Approaches to Introduce Industrial Standards at Lower Engineering Technology Course Levels

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1. Abstract

During several meetings with the industrial advisory board and other industry representatives, there were repeated requests for more and earlier exposure of engineering technology students to industry standards and codes to make them more familiar with it. Introducing these standards in upper level classes can be more common and align with the type of topics and tasks included in these classes. However, introducing the standard in lower level classes can be very beneficial. First, it provides an early exposure for formats, presentation methods and language used in the codes and standards. Second, it can motivate some students in lower level classes and give them a better point of view of the theoretical basics they are studying in that level. Nevertheless, introducing these codes in lower level classes comes with its own challenges. Some of the obstacles that face instructors and students are a) the lack of understanding of technical terms included in the standards, b) the confusion that comes with repeated references to multiple sources/standards, and c) missing some of the required technical backgrounds (especially in math and science). Different approaches may be adopted to overcome these obstacles including the introduction of simplified versions or limited parts of the standards that fit the student background and terminology and using visual aids or hands-on tools to introduce the concepts and link it to the standards/codes. In this study, the authors will explore different methods that can be used to introduce the industrial standards at the 100/200 level classes. Innovative ideas and methods will be discussed based on classroom experiences and trails.

2. Introduction

Engineering education is facing several challenges in the twenty-first century. These challenges may include lack of diversity, low retention rates, inadequate student background and rapid pace of technological changes [1]. Engineering educators are working to address the challenges facing engineering education. For example, they are developing new curricula and teaching methods that are designed to improve student retention and diversity. They are also working to develop partnerships with industry to ensure that their students are learning the skills they need to be successful in the workforce [2-4]. The rapidly changing industries in our current era are continuously seeking for a flexible and dynamic workforce that can quickly adapt to changes in the markets and technologies [5].

Over the years, there has been a lot of research into the causes of the gap between what engineering students learn in school and what they need to know to be successful in the workplace. Research results showed that some of the top weaknesses in engineering curricula (according to industry perspective) include the lack of understanding of safety, regulatory and

liability. Industries also complain that new graduates lack experience with the design process and hands-on activities because engineering schools focus too much on teaching theory [6-8]. Engineering technology programs have made progress in addressing some of these issues by adding more hands-on courses and activities related to real world industry problems. Moreover, the ABET Accreditation Criterion 5 for Engineering Technology programs states that curricula must include (among other requirements) "design considerations appropriate to the discipline and degree level such as: industry and engineering standards and codes; public safety and health; and local and global impact of engineering solutions on individuals, organizations and society" [9]. Nevertheless, one of the concerns the faculty usually receive from industry partners is related to students lacking the knowledge and exposure to the industry standards and codes. This concern is related to the dilemma of achieving both breadth and depth in 4-year engineering and technology programs [10]. Between accreditation requirements, general education courses and other school/department policies and obligations, there is a very limited number of credits that can be dedicated to classes that focus mainly on specific industry code, standards and common practices.

To approach this problem, educators typically respond by introducing industry standards and practices through projects/case studies in higher-level courses (usually 300/400 levels) and, more commonly, in capstone projects and internships [11]. However, the authors believe that this approach may limit students' exposure to industry standards and practices to only the ones directly related to their projects. Moreover, students may sometimes confuse industry standards and codes with textbook illustrations and theories. Since engineering and technology programs have a limited number of credit hours available for design and applications courses, it is important to introduce industry standards earlier in the curriculum to give students more time to learn about them. However, this presents a number of challenges.

3. Challenges

Some of the challenges of introducing the industry standards in engineering curricula and specially for lower-level courses may include, but are not limited to, the following main points:

- Students' limited understanding of the technical terms used in engineering standards can hinder their ability to learn and apply these standards effectively. Additionally, students may not fully understand the difference between standards and guidelines or the difference between requirements and design recommendations. For example, if students do not understand the meaning of the term "yield strength," they will have difficulty understanding and following standards that specify minimum yield strength requirements. Another example can be students who are not familiar with electrical circuits terminology, such as "insulation requirements," and "safety testing" will find it difficult for them to understand and apply the electrical standard.

