Librarian Perspectives on Technical Standards at Academic Institutions with Engineering Technology Programs

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Abstract

Technical standards are resources that are important for engineering and engineering technology students due to ABET accreditation requirements and future professional use of the documents. Previous studies have surveyed librarians at Association of Research Libraries (ARL) institutions with engineering programs and librarians at universities with top-ranked engineering programs about standards. This study fills a gap by focusing on librarians at institutions with engineering technology programs. We surveyed 34 academic librarians at institutions with four-year bachelor programs in the disciplines of mechanical engineering technology or electrical and electronics engineering technology to learn about standards access and challenges at their libraries, standards education for students, and librarians' standards-related professional

development experiences and needs. Key findings include: standards access and standards education efforts are skewed towards larger institutions; librarians encounter significant cost challenges in providing standards access; few librarians receive education about standards until moving into their careers; and there is a need for self-paced librarian training materials focused on standards. Further education for librarians about standards and increased standards access has the potential to have a significant impact on many students, given the reach of librarians in their liaison roles.

Introduction

Engineering information literacy is a much-discussed topic in the literature, especially as it covers many information sources in which engineering students should be knowledgeable (Fosmire & Radcliffe, 2013; Phillips et al., 2018). Peer-reviewed articles are often well-covered when librarians conduct information literacy education. However, engineers and technologists work with many different information sources in addition to peer-reviewed articles, including technical reports, patents, government regulations, and standards. This paper focuses on technical standards, documents that describe expert consensus on how to do or achieve something. "Something" may refer to many things, such as how a product is designed or tested, the steps to implement a particular process, or the terminology used to discuss a topic. An example of a standard is *ISO 8601-1:2019: Date and time − Representations for information interchange − Part 1: Basic rules*, which specifies an internationally accepted method to represent calendar time across time zones and cultural differences (International Organization for Standardization [ISO], 2019). The importance of standards has been a topic in the engineering library literature for decades (Phillips, 2019), dating back to when Budington (1951) discussed incorporating standards into a library course for undergraduate engineering students.

Engineering and engineering technology (ET) programs have many similarities, including their primary accrediting body in the United States, ABET (ABET, 2021a). However, engineering and ET programs differ in their curricular focus and somewhat in their career paths, as engineering curricula require a higher level of math and science courses than ET curricula, and engineering graduates often pursue jobs focused on conceptual design or research and development (ABET, 2021b). ET programs are referred to as "applied" or "hands-on" (Buchanan, 2019), as students tend to take more lab-based, experiential courses (Barbieri & Fitzgibbon, 2008). Regarding accreditation, ABET accredits engineering programs at the four-year bachelor and master levels but accredits ET programs at the two-year associate and four-year bachelor levels (ABET, 2021b). Engineering bachelor programs are more numerous than ET bachelor programs, with 557 institutions in the United States offering at least one ABET accredited

engineering bachelor program, as opposed to 195 institutions in the United States offering at least one ABET accredited ET bachelor program (as of July 20, 2023) ([ABET, n.d.](#)). However, it should be noted that 638 institutions in the US offer at least one ABET accredited engineering or ET bachelor program (as of July 20, 2023) ([ABET, n.d.](#)), indicating there is an overlap between institutions that offer engineering and ET bachelor programs. This also suggests that some, but not all, of the academic libraries that support ET programs also support engineering bachelor programs.

It has been discussed in the literature that standards are atypical resources that present many access and discovery challenges for libraries ([Phillips, 2019](#), [2022](#)). Previous librarian surveys about standards in academic libraries have focused on institutions that are members of the Association of Research Libraries (ARL) ([Pellack, 2005](#); [Wetzel & Grove, 2021](#)) or institutions with top-ranked engineering programs ([Mathews, 2006](#)). Being primarily focused on engineering, it is unclear how extensively these investigations included responses from institutions with engineering technology programs. With funding from the American Society for Engineering Education (ASEE) Engineering Technology Division (ETD), this study focuses on academic libraries at institutions with bachelor's programs in mechanical engineering technology (MET) or electrical and electronic engineering technology (EEET) and seeks to answer the following research questions:

> RQ1: What access to standards do academic libraries at institutions with bachelor's programs in MET or EEET provide to their users? What challenges do these libraries have in providing standards access?
>
> RQ2: How do libraries at institutions with bachelor's programs in MET or EEET support standards education for students?
>
> RQ3: How do academic librarians who work at institutions with bachelor's programs in MET or EEET become educated about standards?
>
> RQ4: What are the professional development needs related to standards of academic librarians who work at institutions with bachelor's programs in MET or EEET?

This study focused on librarian perceptions is part of a larger investigation into technical standards at institutions with bachelor's programs in MET or EEET. Two of the authors of this study, Phillips and McPherson, recently published the results of a survey about ET faculty standards curricular integration practices and an environmental scan of library websites at institutions with bachelor's programs in MET or EEET ([Phillips et al., 2023](#)) that are part of this larger investigation.

Literature Review

The literature review explores the following areas: accreditation and standards education, standards information literacy in engineering programs, and standards information literacy in engineering technology programs. As this is still a growing area of interest in the literature, we chose to look at standards education in both engineering programs and ET programs for a broader perspective.

Accreditation and Standards Education

ABET's Engineering Accreditation Commission (EAC) *Criterion 5: Curriculum* states, "the curriculum must include… d) a culminating major engineering design experience that 1) incorporates appropriate engineering standards…" (ABET, 2022a). This focus on standards supports librarians' and engineering educators' emphasis on standards literacy in engineering programs. Likewise, ABET's Engineering Technology Accreditation Commission (ETAC), *Criterion 5: Curriculum (under Discipline Specific Content)* says the curriculum needs to "include design considerations appropriate to the discipline and degree level such as: industry and engineering standards and codes…" (ABET, 2022b). These criteria, since their first appearances in the accreditation documents, have been cited often in the literature related to standards information literacy. How standards information literacy is conducted by librarians at institutions with engineering programs and engineering technology programs is discussed in more detail in subsequent subsections.

Standards Information Literacy in Engineering Programs

In support of the ABET requirements, the literature includes many case studies where librarians are a critical component of standards literacy education. For example, Rowley, et al. (2020) worked with undergraduate engineering students to introduce an alternative information literacy component to a required technical communication course. In this instance, standards were used for the information literacy unit rather than peer-reviewed articles as previously taught. The paper points out that working in collaboration with the librarian to introduce standards as an information source and having the librarian attend multiple class sessions made for a stronger information literacy unit in the eyes of the instructors and the students.

