance of technical standards and how they often unknowingly interact with products that conform to technical standards on a daily basis. In addition, it serves as a simple example for students to identify areas where standards apply to other common everyday objects. With a rudimentary understanding of standards, the instructor follows this project with a more formal assignment that expands on the impact that technical standards have on the world around us and the structure and role of Standards Development Organizations (SDO's).

B. Standards Instruction and Everyday Objects Assignment

The formal standards assignment starts by requiring students to visit a series of organizational websites including ISO, ASTM, ASME, and ANSI, where they learn about the standards development process. In addition, students are assigned library-produced online tutorials to learn how to navigate the online and print standards databases available through the campus libraries [26-27]. To supplement this material, the instructor holds a discussion based lecture that dives deep into the topic and gets students to identify where they have unknowingly utilized standards in previous courses and during industry experiences (e.g. internships, co-ops, etc.). In this class session the students also meet an engineering librarian and learn more about the library standards collections and support available to assist their standards research.

In the everyday objects assignment, each student is given a list of three commonplace items, such as household appliances, automotive components, and individual components of mechanical systems (e.g. gears, fasteners, etc.), which they must research and locate two standards that directly relate to the design, manufacturing, or testing of each item. A sample list of these items can be found at http://bit.ly/1VEQCjD.

As there are not always standards in existence that pertain to the objects as a whole, students often have to break the item into individual components and find standards that pertain to a subcomponent of the larger device. In order to successfully complete this assignment, students must utilize the diverse resources available through the Purdue Libraries. While there is a vast amount of print standards available, many students turn to the online ASTM and IHS standards databases due to the user friendly interfaces. Once the standards are located, the students are expected to thoroughly review the contents of the standard and develop a two paragraph synopsis about how each standard directly drives the design, manufacturing, or testing of the assigned item, highlighting tables, images, testing methods, or equations that they find interesting and would like to share with classmates. Students must then present their research, showing classmates the object researched, identifying the two standards located, and thoroughly discussing the charts, graphs, equations, or processes presented in the technical document. Ultimately this assignment allows every student to become more knowledgeable about 75 everyday objects.

The goal of implementing this project early in the semester is to get students prepared for future design projects that will require them to research and apply information from technical standards to mechanical designs. As the semester progresses, students undertake a variety of mechanical design projects for which they are expected to identify how standards impact the items incorporated into their designs; from materials selection to the fasteners used for assembly. When presenting on these later designs, it is expected that the students discuss their standards research.

V. Preliminary Results and Observations

The new version of the standards project, researching three common items, has now been implemented into the course for three consecutive terms. Some general observations indicate that students are more engaged with the new version, primarily because they are researching and learning more about items they interact with on a daily basis, rather than hunting for extremely specific bits of information in technical standards and other resources, out of context of their design work. In addition, the authors have found the assignment encourages students to make connections to their prior work with standards in industry. For example, a student who had interned in the testing department of a water heater company discovered the process he had performed in the standard for hot water heaters, but did not realize it was a standard prior to undertaking the everyday objects project. Students also begin to pick up on the notes within the textbook that highlight the standards that are directly associated with the topic at hand and act as a guide for finding additional standards as necessary to complete their mechanical designs. In addition, the instructor has found that students seem to be better prepared for researching standards in future design projects, both within the MET 102 course and in advanced courses in the curriculum.

In an effort determine if these general observations are in line with students' perspectives, the authors conducted a survey. The survey questions and answer options are shown in Table II. While the survey results have not been fully analyzed, the authors have identified the following trends:

1. Students indicate their knowledge and understanding of technical standards have increased after undertaking this project.

2. Students suggest that their ability to identify where standards apply to common, everyday objects has improved.
3. Students who previously held industry positions (internships, co-ops, or industry jobs) may have been exposed to technical standards on the job, but do not feel those experiences gave them a thorough knowledge/understanding of standards.
4. Students' confidence in their ability to locate technical standards has improved.

Table II. ***Student Survey***

Survey Question	Answer Options
1. What is your current classification?	a. Freshman b. Sophomore c. Junior d. Senior
2. What is your current age?	a. 18-20 b. 21-22 c. 23 and older
3. Which of the following applies to you?	a. Started in MET program b. CODO (internal Purdue West Lafayette transfer) c. Transferred from another institution If b or c: -From which program or institution did you transfer?
4. Have you held an internship, co-op, or industry job prior to taking MET 102? Select all that apply.	a. Internship b. Co-op c. Industrial job d. None of the above
5. Based on the definition provided, did your job experience introduce you to, or have you actively apply technical standards?	a. Yes b. No
6. Prior to taking MET 102, how would you describe your knowledge/ understanding about technical standards?	a. Extremely knowledgeable b. Very knowledgeable c. Moderately knowledgeable d. Slightly knowledgeable e. Not knowledgeable at all
7. How would you describe your knowledge/ understanding of technical standards after completing the standards project?	a. Extremely knowledgeable b. Very knowledgeable c. Moderately knowledgeable d. Slightly knowledgeable e. Not knowledgeable
8. Did the standards project improve your ability to identify where standards apply to everyday objects?	a. Yes b. No
9. To what extent did the standards project aid in your ability to identify where/when standards may be applicable?	a. A great deal b. A lot c. A moderate amount d. A little e. None at all
10. Prior to the standards project, how confident were you in your ability to develop appropriate terminology to search for technical standards?	a. Extremely confident b. Very confident c. Moderately confident d. Slightly confident e. Not confident at all
11. How would you rate your confidence in being able to locate technical standards for future design projects?	a. Extremely confident b. Very confident c. Moderately confident d. Slightly confident e. Not confident at all
12. Do you believe it would have been beneficial to have industry professionals present on standards they actively utilize in their industry?	a. Definitely yes b. Probably yes c. Might or might not d. Probably not e. Definitely not

While the project appears to positively impact student learning, the authors have a noted a few areas for improvement. First, students struggle to break their items down into individual components when they are unable to locate a standard about the object as a whole. In addition, it became apparent during student presentations, the majority of students select only ASTM or AHAM standards that focus on the testing aspect of their products, rather than the design or manufacturing aspects. To help mitigate both of these concerns, the authors have plans to develop a tutorial that will break down an item, such as a ladder, into individual components and discuss some of the standards for each component, as well as restructure the project requirements such that students will have to discuss testing for one item, design for one item, and manufacturing for one item.

VI. Conclusions and Future Work

With previous research indicating the need for future practitioners to be knowledgeable about technical standards, the "everyday objects" project has provided a simple yet practical and engaging approach to a topic often considered a dull area of learning. MET students and graduates participate in multiple design projects, both academically and professionally. For this reason, it is key the standards project is implemented early in their educational careers and they are able to independently identify, locate, and apply standards to their work.

As a follow-up to this work, the authors plan to continue improving the project and adding new common items to the extensive list of everyday objects. Also, the authors plan to conduct direct assessment of the "everyday objects" approach by examining students' usage and application of standards in subsequent MET 102 course assignments, and in their MET capstone course, where they undertake a significant, industry driven, open-ended design project.

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