Multimedia Instructional Resources for Nonpractitioners

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Problem Statement

Some fields within the social and behavioral sciences (SBS) suffer from visibility problems. Nonpractitioners have never heard of some disciplines (e.g., human factors), or they know very little about the value of a particular field (e.g., psychology). Fields such as human factors and psychology may be viewed negatively as "soft" sciences that have little in common with other scientific fields such as engineering and physics. One approach to combat such issues is to generate better awareness by conveying critical information to nonpractitioners in an accessible and engaging multimedia format. At present, however, the U.S. lacks a national effort to promote widespread understanding of the value and contributions of SBS.

Background and Discussion

Gaps in Engineering Curricula. One factor impacting a lack of awareness of SBS disciplines stems from gaps in engineering curricula. The National Academies of Sciences has a long history of exploring issues in engineering education. In 1980, an engineering task force conducted a survey to identify top concerns regarding engineering education (National Academy of Engineering Task Force on Engineering Education, 1980). Analysis of survey responses from 396 engineering professionals in academia, industry, and government revealed a concern that engineering curricula do not adequately prepare engineers to contribute to the entire range of activities involved in technology design and development. For example, respondents indicated that university graduates are deficient in the verbal and written communication skills that are critical to effective performance in industry. Respondents also recommended expanding the typical engineering curriculum to include course requirements in other areas such as ethics, the social sciences, history, the arts and humanities, and business management.

These concerns were still evident in a subsequent report published in 2005 (National Academy of Engineering of the National Academies, 2005). The committee for that report concluded that engineering programs should introduce interdisciplinary learning early in undergraduate school:

> Technical excellence is the essential attribute of engineering graduates, but those graduates should also possess team, communication, ethical reasoning, and societal and global contextual analysis skills as well as understand work strategies. Neglecting development in these arenas and learning disciplinary technical subjects to the exclusion of a selection of humanities, economics, political science, language, and/or interdisciplinary technical subjects is not in the best interest of producing engineers able to communicate with the public… (p. 52)

Other experts outside the National Academies have identified and discussed similar gaps in engineering curricula. Vicente (1999) describes the Ontario Power Generation decision to shut down 7 of its 20 nuclear power plants in 1997, not due to flaws in the technical design, but due to numerous human and organizational factors that presented serious threats to safety. The plants had been designed and operated with insufficient consideration of human capabilities and limitations, which placed unnecessary burdens on the operators and increased the probability of human error. As Vicente (1999) states, "the failure to pay sufficient attention to human and organizational factors in this case (and many other cases in industry) is indicative of a significant gap in engineering education" (p. 22). Students receive technical training that prepares them to create the types of innovative technological designs evident in the nuclear power plant reactors, but "the vast majority do not take a single course devoted solely to human factors in contemporary engineering projects" (p. 22). Consequently, engineers may not be equipped to deal with the types of issues that can occur in sociotechnical systems in which people and technologies must interact successfully to achieve effective system performance. Vicente (1999) argues that just a single human factors course is sufficient to expose engineering students to the relevance of human and organizational factors for the engineering enterprise.

Finally, similar issues are echoed in one of the most recent papers addressing the challenges facing engineering education (Schell, Sobek, & Valazquez, 2016). The authors acknowledge the need to include coursework that promotes more diverse development of engineers in order to meet current industry demands; however, they maintain that engineering schools are not yet doing enough to change their programs. Engineers need to be technically competent and well-rounded. If educational programs do not support this goal, the workplace becomes populated with technical experts who lack relevant knowledge in other arenas such as SBS, which creates problems for SBS practitioners who must collaborate with engineers.