Leachman and Leachman (2015) incorporated standards into a senior-level mechanical engineering design course. The engineering librarian included standards, as one form of grey literature, into the instruction. In-class discussions and worksheets aided in emphasizing the importance of these information sources and citing them. Following the lecture, the researchers found that the average citation count in student reports increased. However, this increase was found to be for other grey literature information sources, such as company user manuals, government documents, and technical reports, and not for standards. This discrepancy could not be properly determined due to the small sample size but could have been related to faculty communication of expectations to students. Despite the results, the researchers reiterated the need for additional research related to grey literature in engineering education and the need to develop effective educational methods to increase standards use.

Khan and Karim (2016) surveyed engineers and engineering educators regarding standards in engineering and technology education. They recommended that standards organizations support engineering education by making more standards available online to students and faculty at no cost. This is an important point, as many academic libraries struggle with the cost of obtaining standards, especially electronically. Khan and Karim also recommend that academia and industry should collaborate to create textbooks or develop case studies using standards. Leachman et al. (2023) published a

book about standards and included a section of fourteen case studies using standards in the classroom of a variety of engineering and other disciplines at the undergraduate and graduate levels. The book is openly accessible online, which can be useful to libraries or instructors with limited budgets.

Workshops are another way to introduce a topic and information source to students and the greater campus community. Gbur and Solomon (2016) invited guest speakers from national and international standards bodies to speak with attendees on standards and the role these documents play in research. As opposed to an in-class lecture, any student or faculty member from anywhere on campus was able to attend to learn about standards. Attendees included those affiliated with the School of Engineering, School of Arts and Sciences, School of Business, and the library. Regardless of affiliation, attendees said that the topic of standards was of great interest to them. This study reveals that engineering students and faculty want to learn more about standards, but standards are of interest to others as well. It also demonstrates that a workshop model is appealing to those interested in standards, and that instruction does not always need to take place in a classroom setting.

A 2019 scoping review (Mercer et al., 2019) set out to examine how engineering students' access, use, and understand information, as well as identify gaps in the literature. The purpose was to better understand how to support information literacy instruction in engineering disciplines. While the review looked at many information sources used by engineering students, the authors found that there was not a significant number of studies exploring how standards and other grey literature influence information-seeking behavior.

Standards Information Literacy in Engineering Technology Programs

While the initial body of research focused on standards literacy in engineering programs, standards literacy in engineering technology programs appears to be an area of growing interest. Engineering technology programs fall under the jurisdiction of ABET and have their own criteria for accreditation. Harding and McPherson (2009) discuss how ABET began the process of developing requirements for standards education by amending accreditation criteria. These since-revised criteria have continually been cited in subsequent papers examining the importance of standards and standards education. Researchers (Cioc et al., 2021, 2022; Phillips & McPherson, 2016) also examined standards used in engineering technology, specifically standards literacy in mechanical engineering technology curricula. The goals of the Cioc et al. (2021) in-class project were to align with the new ABET Criterion 3 and Criterion 5. Students reported that the project-based learning assignment improved their knowledge of the technical topic as well as their information seeking skills, including searching for and using technical standards.

Huderson, et al. (2019) examined the need for "standards infusion" into both mechanical engineering (ME) and mechanical engineering technology (MET) programs. The paper details the process for the creation and dissemination of instructional modules and guides to be used in ME and MET degree programs. The researchers, all from the American Society of Mechanical Engineers (ASME), collaborated with faculty

from ME and MET programs across the country to develop standards education modules at all levels of undergraduate engineering education. This paper focused on the initial development of the instructional modules and did not contain data on how students received the modules. The number of institutions that agreed to participate in the development and pilot (nineteen institutions) indicates that faculty understand the need to incorporate standards into ME and MET curriculum.

McPherson, et al. (2019) shared how standards are integrated into the ET curricula to meet ABET requirements and industry needs. One example of how faculty incorporate standards into MET curriculum is the "Standards are Everywhere" materials developed by the Purdue University Libraries (Phillips, et al., 2017). While the McPherson et al. paper identifies other openly available resources related to standards literacy, the authors also put a call out to the standards industry for additional support. By calling for industry to assist in standards education for undergraduate students, the authors recognize another stakeholder group that understands the need of standards literacy.

More broadly speaking, Fosmire (2020) conducted a study of engineering librarians and mechanical engineering technology departments to understand the assessment of information literacy competencies. The study also investigated the role librarians play in information literacy. As Fosmire admits, engineering technology programs are often overlooked when it comes to examining student outcomes related to information literacy, but librarians are an unused asset when it comes to students' information literacy skills.

Ultimately, there is a need for more research on the impact of standards literacy on engineering technology programs. The goal of this study, therefore, is to add to the existing literature by gathering data about standards access within libraries supporting MET or EEET bachelor's programs and the standards educational experiences of their librarians. This study also explores librarians' self-reported needs for additional standards education, which can lead to future projects and research, as will be detailed in the Discussion section.

Methods

The study was reviewed and approved as exempt by Purdue University's Institutional Review Board (No. 2021-1802).

Data Collection

As a first step, one of the authors (Phillips) interviewed three academic librarians, using a convenience sampling approach to target individuals who were liaisons to either a mechanical engineering technology (MET) or electrical and electronics engineering technology (EEET) bachelor program. The interviews were approximately 30-45 minutes in length and were conducted over Zoom, recorded, and transcribed using Scribie.com. The twelve interview questions were largely open-ended with a few rating scale questions focused on standards access, challenges to providing access, standards outreach, and standards education for library users. Next, two of the authors, McPherson and Phillips, read the transcripts over multiple times to gain a thorough

understanding of the responses to help guide the development of a twelve-question survey in Qualtrics. Both the interview and survey questions were informed by instruments used in prior investigations of standards in academic libraries (Mathews, 2006; Wetzel & Grove, 2021). The survey instrument is available in Appendix A. Since the vocabulary surrounding standards can often be confusing, with the word "standards" itself is used in a variety of ways, the authors included a paragraph in the preamble to help respondents understand how the word "standards" was intended for this survey. Respondents did not have to answer all survey questions to participate, and some questions allowed for multiple responses (i.e., select all that apply).

The anonymous survey was disseminated to a targeted email list of librarians at institutions with bachelor's programs in MET or EEET. To create this email list, Phillips first generated a list of institutions with ABET accredited bachelor's programs in the United States on April 16, 2021, limiting the results to the disciplines of mechanical engineering technology (MET) and electrical and electronics engineering technology (EEET) (ABET, n.d.). These two disciplines were chosen since ABET accredits more ET programs in these areas than others (ABET, n.d.). This process generated 125 results; however, many were duplicates. Once duplicates were removed, 102 unique institution names remained. Of these 102 intuitions, 31 offer only an MET or EEET program, or both, and no engineering programs. It should be noted that while the disciplines are titled "mechanical engineering technology" and "electrical and electronics engineering technology" in the ABET system, program names at individual institutions may differ. For example, programs accredited under the discipline EEET are titled "electrical engineering technology" (EET) at Purdue University, as well as at many other institutions.