- Students can get confused by the complex and interconnected web of standards and codes, which often reference each other in a repeated and branched manner. This can be especially challenging for students in the freshman and sophomore years, as they may not yet have an understanding of the relationships between different standards or subjects. For example, a standard for designing electrical circuits may reference standards for wire

sizing, insulation requirements, and safety testing. Or, a standard for designing bridges may reference standards for concrete mix design, steel fabrication, and load testing. These referenced standards may in turn reference other standards, and so on. This can create a complex network of standards that can be difficult to navigate, even for experienced engineers.

- Students often lack the necessary foundation in mathematics and science to fully understand and apply the methods and techniques used in industry standards and codes. This can be a significant barrier to learning and mastery, as many standards and codes rely on complex mathematical and scientific concepts. For example, a student who is not familiar with statics and structural analysis concepts may have difficulty understanding and applying standards that specify minimum design loads for structures. Or, a student who does not have a strong foundation in chemistry may have difficulty understanding and following standards that specify material requirements for corrosion resistance.

4. Approaches and Methods

In this paper, the authors are proposing a variety of approaches to address the challenges of teaching engineering standards to students. These ideas were generated based on discussions with educators, industry partners and alumni. Few of these approached were partially applied in engineering technology classes at Southeastern Louisiana University. Some of these approaches are planned to be introduced for future classes and programs. The approaches suggested here can be implemented over a sequence of courses or within a single course. These methods should also be adjusted to fit the students' level of knowledge and the specific focus of the program or major.

4.1. Simple Guidelines

In this approach, the concepts of standards and codes may be introduced as early as the first semester or in a program introductory course. The idea is to introduce a simple set of rules/guidelines that the students can follow during working on a simple project or task. The project can be any simple project related to the major such as building a bridge from popsicle sticks, a night light electrical circuit or a simple pulley system. These guidelines should be tailored to the specific project or task, but they should generally be clear, concise, and easy to follow. The primary objective is to draft the rules and guidelines for these projects and tasks in a technical and standardized language and format that is as similar as possible to the language used in engineering standards and codes. This will allow the students to have very early exposure to the legal languages and style they will encounter in engineering practice. It will also create a sense of professionalism and credibility. Moreover, to help students become familiar with complex reference systems, instructors can link the guidelines and rules for multiple projects or multi-phase projects.

4.2. Freshman Design Courses

Freshman design courses or cornerstone courses were common in engineering schools during the 1970s and 1980s. By the 1990s, the engineering curriculum had gradually squeezed out the teaching of engineering standards and codes to make room for new techniques and tools like

computer programming and CAD software [12]. More recent studies indicate that these freshman design courses may have a positive impact on many academic aspects such as student intellectual development and student retention rates [13]. The authors believe that these courses, if adopted, can be a perfect vehicle to early introduction of industry standards and codes. Students can focus on one or two industry standards for their project. These standards should be carefully selected by instructors and advisors to minimize confusion and to ensure that they are relevant and applicable to the student's project. Focusing on a small number of standards allows students to develop a deeper understanding of each standard and how to apply it to their project. Additionally, instructors/advisors should explain the standards clearly to students and provide them with resources to help them understand and apply the standards.

4.3. Standard-Based Projects

One way to improve the teaching of engineering standards in 200-level classes is to incorporate class projects that are designed around specific standards. This would allow students to gain hands-on experience with applying standards to real-world problems. It would be also beneficial to select these standards to be relevant to the course materials and/or the engineering discipline. The selected project should be challenging but achievable for the students in that level. Thus, the standard used should be limited to one or two at most to minimize confusion and the instructor may point out specific sections of the standards to use for certain tasks. It should also be presented with clear instructions and expectations along with access to the resources needed to complete the project like copies of the relevant standards, online tutorials and sample calculations. Completing these projects either individually or in groups can also be integrated with a larger strategy of experiential learning. Examples of these projects and standards can be

- Evaluating mechanical properties of a material using standard tensile test procedure (ASTM E8). This project can be a perfect application for an introduction materials course, mechanics of materials lab or introductory course of engineering measurements.

