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HOW DO PROFESSIONAL ENGINEERS USE INFORMATION COMPARED TO UNDERGRADUTES, AND HOW CAN LIBRARIES PREPARE STUDENTS AND SUPPORT ENGINEERS FOR FUTURE SUCCESS?

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Abstract
Librarians at Purdue University seek to develop engineering graduates who are effective information users. Similarly, information specialists at Caterpillar Inc. are concerned with how well new hires are prepared for the information landscape at work as practicing engineers. Librarians from Purdue University and Caterpillar partnered to create and disseminate a survey to compare how students and practicing engineers seek and use information in the research process. Within a framework that asked survey participants to think about information use in a recently completed project, responses highlighted several gaps in information literacy training, including the use of external standards and internal document storage systems, documentation practices, and resource awareness. We also explored information habits and frustrations of both user populations and found that, while students have more confidence in their abilities, they consult many fewer types of literature and utilize fewer strategies for organizing information effectively. Additionally, the findings suggest students tend to use more social media tools to keep abreast of developments in their field than practicing engineers, while engineers rely heavily on internal knowledge management systems to track information generated by the company that augments externally produced information.

The goal of this project was to better understand both consistencies and gaps in university engineering education and industry expectations. This paper presents preliminary findings from this project and discusses how the authors plan to use the results to update undergraduate curricula and improve library services and resources for both populations.

Keywords: information literacy; information habits of engineers; future of libraries; surveys

Introduction
In an increasingly globally connected and technologically accelerated modern work environment, getting up to speed and maintaining currency in one's field can be quite daunting. One’s proficiency in locating information is affected by geographic location and culture, internal policies and processes, and individual characteristics (Tenopir & King, 2004, p. 72). Each of these particulars are diverse within industry, and students entering a complex information landscape can be underprepared for the comparative privation of structure of information needed for projects. Complicatedly, undergraduate students hold an inflated opinion of their information literacy skills, which are not as developed as they might believe (Ganley, Gilbert, & Rosario, 2013)This kind of inflated student self-assessment yields a “novice effect,” which leads students to hold a misperception of competency (Ross, Fosmire, Wertz, Cardella, & Purzer, 2011), a phenomenon which is also observed in this study.

Traditionally, there are two channels for engineers to obtain information independently: through interpersonal communication, or by reading written material, such as journal articles, reports, standards, and patents (Tenopir & King, 2004, p. 59). Undergraduate projects generally follow set guidelines and a pattern of finding requirements, prototyping, etc., while in industry engineering projects, these processes can often overlap or be interrupted. Students entering an information environment that is comparatively more complex and decentralized than a typical course project will find themselves required to pivot and continuously search for new information. Industry project deadlines and limited time for research lends to the trend of asking colleagues for information rather than conducting a formal literature search (Tenopir & King, 2004, p. 63). Given the limited time to complete a task, engineers need to gather information as efficiently as possible. This can be described as a “just in time” approach for information seeking (Rodrigues, 2001). Because engineers often have limited time set aside specifically for information gathering, they prioritize information-seeking methods by ease of access (Tenopir & King, 2004, p. 58).

Information literacy is everywhere in industry but presents in various forms, depending on the nature of business, department function, and personal role (Forster, 2017, p. 135). Information literacy influences business efficiency, profitability, customer service, morale of staff, and regulation regimes (Forster, 2017, p. 71). Furthermore, lack of awareness of library services leads to ineffective information systems (Tenopir & King, 2004, p. 67). As such, this paper posits several concepts for new information literacy training that may better prepare students for the complex information landscape of industry. Likewise, corporate librarians ought to enhance onboarding training of new hires to familiarize incoming professionals with effective information seeking habits at work in a manner that matches students’ learning preferences.