Next, Phillips searched library websites for each institution and collected names and email addresses of librarians to invite to take our survey. Since many libraries do not operate on a department liaison model, or do not share their liaison names and responsibilities on their library website, it was difficult in some cases to identify the "best" person to target for our survey topic. To help mitigate the issue, we stated in our email recruitment message: "From your library website, we identified you as a librarian who may support engineering technology (ET) programs and/or technical standards. We are interested in learning about how libraries and librarians support ABET ET program accreditation requirements through their technical standards collections and services."

Our intention was to gather as many responses as possible from institutions that serve at least a MET or EEET program. We first targeted individuals who were listed as liaisons to MET or EEET bachelor programs (typically the same person if an institution had both programs). If this information could not be found, we targeted individuals listed as having a specific responsibility for standards. If a person could still not be identified, we checked to see if there was anyone listed as working with any engineering programs, with the thought that the individual may understand standards collections and practices at the institution. Lastly, when no names could be identified, we sent the email invitation to a general library address requesting that it be forwarded to the most appropriate individual.

Phillips sent two rounds of survey invitations to 102 email addresses (96 individual email addresses and six general library email addresses). The first round was sent on January 24, 2022, and a reminder message was sent in two weeks, on February 7, 2022. The survey remained open until February 28, 2022. A drawing for two $50 Visa gift cards was offered as an incentive for completing the survey. Individuals who wished to be entered into the drawing provided their names separately from their survey responses to maintain anonymity.

Data Analysis

We exported the survey data from Qualtrics into a .csv file. Next, we used Microsoft Excel to perform quantitative analysis on the multiple-choice questions and qualitative analysis on the open-ended response questions. For the open-ended responses, we used inductive analysis to identify the major themes. To perform the inductive analysis, the responses were first copied into two separate Excel files and two of the authors, McPherson and Phillips, independently read over the responses multiple times to become very familiar with the data. Each author labeled each response with initial themes. The authors then compared their coding and themes, re-read the responses several more times, and adjusted the themes until they reached an agreed-upon coding structure.

Results

The results of this study are presented in four sub-sections and align with our research questions as indicated: Description of Participants, Standards Access (RQ1), Standards Instruction & Outreach (RQ2), and Librarian Standards Education & Professional Development (RQ3, RQ4).

Description of Participants

We received 34 survey responses, a response rate of 33.3%. Most of the librarian respondents were from public academic institutions (n=29) rather than private (n=5). For anonymity purposes, the survey did not ask respondents to provide the name of their institution, so it is possible that there were multiple responses from the same institution. However, we did target individual email addresses when possible (96/102 of the email messages were sent to individuals). When an email was sent to a general library address because an individual could not be identified, we asked that the survey message be forwarded to the most appropriate person.

The number of students enrolled at the respondents' institutions was distributed fairly evenly, with "less than 5,000 students" (n=9), "5,000-10,000" (n=5), "10,001-15,000" (n=8), "15,001-20,000" (n=5), "20,001-25,000" (n=2), and "25,001+ students" (n=5). The overwhelming majority of respondents (n=28) indicated that they work with or have worked with standards in their careers as academic librarians. However, 43% of those who have worked with standards reported five or less years of experience. Figure 1 provides a breakdown of respondents' years of experience with standards as an academic librarian.
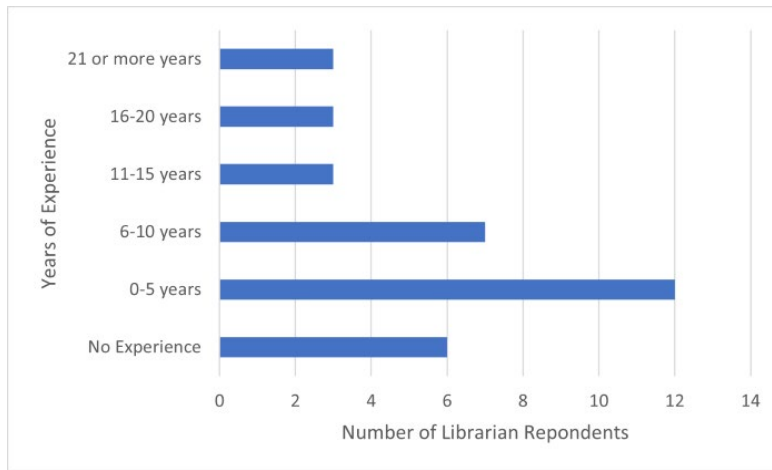
Figure 1. Survey respondents reported years of experience with standards as an academic librarian (n=34)

Additionally, in an open-response question we asked the respondents which programs they currently have liaison responsibilities to at their institutions (Question 4 in Appendix A). We encouraged the respondents to list all the programs they are liaising to, including those not engineering or engineering technology related. The responses (n=33) varied greatly and are difficult to compare, since some respondents listed individual programs, and others listed all programs at the institution or all programs in a specific college or discipline. The most frequent response (7) described being responsible for "all" or "most" programs at the institution. Two of these respondents further commented that their libraries do not operate on a liaison model, therefore they work with all programs at the institution. Relatedly, multiple respondents described being responsible for all programs in a college or discipline or all STEM-related programs, including, all engineering (5), all engineering and engineering technology (3), all engineering technology (1), all engineering and hard sciences excluding medical sciences (1), all engineering programs aside from biomedical engineering and computer science (1), all STEM programs (excluding health sciences) (1), all programs under college of agriculture, food and environmental sciences (1), all science and technology (1), and all college of medicine (1). Of those who detailed individual programs, the responses ranged from one to ten programs and the most frequent responses were computer science (6), mechanical engineering (6), and mathematics (5). In some cases, respondents listed only "mechanical" or "electrical" and it was not clear if they meant engineering, engineering technology, or both.
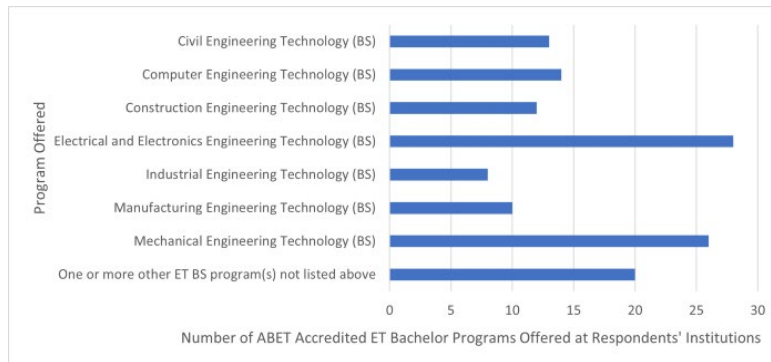
Figure 2. ABET accredited engineering technology bachelor programs offered by respondents' institutions (n=34)

Figure 2 shows the counts of the ABET accredited engineering technology bachelor programs at the survey respondents' institutions. The most frequent responses were electrical and electronics engineering technology (EEET) and mechanical engineering technology (MET), which were expected since we targeted institutions with at least a EEET or MET bachelor's program and ABET accredits more programs in these disciplines than any other areas of ET. The mean, median, and mode of the survey responses to the number of programs offered was 3.9, 4, and 4, respectively, and the range of responses to the number of programs offered was 1-8.