- Non-destructive testing of materials or welding using the industry standards (ASTM E18, ASTM E92 ,and ASTM E164). This also can be used in multiple materials, manufacturing and quality control courses.

- Building solar powered charging stations for electronic devices. This project may include multiple electrical and communication industry standards and protocols. It can be part of an introductory electrical circuits or energy courses.

4.4. Industry Connections

One of the most effective ways to introduce engineering standards to students is to do so through partnerships with industry. This can be done in a variety of ways, such as

- Inviting guest speakers from industry to the classroom. Guest speakers can share their experiences using engineering standards in the workplace and can answer students' questions about the importance of standards.

- Organizing field trips to industrial facilities. Field trips allow students to see how engineering standards are applied in real-world settings.

- Establishing mentorship programs between students and industry professionals. Mentors can provide students with guidance on how to meet the expectations of the engineering profession and can help students to develop the skills and knowledge they need to be successful.

- Working with industry partners to develop curriculum and projects. Industry partners can provide input on the skills and knowledge that students need to be successful in the workplace. They can also help to develop projects that allow students to apply engineering standards to real-world problems.

By carefully selecting the suitable industries and predesigning the type of student interaction with them, this can be done in lower level classes. Moreover, this can help the students to realize the relevance of engineering standards to the real world and learn about the latest trends and developments.

5. Summary and Conclusions

The authors believe that it is essential to introduce industry standards into the curricula of engineering and engineering technology programs, given the highly competitive and ever-changing STEM job market and requirements. This should be done as early as possible in the academic program to allow students to have sufficient exposure to these standards by the time they graduate. This early introduction comes with multiple challenges. The challenges can be summarized in the lack of adequate knowledge of the terminology and language used in the standards, the confusion that comes with the complex reference system used in many of the standards and codes and finally the insufficient technical background to understand and apply some of the methods and techniques used in the standards.

Several approaches were suggested to overcome the technical and educational difficulties to introduce industry standards as early as the first semesters. These approaches include using a languages and formats similar to industry standards in some low-level classes assignments/ projects, reintroducing the freshman design class were industry standards can be incorporated, utilizing carefully selected standard-based projects in low to mid-level technical classes, and increase the interaction between student in the low level classes with the industries relevant to the field of study. However, additional research is needed with a designed measurable parameter to examine each of the suggested approach. Studies are needed to investigate the effectiveness of these approaches, their potentials and practical implementation problems.

The authors' opinions align with some of the previous research studies [2], [4], [12], [13] , which have shown that implementing some of the suggested approaches has a positive impact on several aspects of students' academic performance. These positive impacts may include

- *Increased hands-on experience*: Students who participate in hands-on activities are more likely to learn and retain information. Hands-on activities also help students to develop the skills that they will need to be successful in their careers.

- *Enhanced familiarity with technical terminology and methods*: Early exposure to technical terminology and methods can help students to develop a strong foundation in their field of study. This can make it easier for them to learn new concepts and to apply their knowledge to real-world problems.

- *Improved motivation*: Students who are engaged in hands-on activities are more likely to be motivated to learn. This is because they are able to see the relevance of what they are learning to their future careers.

- *Improved retention rates*: Students who participate in hands-on activities and have better understanding of the career are more likely to complete their degree even if they are having initial difficulties with theoretical concepts in the early general education classes.

- *Increased student satisfaction*: Students who participate in hands-on activities are more likely to be satisfied with their educational experience. This is because they are able to learn in a way that is meaningful and engaging to them.

- *Improved job market readiness:* Students who have hands-on experience are more likely to be competitive in the job market. This is because they have the skills and knowledge that employers are looking for.

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