Project Context

Purdue University is a public research university with more than 40,000 students and 3,000 employees located in West Lafayette, Indiana, USA. Purdue has large and highly ranked engineering programs in its College of Engineering, which include academic programs in 16 engineering disciplines (e.g., mechanical engineering, electrical engineering, aeronautical and astronautical engineering). Purdue Polytechnic Institute, another College on Purdue's campus, (formerly known as the College of Technology), offers programs in 12 engineering technology, or "applied engineering," areas, including mechanical engineering technology, industrial engineering technology, and electrical engineering technology. Engineering programs differ from engineering technology programs in that they "focus on theory and conceptual design, while engineering technology programs usually focus on application and implementation," typically resulting in different but potentially overlapping career paths for graduates (ABET, n.d.).

For more than 90 years, Caterpillar Inc. has been making sustainable progress possible and driving positive change on every continent. Customers turn to Caterpillar to help them develop infrastructure, energy and natural resource assets.

With 2017 sales and revenues of $45.462 billion, Caterpillar is the world’s leading manufacturer of construction and mining equipment, diesel and natural gas engines, industrial gas turbines, and diesel-electric locomotives. The company principally operates through its three primary segments—Construction Industries, Resource Industries, and Energy & Transportation—and also provides financing and related services through its Financial Products segment.

In 2016 librarians from Purdue and Caterpillar partnered to investigate the information habits and experiences of engineering and engineering technology undergraduate students and engineers working in industry. The goals of the project were to better understand both consistencies and gaps in university education and industry expectations in order to identify ways to revise undergraduate information literacy curricula and improve library services and resources for both populations. This paper presents preliminary findings from this project. The authors plan to publish the full results in a journal article.

Methods

The researchers created and disseminated surveys (Phillips, Fosmire, Petersheim, & Turner, 2016) with multiple common questions to compare how students and practicing engineers seek and use information.

At Purdue, data was collected using an anonymous, online survey from 63 students in three upper-level engineering and engineering technology undergraduate courses: MET 451 (manufacturing quality control), MET 401/ECET 430 (a cross-listed engineering technology senior Capstone design course), and ME 463 (engineering senior capstone design). At

Caterpillar, the researchers also conducted an anonymous, online survey and received responses from 134 engineers in North America, Europe, and the Asia/Pacific region. Participants were not required to complete all of the questions in order to submit a survey, resulting in some questions receiving a higher number of responses than others.

Both quantitative and qualitative data analysis was performed on the survey results. The researchers ran two-sided, unpaired sample t-test comparisons between the engineer and student responses of the common quantitative questions. Similar t-tests were used to compare Caterpillar responses by region. Additionally, they performed a combination of deductive and inductive content analysis on the shared open-ended questions to identify overall themes and sub-themes in the data.

The research was reviewed and approved as exempt research by Purdue University's Institutional Review Board (IRB #1610018238).

Results

Quantitative

Within the surveys, the researchers asked seven identical quantitative questions to engineers and students. In the form of a seven-point Likert scale, both participant groups were asked to rate their confidence in relation to specific strategies related to information seeking and use, utilizing questions modified from the Self-directed Information Literacy Scale (SIL) (Douglas, Purzer, Fernandez, Fosmire, & Van Epps, n.d.) In this paper, the researchers analyze three of the seven questions.

When comparing students and engineers, the most significant differences in results, as shown in Figure 1, were seen in questions related to knowing where to look for information, identifying the information most needed, and having an effective organizational system. For each category, student responses had a significantly higher mean ($p<.01$), indicating a higher level of confidence in their understanding of information literacy competencies. The fact that more novice respondents (the students) exhibit higher confidence levels than experts is a well-known effect (Kruger & Dunning, 1999) that has been observed in many disciplines, including in libraries (Gross & Latham, 2007, 2012). It might also be that students are faced with less complex and more well-structured problems than practitioners, so they may feel more confidence because they have had more straightforward tasks to complete in their educational experience. From an educational perspective, in order to prepare students to be effective in their workplace, we may need to a) help them achieve a realistic idea of their own skill level, so that they are amenable to improving, and/or b) provide more authentic problems that require students to engage more deeply with information and assess that work to reinforce its importance.