Standards Access

Figure 3 provides a summary of standards access by student enrollment. Out of 34 responses, 26 respondents (76%) indicated they purchase standards in some format, four respondents (12%) said they were unsure if their library purchases standards, and four respondents (12%) indicated their library does not purchase standards. The data shows a pattern between institution size and standards access, with the four "no access" responses coming from institutions with lower student enrollments. For those respondents who indicated their institutions did purchase technical standards, the most frequent methods of obtaining standards were electronically via subscriptions (69%), electronically via one-off purchases (58%), and in print (i.e., in hard copy) (58%). Respondents were allowed to select multiple modes of access, but three respondents selected only electronically via subscription, one respondent selected only electronically via one-off purchases, and three respondents selected only in print. One respondent replied "other" and explained that "other" referred to a deposit account with Techstreet, a standards vendor, which we counted as an "electronic one-off." It should be noted that technical standards subscriptions differ from traditional library database subscriptions, and this can sometimes cause confusion concerning the model of access.
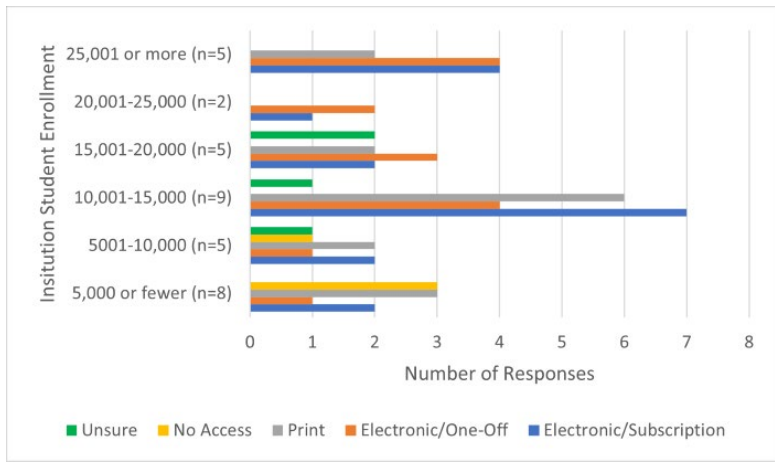
Figure 3. Librarian reported standards access by institution student enrollment (n=34)

Figure 4 shows that ASTM and IEEE are the most popular standards collections that libraries responding to this survey subscribe to electronically. This finding is not surprising since ASTM and IEEE standards are frequently used by MET and EEET programs and our survey targeted librarians that work at institutions with at least a MET or EEET bachelor's program.
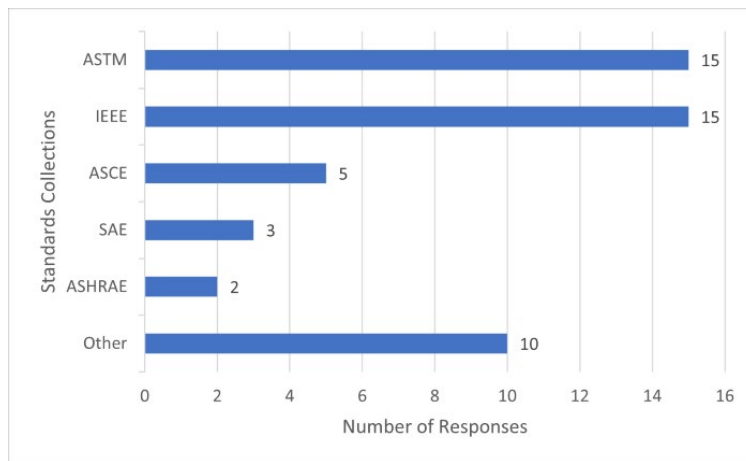

Figure 4. Standards collections reported as subscribed to by librarian survey respondents (n=18)
Other (one in each response): ASME, ASME BPVC, ASABE, ICC, IBC, NFPA, Federal guidelines, Virginia State Code, Maryland Code, Indiana Administrative Code

When asked about barriers to standards access, the most frequent response was "cost/budget," with 91% of librarian respondents noting this as an issue for their institution. Librarians also noted digital rights management restrictions, interlibrary loan challenges, working with standards vendors, and navigating standards to identify the right document for a user's need as challenges. Three respondents were unsure what challenges their institution experiences in providing access to standards (see Figure 5).
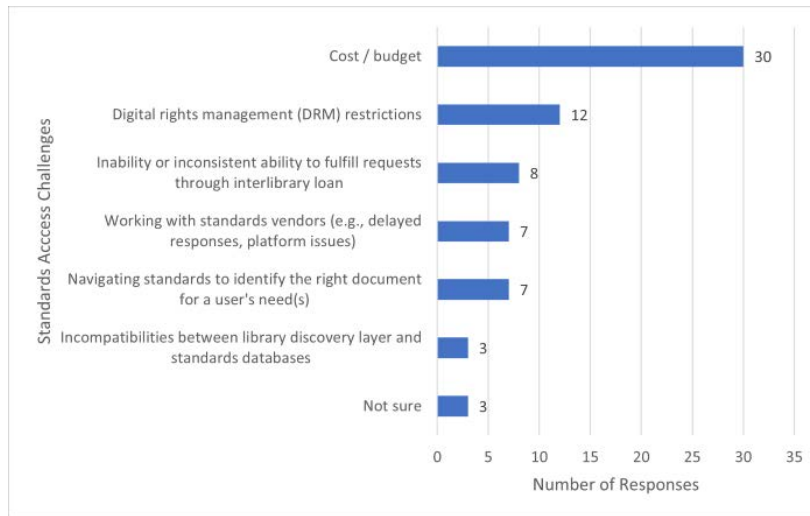
Figure 5. Standards access challenges reported by librarian survey respondents (n=33)