Perceptions of SBS. An additional issue is the common perception among professionals outside the SBS community that human behavior is too variable and unpredictable to adequately portray within a system. The end result is that the technological component of a system becomes the focus of attention. The human component of the system may be poorly addressed, if it is considered at all (Schatz, 2016). As Cerri (2016) puts it:

> There are several generally accepted ideas held by many, if not most people, including engineers, scientists, technologists, and technical managers. The first idea is that people are mysterious and unpredictable creatures. For the typical engineer, scientist, or technologist, this idea often takes the form of a statement such as, "Science and the laws of physics are predictable and consistent. People, on the other hand, are just about as predictable as the weather."…it is much easier to deal with the laws of physics, or software, or circuitry, or biology, or dynamics, or geology, than it is to deal with the constant emotional unpredictability of people. (pp. 19-20)

Generating Awareness for Nonpractitioners. While an ideal approach to address SBS visibility among nonpractitioners would entail implementing requirements for SBS coursework in all engineering programs, it is important to recognize that instilling an appreciation for SBS and its critical role among other scientific fields does not necessarily require formal education *per se*. In recognition of this notion, See (2017) conducted a pilot study to generate awareness of the value and applicability of human factors for safety assessors in the U.S. Nuclear Security Enterprise, most of whom possess bachelor's or master's degrees in engineering. See (2017) developed a condensed "Human Factors 101" course that included short one-page descriptions of 18 core human factors topics. The topics were explicitly written to be informative, yet also engaging and interesting for a general audience. Each topic contained four basic elements:

- Real-world example
- Fundamental information for each topic
- Example specific to the Nuclear Security Enterprise
- References for additional information

Over a period of 18 months, one topic per month was e-mailed to safety study members at Sandia National Laboratories, one of eight sites within the Nuclear Security Enterprise. Feedback at the end of the pilot study indicated the approach was successful in generating awareness of human factors and useful for on-the-job applications. Respondents rated their current knowledge of human factors as "somewhat" to "much" better and stated they were aware of a broader range of human factors concerns by the end of the study. All respondents stated they applied information from one or more of the 18 topics in some way on the job.

The success of this simple paper-based approach was encouraging. However, See (2017) concluded that a set of interactive multimedia instructional modules might be even more effective to reach diverse audiences. In fact, the *multimedia principle* asserts that people learn more deeply from words and graphics than from text alone (Mayer, 2014). For example, in 11 different experiments, Mayer (2014) found that students who experienced multimedia instruction were better equipped to apply what they had learned in novel situations (i.e., transfer tests) as compared to students who learned from text alone. Further, one of the core assumptions of the cognitive theory of multimedia learning—*active processing*—has considerable research evidence indicating that meaningful learning occurs when students are actively engaged in the learning process (Czaja & Drury, 1981; Mayer, 2014). Active processing includes selecting relevant material, organizing it, and integrating it with prior knowledge.

Recent advances in graphics technology now more fully support a broad range of multimedia presentations such as illustrations, charts, photos, videos, and animation. Some SBS multimedia approaches do currently exist, but they tend to take an academic approach or target very specific audiences (e.g., the FAA 10-module Web-based course for the FAA workforce). They may adequately convey the facts, but do not necessarily "sell" the excitement of SBS or promote an understanding of the value and contributions of SBS. There is currently no organization-independent approach that is accessible to everyone, regardless of affiliation; appeals to general audiences; and fully incorporates research-based principles for effective learning.

Recommended Research Strategies

The research necessary to implement a standard set of SBS multimedia awareness approaches already exists. The task at hand would be to convene an organized forum of SBS experts to strategize an overall approach for a national effort to promote widespread understanding of the value and contributions of SBS. Critical questions to address include the following:

- Should there be an overarching module that covers SBS in general?
- Can the various SBS disciplines be prioritized with respect to the need for generating awareness?
- Can a consistent approach that crosses disciplines be developed?

Benefits

Investment in a standard set of SBS instructional approaches for nonpractitioners could have far-reaching benefits. In terms of the possible contributions identified in the *Second Call for White Papers*, this effort would build coordination and improve communication among researchers, analysts, policy and decision makers and among teams. It would help address the recurrent observation that engineering curricula require more diversity to promote development of well-rounded engineers who approach design with all elements of sociotechnical systems in mind. Finally, this effort could help combat common SBS myths and misconceptions among nonpractitioners.

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