When looking at the engineers' responses, we see that the questions of knowing where to look for information and having a highly effective organizational system received mean responses of about 4 out of 7, or a 'neutral' level of confidence. The level at which engineers feel confident in identifying the needed information for their projects was less than 5 out of 7, or just slightly higher than neutral. These indicate that engineers struggle with searching for information, scoping the problem, and organizing information effectively. Organizing information effectively was also the area in which students were least confident in their ability. The engineer responses are reinforced by their answers to the open-response questions of the survey, discussed below.

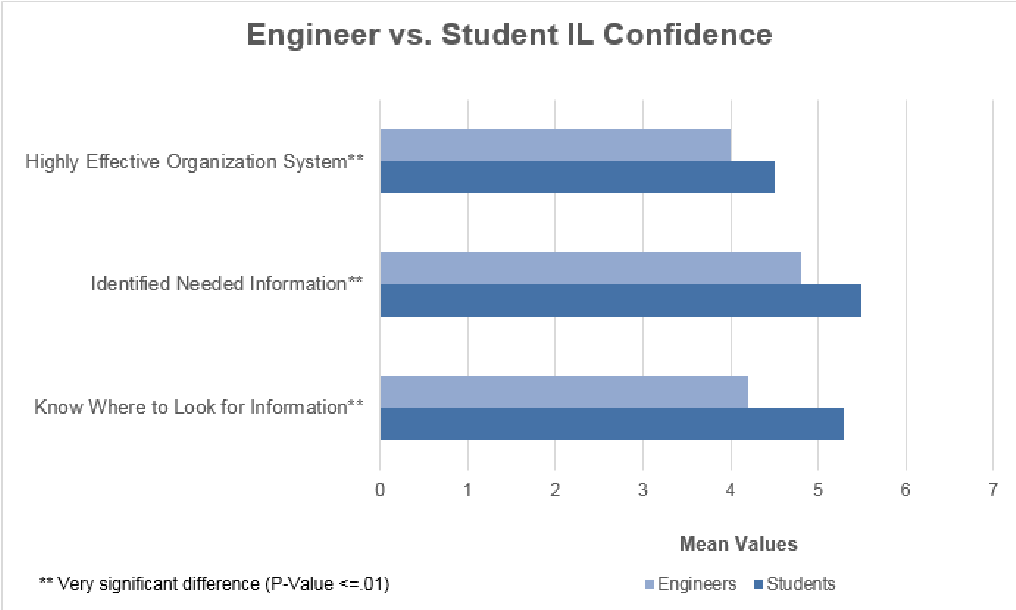

Figure 1: Comparison of student and engineer response to questions about their confidence in information literacy practices.

The Caterpillar survey was made available to engineers at all their corporate locations. Across different regions, the most significant differences in response were observed between North America and Asia Pacific. Uniformly, the mean responses from North America were higher than Asia Pacific responses, and in four out of the seven questions, the differences were significant ($p<.05$). Figure 2 shows a breakdown of the engineer responses by region for three selected questions. These differences could be a result of the main physical branch library being located in North America (e.g., the lack of a physical library location in China may decrease the confidence of respondents from the Asia Pacific region). Caterpillar info specialists need to determine whether the differences may be due to different cultural behaviors and attitudes, access to resources in different locations, training in research strategies while in school, awareness of the information systems generated and maintained by groups in the U.S, or other factors or combinations of factors.