Standards Instruction & Outreach

Figure 6 details how many respondents indicated their library provides education about standards by student enrollment. Despite 76% of respondents stating that their libraries purchase standards, only 48% stated they provide standards education. The remaining respondents indicated that either their library does not provide standards education (33%), or they are unsure if standards education is provided (18%). Like standards access, the data shows a pattern between institution student enrollment and standards education, with more institutions with larger enrollments reporting "yes" their library provides standards education than institutions with smaller enrollments.
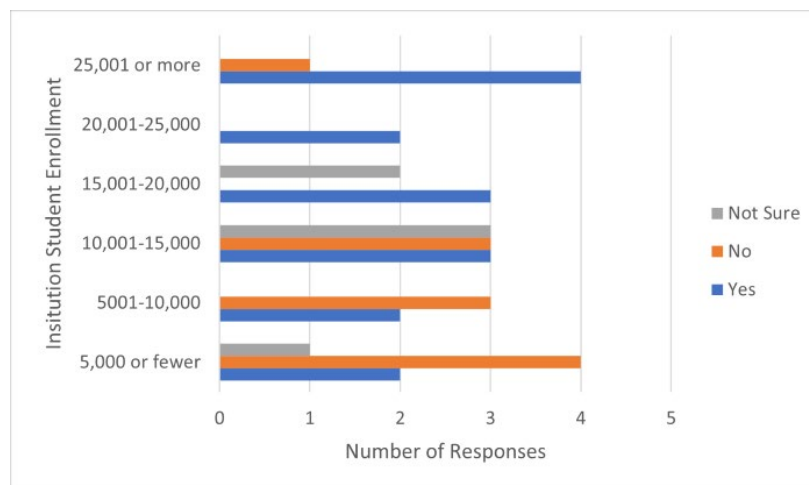

Figure 6. Librarian provided standards education by student enrollment (n=33)

Figure 7 illustrates how the librarian respondents reported educating users about standards. Library research guides (e.g., LibGuides) were the most popular selection (100%), along with one-shot guest lectures provided by librarians (81%) and individual research consultations (69%). One survey participant noted "other" as a method of delivering standards instruction and elaborated to clarify that standards instruction was part of their one-shot guest lectures, but just one of several topics covered in the

capstone project class. No respondents indicated that standards education was provided through a credit-bearing course where librarians were the formally designated instructors.
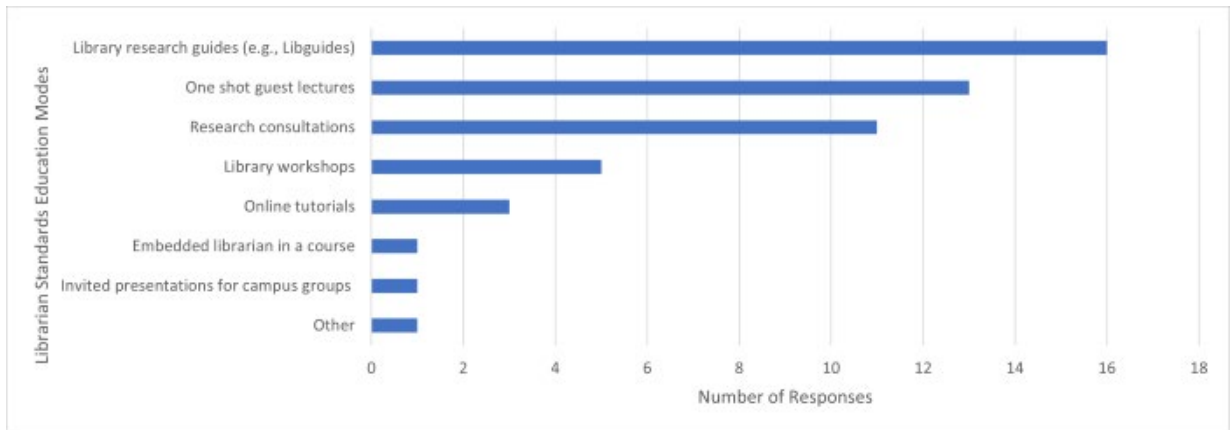

Figure 7. Modes of standards education reported by librarian respondents (n=16)

Participants who indicated that their library provides standards education were asked about the standards topics covered in their educational offerings (see Figure 8). All available options were selected by at least one participant, with no respondents selecting "other." Searching for specific standards (100%), searching for and identifying standards related to a general topic (94%), accessing the full text of standards (81%), and providing an overview of standards databases (75%) were the most common responses.

Figure 8. Standards education topics reported by librarian respondents (n=16)

As far as the user groups librarian respondents indicated that they educated about standards, undergraduate students were the most common response (100%), with graduate students (56%) and faculty (38%) following. No respondents selected options for staff or local community members (non-university affiliated). There were seven librarian respondents (44%) who selected only the user group undergraduate students. The finding that most of the libraries we surveyed educate user groups beyond undergraduate students may indicate that those libraries focus more on standards overall than libraries that only educate undergraduate students about standards.

In terms of outreach about standards, most respondents (24 out of 33, or 73%) indicated that their library did not conduct any specific activities to promote standards collections or services to users. Two respondents (6%) were unsure about this. For those that did conduct outreach (21%), a variety of methods were utilized. LibGuides, classes, and email announcements were the options most often selected.

Librarians' Standards Education & Professional Development

When asked how they became educated about technical standards, the most frequent response was "on the job as a librarian" (96%) (see Figure 9). Respondents were encouraged to select all the options that apply to them for this question, but nearly half (46%) listed "on the job as a librarian" as their only response. Additional responses included learning about standards through professional association offerings (e.g., workshops, conferences) (29%), during graduate education (library-related, 14%; non-library related, 7%), and "other" (4%) where the respondent explained they learned about standards through discussions with faculty instructors and local engineering firms about how they use standards. No respondents selected the "during my undergraduate education" option.
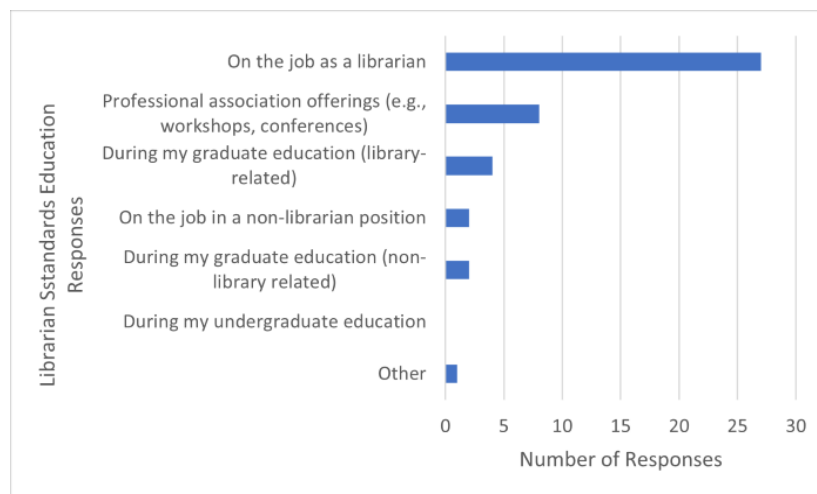

Figure 9. Librarian survey respondents' methods of becoming educated about standards (n=28)

We also asked respondents about additional education for themselves (or other librarians) concerning standards. The majority, (20 out of 33, or 61%), said yes, they would be interested in further education about standards, while 21% indicated they might be interested. We gave the participants an open prompt to express the standards topics they would be interested in learning about. There were a variety of responses, with themes centering on standards full text availability (including the variety of vendors and free or low-cost options), searching for standards, examples of librarian-led standards instruction and outreach, and paying for standards on limited library budgets. One participant did note that it is difficult to say what they would be interested in learning because they "don't know what they don't know" about standards. Regarding preferred learning formats, the most frequent response was a self-paced tutorial (70%). Other frequent options selected include professional association offerings (e.g., workshops, webinars) (55%), online courses (e.g., Library Juice

Academy) (39%), and seminars or workshops featuring outside speaker(s) in their library region (33%).