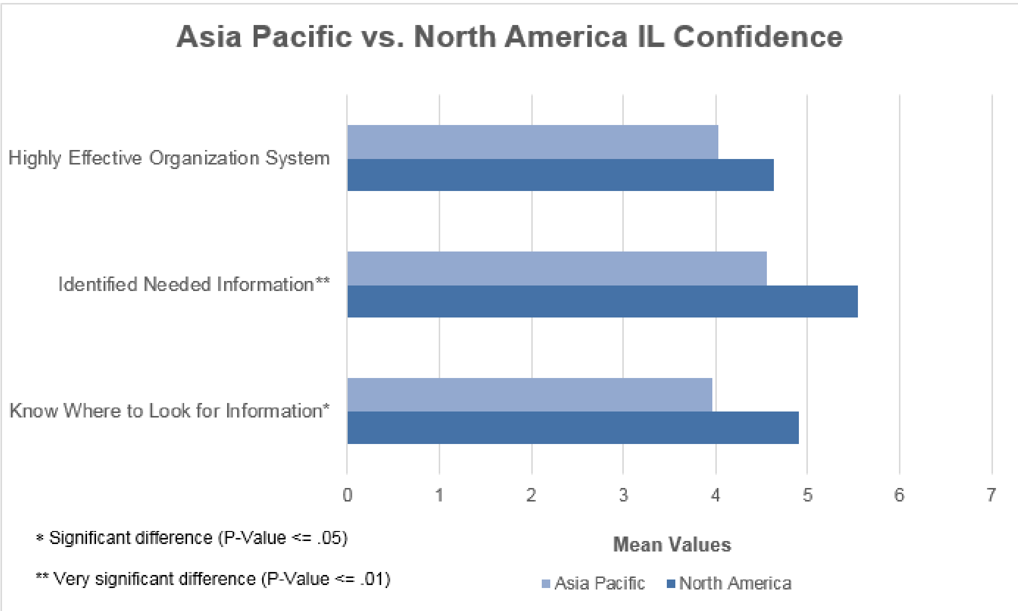

Figure 2: Comparison by geographic region of Caterpillar engineers' responses to questions about their confidence in information literacy practices.

Qualitative
The surveys asked three common open-ended questions of the students and engineers, pertaining to: their frustrations with information gathering or use, information resources to which they did not have access that they would have liked for a particular project, and keeping abreast of information in their field or major.

There were 115 responses collected from 55 students pertaining to information frustrations. As shown in Figure 3, locating information or data is the students' top frustration (45% of all responses), followed by evaluating information (17%), accessing information (10%), and other frustrations (28%). The "other" category includes training, using information, determining information needs, and general frustrations.

134 engineers gave 224 responses about their information-gathering and use frustrations. The results show that locating information or data (71%) is also the primary frustration to engineers. It should be noted that 67% of the engineers' comments about locating information or data referred to challenges with internal systems, such as there being too many places to look or an internal search engine not performing as expected. Accessing information (10%) and evaluating information (9%) ranked as the second and third top frustrations for engineers.

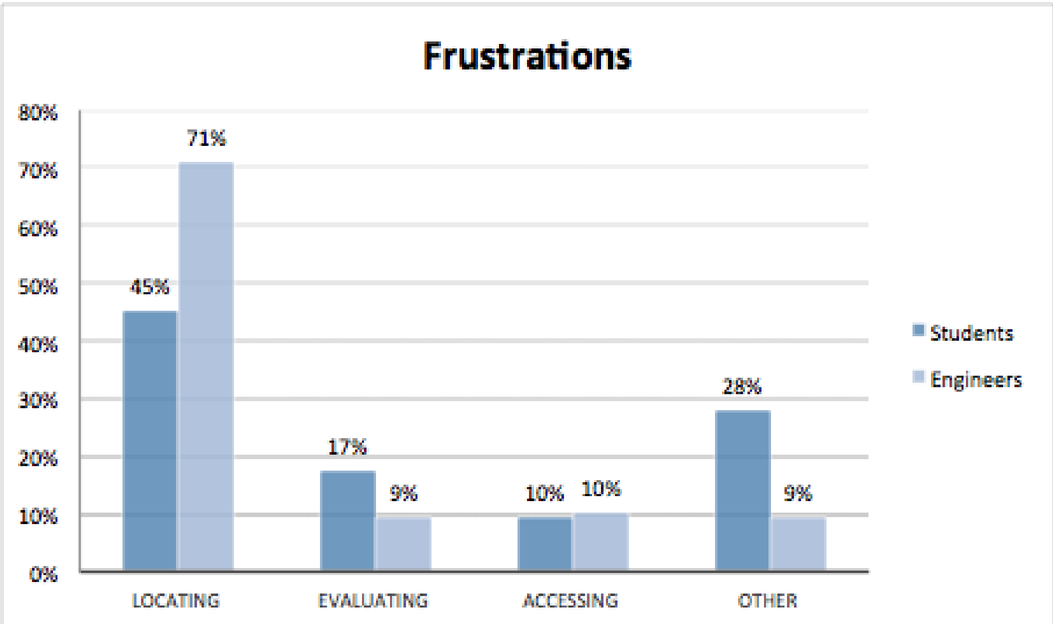

Figure 3: Percentages of open-ended responses describing different kinds of information-related frustrations respondents encountered during their last project. *Note: the engineer percentages do not add up to 100% due to rounding.*

In regard to information resource access, 53 responses were collected from students and 67 responses were collected from engineers. The students and engineers held distinct views on whether they had desired access to the information resources. As shown in Figure 4, over half (57%) of the students believed that they had access to enough information to complete projects, while 26% of the students responded that they needed access to information such as standards, existing product information, and marketing data. However, only 25% of engineers thought they had adequate access to needed information or data. 66% of the engineers indicated needs for more access to either internal and external information or data. The "other" category represents resources like people, labs, and software.

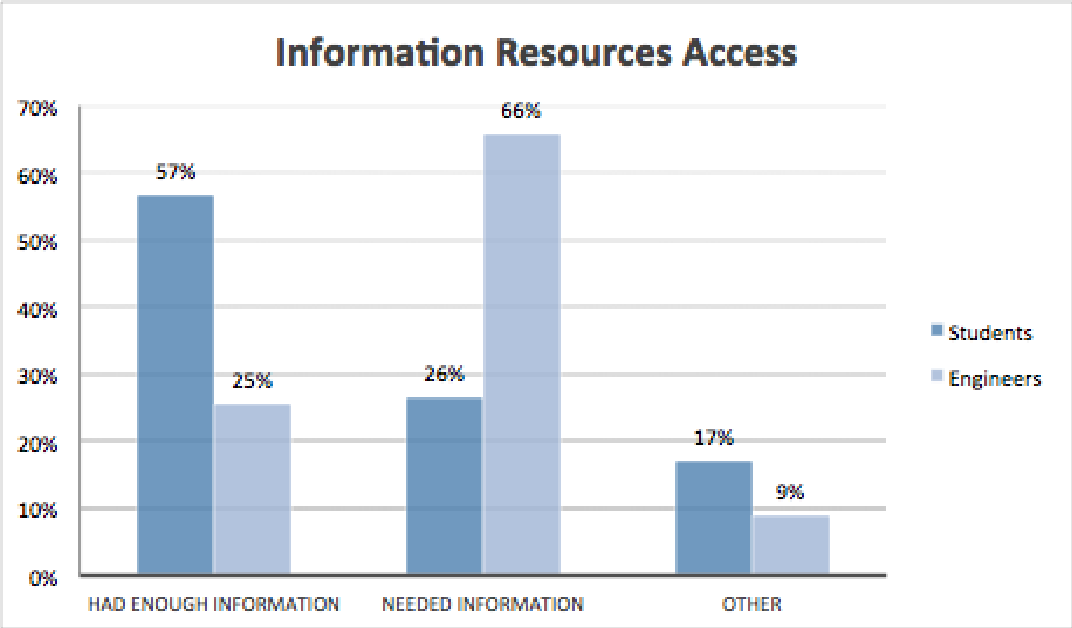

Figure 4: Percentages of free responses indicating students/engineers a) were able to find enough information for their last project, b) needed to find more information, and c) comments of need not explicitly related to information (e.g., needed more time to work).

The researchers collected 71 responses from students and 195 responses from engineers to for the question pertaining to how they keep up-to-date with information in their field.
Figure 5 shows the students and engineers expressed different preferences on keeping abreast. The students considered news (25%) as their prominent method of staying up-to-date with information in their field or major. Communicating with instructors, peers, classmates, or other people (20%) is the second primary way for students to be informed. 13% of the students indicated that they used social media for updates. Both students and engineers shared similar preferences on using the Internet and reading journals to learn current trends. The engineers showed much less interest in news (6%) and using social media platforms (1%). Communicating with people (16%) is the most prominent way engineers report staying informed, which is consistent with previous studies by Tenopir & King (2004). Additionally, in another survey question, 65% of the students indicated they use online videos (e.g., YouTube) to acquire information.