Lastly, we gave the librarian participants an open prompt to share any additional comments that come to mind about standards, to which thirteen participants contributed. The most frequent responses (n=6) centered around the costs of acquiring standards, with one librarian commenting, "funding for electronic standards is probably the biggest barrier to access and wider use," and another,

> [Standards] are simply too expensive to acquire! If the societies and organizations that develop them want them to be used by industry professionals (their members), they need to begin to learn how to use and access them as students...and the societies/organizations are pricing the students/libraries out of that opportunity. … The lengths we have to go through to provide access to an expensive product on a tight budget. Librarians are some of the most creative people I know!

The next most frequent theme (n=4) focused on wanting more librarian training on standards, with one respondent sharing, "I am new to a college offering engineer technologies, would like to learn more and make it a part of the library toolbox." The remaining responses, with one response provided in each area, focused on standards being a high value resource critical for engineers, so as a librarian, they make every attempt to introduce students to the documents, a desire to do more to meet user needs, a statement that standards are multidisciplinary in that many different disciplines use them, and a further note that at one respondent's institution they purchase all standards in print other than IEEE and ASTM.

Discussion

The discussion is presented in four sub-sections and aligns with our research questions as indicated: Standards Access (RQ1), Standards Instruction & Outreach (RQ2), Librarians' Standards Education & Professional Development (RQ3, RQ4), and Limitations.

Standards Access

The data show that 76% of librarian respondents are purchasing standards in either electronic or print format. This indicates that librarians who work at institutions with at least a MET or EEET program understand the importance of providing standards access to patrons. The results show a pattern between standards purchasing and institution size as the four respondents (12%) who indicated their library does not purchase standards came from institutions with smaller student enrollments (see Figure 3). However, we are not able to determine why this is the case. One factor could be that larger institutions offer more programs that incorporate standards (i.e., multiple engineering and engineering technology programs) than smaller institutions. Another factor could be that larger institutions have more funding available than smaller institutions, but we know it is not always the case that larger institutions have bigger library budgets.

The most prominent standards access challenge identified through this survey was cost with 91% of respondents indicating cost/budget as a challenge their library faces when it comes to providing (or attempting to provide) access to standards (see Figure 5). In the context of this survey, "cost/budget" refers to the actual cost of the standards (whether a one-time cost or an annual subscription cost) or the library budget allocated for collections or accessing resources. This finding is consistent with prior librarian surveys related to standards (Phillips, 2019; Wainscott & Zwiercan, 2020; Wetzel & Grove, 2021) and not a factor unique to libraries that serve MET or EEET programs. While the item price is something librarians consider with any purchase, the cost issues with standards are compounded by the additional challenges of interlibrary loan and digital rights management (DRM).

Standards have become difficult to borrow from other institutions via interlibrary loan (ILL), with 24% of the respondents to our survey noting ILL challenges, and 36% indicating challenges with digital rights management (DRM) restrictions. The responses are consistent with prior literature regarding standards access (Pellack, 2005; Phillips, 2019; Wainscott & Zwiercan, 2020), however, it should be noted that these standards access issues are also not unique to libraries supporting MET or EEET programs. As more libraries move to electronic access for standards, the terms and conditions of these subscriptions typically preclude libraries from loaning or distributing the documents to users outside of the subscribing library. One-off electronic (PDF) standards purchases are not able to be loaned through ILL as they often are locked to the computer that completed the purchase. Libraries that purchase individual print standards may catalog the documents as "not loanable" if they are shelved in a reference collection for patron access. As one respondent noted when asked about challenges in providing access to standards, "the lockdown that standards creators and resellers have on [standards is the challenge]." While many standards require payment, there are standards that are accessible freely or at reduced rates (Phillips, 2023; Rowley, 2023). However, it may be the case that many librarians are not aware of the free and low-cost standards access options.

Electronic access to standards, meaning both subscription access and one-off PDF document purchases, is becoming an increasingly popular method of access in academic libraries (Pellack, 2005; Phillips, 2019; Wainscott & Zwiercan, 2020; Wetzel & Grove, 2021). This can alleviate issues with accessing documents that had previously been purchased in print. For example, if standards in print are only available in a reference section or from course reserve, students are confronted with a restricted timeframe to consult the documents. However, electronic access typically means that access is a continuing commitment (e.g., a subscription), which puts a greater burden on library budgets. Librarians need to have conversations with standards developing organizations about the need for access to standards for educational purposes while making budgetary constraints known. Free and low-cost access options could alleviate cost concerns and other potential issues related to access.

Standards Instruction & Outreach

Roughly half of the respondents (48%) stated that standards instruction was provided to users, with 33% not providing standards education and 18% stating they were unsure

if standards education is provided. One reason for these response rates could be tied back to the number of disciplines librarians are responsible for. While it was difficult to compare the information provided by respondents related to the disciplines they work with (as the question was an open text field), the most common answers were "all" or "most" disciplines. This indicates that these librarians work with users from all or many disciplines offered by their institutions, not only MET or EEET programs. Therefore, developing standards instruction could be a lower priority for some due to their other responsibilities. Another possibility is that librarians are not receiving requests for standards instruction that may lead them to create standalone, self-serve standards educational material, such as a LibGuides page on standards.

Survey respondents mostly pointed to LibGuides and research guides when asked about modes of standards instruction and outreach, while librarian-taught one-shot, guest lecture sessions and research consultations were among the top selected responses to standards education (see Figure 7). Using LibGuides and research guides is interesting as this differs from the standards education literature which focuses on the forms of workshops and case study instruction (Rowley et al., 2020; Solomon et al., 2019). Self-serve options for standards education, such as self-paced tutorials (Phillips et al., 2017), can be made accessible and discoverable online. This option also allows interested users outside of specific courses to access and use the educational materials. Using LibGuides and research guides for standards education and outreach also opens up a potential future research area.