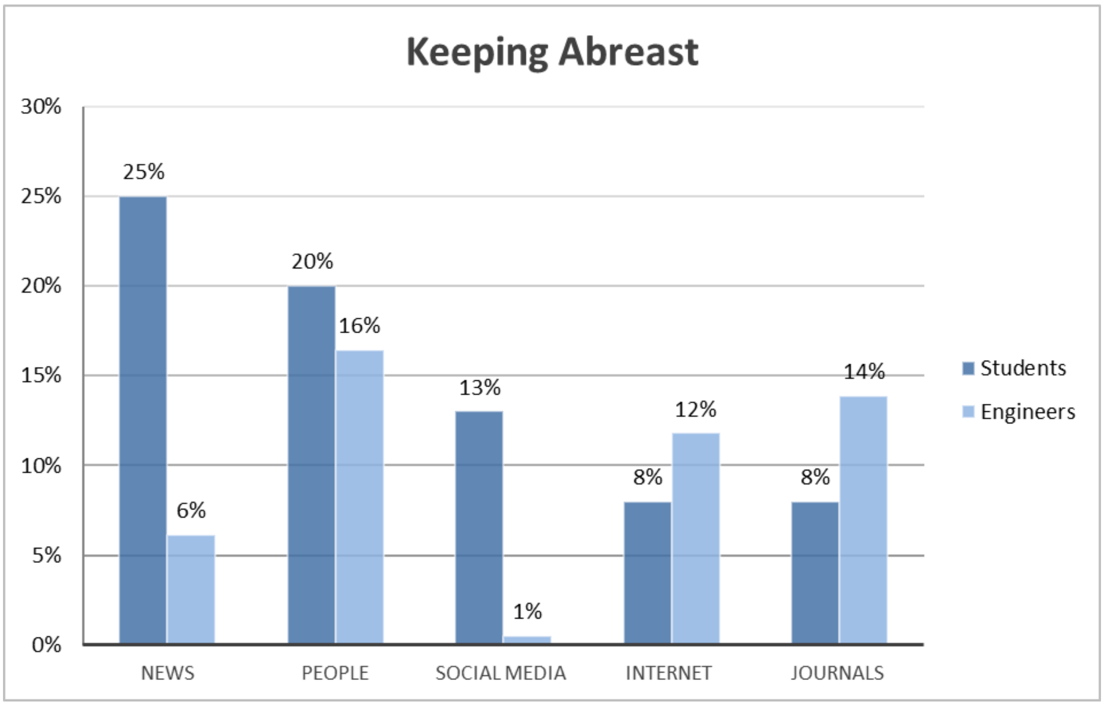

Figure 5: Most popular external resources (i.e., outside of the internal organization) students and engineers indicated they used to stay abreast of developments in their major/field, as a percentage of all responses.

Discussion

Engineers

Based on the observed significant differences in information-seeking habits between students and practicing engineers outlined above, the Caterpillar researchers are developing new information delivery strategies. Part of this strategy centers on adjusting onboarding practices to better align with information behaviors and preferences of recent graduates. While very few engineers reported following social media or watching videos as a preferred method for finding information for a project, the majority of students indicate they use these modes as resources. Assuming newly hired recent graduates will have similar information-seeking behaviors to engineering students, the researchers created an internal social media strategy for communicating information about available resources, video-based tips for searching, and simplified steps for using internal systems.

The authors are also developing a more formalized onboarding training process for newly hired engineers to improve awareness and use of library services and subscriptions, and of internal knowledge management systems. One quick-start method was to initiate a process for sending welcome emails to new engineering hires globally, to bring attention to available library resources, knowledge management systems, and research services. The inclusion of a short introductory video will be added, along with a link to the collaborative social media community.

In the future, the authors plan to develop an online information literacy course for Caterpillar engineers, with the objective of coaching new hires on how to best navigate the unfamiliar and decentralized information environment at Caterpillar. A secondary goal for this course is to embed the learning of information seeking skills for participating engineers using a combination of videos and outlined research tasks that will require participants to utilize library resources.

Students

The results of the study led the Purdue authors to focus on developing new skills for their students, including being more intentional about teaching information organization skills and exposing students to a wider variety of technical information resources. The authors also renewed investment in developing online content to address students' preferred learning styles.

Although many libraries provide instruction on using citation-management software, we believe the problem goes deeper than just a “tools” problem. Rather, students need to think about a coherent organizational and communication strategy for the information they gather and utilize in their projects. They need to consider file structures, sharing mechanisms, annotating, evaluating, and summarizing information sources, among other considerations. The authors have worked with disciplinary instructors to broaden the time spent with students to include a knowledge management component, before the students even start searching, in alignment with the Information-Rich Engineering Design (I-RED) model for informed engineering design (Fosmire & Radcliffe, 2012).

Armed with the evidence of student information habits, the authors have also successfully advocated for the inclusion of in-depth instruction on the relevance and use of technical standards, patent information, and materials properties. In the case of technical standards, two of the authors received a grant from NIST to develop an online standards education program (Phillips, Fosmire, & McPherson, 2017), which can be used as the basis for a flipped classroom approach to integrating standards, or as a point-of-need resource for instructors to have students work through to prepare them to understand, locate, and use standards effectively in the context of a project.

The evidence of student use of online resources justified the investment in hiring an instructional developer in the science, engineering, and technology division of the Purdue Libraries to facilitate librarians sharing their expertise in an online environment.

Conclusion

The comparison of the academic and corporate information environments gave both the Purdue and Caterpillar authors’ significant insights into gaps practitioners and students face in their ability to navigate, incorporate, and share information effectively and efficiently. We also uncovered differences within each organization, between North American and Asia/Pacific employees and between engineering and technology students. Libraries, both corporate and academic, need to take a proactive approach to address the changing information landscape as well as the changing characteristics of the workforce.

On the corporate side, information centers need to embrace the “digital native” employees that are coming on board, who may not necessarily have stronger technical skills than previous generations but do have different ways of navigating for information. This means providing short videos and just-in-time navigation aids for corporate knowledge management systems and considering how the “point-and-click” generation of searchers will interact with knowledge management infrastructure. One facet that has traditionally distinguished corporate and academic libraries has been the internal knowledgebases that corporations use to steward their intellectual property for competitive advantage; however, with the rise of academic institutional repositories for data and documents, the distinction has blurred. With so much information available from a variety of sources—the “big data” phenomenon—the corporate information center needs to embrace its role as a leader in knowledge management principles for the entire organization, perhaps collaborating with central information technology to develop efficient, effective, and user-friendly ways of accessing information.

From the academic side, libraries traditionally tend to concentrate on organizing and making accessible the published literature, which leaves students unprepared for working in a modern work environment that generates its own information ecosystem with both external and internal information sources. Libraries can benefit from recognizing the preferences of engineering and engineering technology students, who can be less excited by textual resources in favor of dynamic, visual, practical sources of information (e.g., YouTube how-to videos) and understand how libraries can address the learning needs of students in more engaging, hands-on ways. Students need to be made aware of information practices that involve not only consuming but also generating information for the organization, in alignment with ACRL's Framework (Association of College & Research Libraries (ACRL), 2016). Universities tend to have much larger collections, both electronic and physical, than corporations, reflected perhaps in the much higher satisfaction with availability of resources among students than engineers (although they may also have lower needs for information). Certainly, preparing students for the transition from ubiquitous access to peer-reviewed information to a more focused and internally generated literature landscape will be important.