Many respondents reported having five years or less (35%), or no experience (18%) with standards as an academic librarian (see Figure 1). Having limited experience working with standards could result in librarians feeling uncomfortable providing standards instruction, especially if they are responsible for many other academic areas. This then ties directly to the need for standards education and professional development for librarians.

Librarians' Standards Education & Professional Development

When it comes to standards education for librarians, 96% reported that they have learned about standards "on the job as a librarian" (see Figure 9). The question allowed respondents to select all applicable answers, and nearly half (46%) selected this option as their only response. While the survey did not ask respondents about their educational background, this would imply that most do not have educational backgrounds that required standards to be integrated into their curricula (e.g., engineering or engineering technology). Only four respondents selected "during my graduate education (library-related)" as where they learned about standards. This suggests that a course introducing standards, such as a STEM resources course, was not a class most respondents completed in their graduate program. Reasons for this could vary, including lack of course availability or not knowing at the time they may work in a capacity where the standards information would be useful.

Most respondents (82%) indicated they would or would possibly be interested in such education. The high number of respondents interested in educational opportunities related to standards could indicate a lack of confidence in providing instruction on

standards. The education topics that respondents provided suggest this possibility. For example, one response stated, they were interested in "learning how other librarians teach and provide standards," while another listed several topics they were interested in, including "examples of standards-related instruction." This could mean that respondents recognize the need to provide standards instruction, but they feel they need additional support to offer such instruction. Sharing case studies or other instruction examples is common in the literature (Fosmire, 2020; Huderson, et al., 2019; McPherson, et al., 2019; Phillips & Zwicky, 2018; Rowley, et al., 2020), however, it is possible that the respondents are not aware of these case studies, or they desire a different model for learning. Instruction was not the only area respondents signaled as a topic needed for librarian-focused education. Information pertaining to standards vendors and free or low-cost options were also revealed to be areas of need among respondents.

In terms of preferred learning format, the option of a "self-paced tutorial" was selected at a comparatively high frequency (70%). Requesting self-paced options could be an indication of librarian respondents with multiple job responsibilities that leave limited time to devote to synchronous professional training opportunities for standards. Librarians at institutions that serve MET or EEET programs could potentially have instruction, research, reference, and collection development duties for other disciplines, STEM-related or outside of STEM. Other options, such as professional association offerings, online courses, or outside speakers, often require a commitment to a specific date and time. These options may also require funding for travel or registration, which can be prohibitive for many libraries and librarians. While many self-paced tutorials exist freely online, such as the Standards Are Everywhere series (Phillips et al., 2017), a need exists for resources to be developed specifically for librarians. It should be noted that a few select professional associations offer professional development that could be helpful, such as the American Society for Engineering Education (ASEE) Engineering Libraries Division (ELD). However, it is possible that some librarians are not part of discipline-focused professional associations that offer these trainings and discussions on standards since they have responsibilities for many areas.

Librarians often have the capacity to reach significant numbers of students. Two of the authors of this paper, Phillips and Rowley, are liaisons to engineering and engineering technology programs with approximately 3,000 and 5,000 students at their respective institutions. In addition, they are liaisons to programs with approximately 125 and 200 discipline faculty members. While these are just two examples, this reach makes it even more critical to develop standards education materials specifically designed for librarians, as they can then disseminate this information to the relevant populations of students and faculty they work with.

Limitations

As explained in the Methods section, since many libraries do not operate on a liaison model or do not provide details about their liaisons' subject areas on their website, it was challenging at times to identify the best person at an institution that serves at least a MET or EEET program to participate in our survey. It is possible that despite the

efforts we took, we were still not able to connect with the individual with the most knowledge about standards and MET or EEET programs.

In addition, our survey did not specifically ask if the respondent's institution supports both ET and engineering programs or only ET programs, and for anonymity purposes we did not ask respondents to provide the name of their institution with their response. Therefore, it is not possible to compare institutions that only serve ET programs with those that serve both ET and engineering programs. To help mitigate this issue, future studies could include a question that clearly asks if a respondent's institution supports both ET and engineering programs or only ET programs.

Response bias is also a limitation of this study. Librarians who are familiar with standards in academic libraries might feel more inclined to answer a survey about standards rather than a librarian who is not as familiar with the document type. This could have potentially skewed the results as there could have been librarians who did not respond to the survey if they felt uncomfortable answering questions about an information source they are not familiar with, although we stated in the preamble of the survey that no experience with standards was required, and we phrased our survey questions to be inclusive of librarians with no or little experience with standards (see Question 5 in Appendix A, as well as the questions with "I'm not sure" options).

Lastly, the data in this study is self-reported. There is a possibility of bias in responses when the data is self-reported. However, the results of this study align with Phillips et al.'s (2023) investigation of library websites that also shows there are standards access challenges for academic libraries that serve MET or EEET programs and the challenges are more pronounced at institutions with lower student enrollments.

Conclusion

Standards documents are important for students of engineering and engineering technology programs. This study shows that academic libraries at institutions with MET and EEET programs generally recognize that importance and strive to provide standards access and education to students, but standards access and education efforts are skewed towards institutions with larger student enrollments, a potential disadvantage to students studying MET or EEET at smaller colleges and universities.

Additionally, the librarian respondents have significant concerns about the costs of standards. It is possible that many of the librarians are not aware of free and low-cost options for accessing standards, of which there are many, including the National Fire Protection Association (NFPA) standards (Phillips, 2023). Librarians should encourage more standards developers to offer free and low-cost options for students. As students go into internships and graduate, those who have been introduced to standards in academia are more likely to be comfortable with seeking and using standards in their professional roles.

Lastly, this study shows that most of the survey respondents did not receive any education about standards until moving into their librarian careers and there is a need for self-paced librarian training materials focused on standards. Further education for

engineering librarians about standards has the potential to have a positive impact on students, given the wide reach of librarians in their liaison roles.

Acknowledgments

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Appendix A: Survey Instrument

This survey was built in Qualtrics.

Thank you for your participation in this survey.

There are 12 questions that should take approximately 5-7 minutes to complete.

For the purposes of this survey, we consider "standards" to be documents produced by domestic or international organizations which plan, develop, establish, or coordinate voluntary consensus standards using agreed-upon procedures. These bodies may include accredited standards developers (like ASTM International or ISO, the International Organization for Standardization), professional societies (like ASME or IEEE), and industry associations (like NEMA, the National Electrical Manufacturers Association).

No experience with technical standards is required to complete this survey.