Working in an increasingly connected environment, corporations might have employees spread out across the globe, staffed by employees raised in different cultures. Similarly, universities with increasingly international student populations need to be responsive to the variety of cultural backgrounds of their students. As seen from the responses from North American and Asia/Pacific engineers, there can be a much different familiarity with information resources and confidence in navigating those resources. This means regionally responsive training and orientation programs might be required to effectively onboard and integrate employees from different areas.

The authors present results from a relatively small sample of the universe of corporate and academic institutions; nevertheless, the results have yielded helpful insights for all of the authors that have already led to changes in instruction, infrastructure, and even fundamental perspectives of the role of libraries and information centers in the two parent organizations. Nevertheless, the authors believe more investigation of information habits, needs, and opportunities needs to occur to address different populations of students, including academic institutions across the globe, as well as different kinds of corporate, governmental, and non-governmental organizations working in technical areas. The authors encourage others to explore these questions with their own constituents to add to the global knowledgebase of information needs, as well as target changes in their organizations to address information gaps they identify.

References

ABET. (n.d.). Engineering vs. engineering technology. Retrieved April 11, 2018, from http://www.abet.org/accreditation/new-to-accreditation/engineering-vs-engineering-technology/

Association of College & Research Libraries (ACRL). (2016). Framework for information literacy for higher education. Retrieved April 11, 2018, from http://www.ala.org/acrl/standards/ilframework

Douglas, K., Purzer, S., Fernandez, T., Fosmire, M., & Van Epps, A. (n.d.). *Self-directed information literacy scale*. West Lafayette, IN: Unpublished, School of Engineering Education, Purdue Unviersity.

Forster, M. (2017). *Information literacy in the workplace*. London, England : Facet Publishing.

Fosmire, M., & Radcliffe, D. F. (2012). Knowledge-enabled engineering design: Toward an integrated model. In *Proceedings of ASEE Annual Conference and Exposition*. San Antonio, TX. Retrieved from https://peer.asee.org/21631

Ganley, B. J., Gilbert, A., & Rosario, D. (2013). Faculty and student perceptions and behaviours related to information literacy: a pilot study using triangulation. *Journal of Information Literacy*, *7*(2). https://doi.org/10.11645/7.2.1793

Gross, M., & Latham, D. (2007). Attaining information literacy: An investigation of the relationship between skill level, self-estimates of skill, and library anxiety. *Library & Information Science Research*, *29*(3), 332–353. https://doi.org/10.1016/J.LISR.2007.04.012

Gross, M., & Latham, D. (2012). What's skill got to do with it?: Information literacy skills and self-views of ability among first-year college students. *Journal of the American Society for Information Science and Technology*, *63*(3), 574–583. https://doi.org/10.1002/asi.21681

Kruger, J., & Dunning, D. (1999). Unskilled and unaware of it: How difficulties in recognizing one's own incompetence lead to inflated self-assessments. *Journal of Personality and Social Psychology*, *77*(6), 1121–1134. https://doi.org/10.1037/0022-3514.77.6.1121

Phillips, M., Fosmire, M., & McPherson, P. B. (2017). Standards are everywhere: An information literacy approach to standards education. Retrieved April 11, 2018, from https://docs.lib.purdue.edu/lib_fscm/16

Phillips, M., Fosmire, M., Petersheim, K., & Turner, L. (2016). Survey protocols to investigate the information habits and needs of engineering and engineering technology students and practicing engineers. Retrieved April 23, 2018, from https://docs.lib.purdue.edu/lib_fscm/17

Rodrigues, R. J. (2001). Industry expectations of the new engineer. *Science & Technology*

Libraries, *19*(3–4), 179–188. https://doi.org/10.1300/J122v19n03_12
Ross, M. C., Fosmire, M., Wertz, R. E. H., Cardella, M. E., & Purzer, S. (2011). Lifelong learning and information literacy skills and the first year engineering undergraduate: Report of a self-assessment. In *Proceedings of ASEE Annual Conference and Exposition*. Vancouver, Bristish Columbia. Retrieved from https://peer.asee.org/18284
Tenopir, C., & King, D. W. (2004). *Communication patterns of engineers*. Hoboken, NJ: Hoboken, NJ : John Wiley.