1.   Approximately how many students are enrolled at your institution?
   a. <5000
   b. 5,001-10,000
   c. 10,001-15,000
   d. 15001-20,000
   e. 20,001-25,000
   f. 25001+

2.   Is your institution public or private?
   a. Public
   b. Private

3.   Which ABET accredited engineering technology bachelor degrees does your institution offer? (Not sure?: Look up Engineering Technology Accreditation Commission (ETAC) programs here: https://amspub.abet.org/aps/category-search?commissions=4).
         Select all that apply.
   a.   Civil Engineering Technology (BS)
   b.   Computer Engineering Technology (BS)
   c.   Construction Engineering Technology (BS)
   d.   Electrical and Electronics Engineering Technology (BS)
   e.   Industrial Engineering Technology (BS)
   f.   Manufacturing Engineering Technology (BS)
   g.   Mechanical Engineering Technology (BS)
   h.   One or more other ET BS program(s) not listed above

4.   To which programs do you currently have liaison responsibilities to? (Please list all programs, including those not engineering or technology related):

5.   Have you worked with standards as an academic librarian?
   a. Yes
   b. No

5a [If 5 Yes] How long have you worked (or did you work) with standards as an academic librarian?

- a. 0-5 years
- b. 6-10 years
- c. 11-15 years
- d. 16-20 years
- e. 21 or more years

5b [if 5 Yes] On a scale of 1 to 5, with 5 being the highest, rate your knowledge of standards.

[1-No knowledge   5-Very knowledgeable]

5c [if 5 Yes] How did you become educated about technical standards? Select all that apply.

- a. During my undergraduate education
- b. During my graduate education (library-related)
- c. During my graduate education (non-library related)
- d. On the job as a librarian
- e. On the job in a non-librarian position
- f. Professional association offerings (e.g., workshops, conferences)
- g. Other, please explain:

6. Does your library purchase standards?
- a. Yes
- b. No
- c. I'm not sure

6a) [if 6 Yes] How does your library purchase standards? Select all that apply.
- a. Electronically via subscription
- b. Electronically as one-off purchases
- c. In print (i.e., hard copy)
- d. Other, please explain:
- e. I'm not sure

6b) [if 6a a is selected] What standards collections does your library subscribe to electronically? Select all that apply.
- a. ASCE
- b. ASHRAE
- c. ASME
- d. ASME BPVC
- e. ASTM
- f. IEEE
- g. Other, please list:
- h. I'm not sure

6c) [If 6 a, b, c, d selected] What different user groups access standards through your library? Select all that apply.
- a. Undergraduate students
- b. Graduate students

c. Faculty
d. Staff
e. Local community members (non-university affiliated)
f. Other, please explain:
g. I'm not sure

7) What challenges does your library face in providing access to, or attempting to provide access to, standards for users? Select all that apply.
a. Cost / budget
b. Digital rights management (DRM) restrictions
c. Lack of requests / interest from users
d. Lack of librarian / staff knowledge about standards
e. Navigating standards to identify the right document for a user's need(s)
f. Lack of support from library administration
g. Librarian / staff time
h. Incompatibilities between library discovery layer and standards databases
i. Inability / inconsistent ability to fulfill requests through interlibrary loan
j. Working with standards vendors (e.g., delayed responses, platform issues)
k. Other, please explain:
l. None
m. I'm not sure

8) Does your library educate users about standards?
a. Yes
b. No
c. I'm not sure

8a [if 8 Yes] How does your library educate users about standards? Select all that apply.
a. One or more librarians teach about standards in one shot/guest lecture sessions
b. One or more more librarians teach about standards as an embedded librarian in a course (i.e., teach multiple sessions in the same course throughout a term)
c. One or more more librarians teach about standards as an instructor-of-record in a course
d. Invited presentations for campus groups outside of courses
e. Library workshops
f. LibGuides / research guides
g. Online tutorials
h. Research consultations
i. Other, please explain:
j. I'm not sure

8b [if 8 Yes] What standards topics does your library educate users about? Select all that apply.
a. Standards databases
b. Searching for specific standards (e.g., ASME Y14.5-2018)
c. Searching for / identifying standards related to a general topic
d. Accessing full text standards documents
e. Free / low cost standards availability (e.g., NFPA and UL standards are freely available online in read only format, ANSI University Outreach Program)
f. Parts of a standard
g. Standards developing organizations
h. Standards development process
i. Citing standards

j.   Other, please explain:

k.   I'm not sure

8c [if 8 Yes] What user groups does your library educate about standards? Select all that apply.
     a.   Undergraduate students
     b.   Graduate students
     c.   Faculty
     d.   Staff
     e.   Local community members (non-university affiliated)
     f.   Others, please explain:
     g.   I'm not sure

8d [if 8c a undergraduates selected] What are the majors of the undergraduate students that your library educates about standards? Select all that apply.
     a.   Electrical and Electronics Engineering Technology (EET)
     b.   Mechanical Engineering Technology (MET)
     c.   Engineering Technology program(s) other than EET or MET
     d.   Mechanical Engineering
     e.   Electrical Engineering
     f.   Civil Engineering
     g.   Other, please specify:
     h.   I'm not sure

8e [if 8c b graduates selected] What are the majors of the graduate students that your library educates about standards? Select all that apply.
     a.   Electrical and Electronics Engineering Technology (EET)
     b.   Mechanical Engineering Technology (MET)
     c.   Engineering Technology program(s) other than EET or MET
     d.   Mechanical Engineering
     e.   Electrical Engineering
     f.   Civil Engineering
     g.   Other, please specify:
     h.   I'm not sure

9. Does your library conduct outreach activities (e.g., email, orientations, social media posts) to promote its standards collections/services to users?
     a.   Yes
     b.   No
     c.   I'm not sure

9a [If 9 Yes selected] How does your library make outreach to users about standards? Select all that apply.
     a.   Email announcements
     b.   Faculty meeting(s) / orientation(s)
     c.   Classes
     d.   Student orientations
     e.   Word of mouth
     f.   LibGuides
     g.   Library webpage or blog
     h.   Newsletter
     i.   Social media
     j.   Other, please describe:

       k.   I'm not sure

10) Would you be interested in education/further education about standards?
       a.   Yes
       b.   No
       c.   Maybe

       10a [If 10 a or c] Please describe the standards related topic(s) you are (or may be) interested in learning about:

       10b [If 10 a or c] What is your preferred format for learning about these standards topics? Select all that apply.
       a.   Professional association offerings (e.g., workshops, webinars)
       b.   Online courses (e.g., Library Juice Academy)
       c.   Self-paced tutorials
       d.   Outside speaker(s) seminar/workshop for my library/library region
       e.   Other, please explain:

11) Please share any other comments that come to mind about standards at your institution, or in general.

12) We are offering a drawing for two $50 Visa gift cards as an incentive for completing this survey.
Do you wish to receive this incentive? If you answer yes, you will be taken to a form where you can enter your name and email address for a random drawing of respondents.

       a.   Yes
       b.   No

12a) [If 12 a] Enter link to a separate Qualtrics form that asks for the respondent's name and email