UNIVERSAL DESIGN OF ENGINEERING EDUCATION

Variawa, C; McCahan, S.

Department of Mechanical and Industrial Engineering, University of Toronto, Ontario Canada
variawac@mie.utoronto.ca; mccahan@mie.utoronto.ca

INTRODUCTION

An accessible learning environment, ideally, is an environment in which every student has equal access and is assessed on an equal basis. Given the diversity of the student population this ideal may never be fully achieved. However, recognizing that the accessibility of learning, from the student perspective, is a function of many factors including cultural factors, learning styles, and learning disabilities, can aid us in developing learning environments that are more accessible to a broader range of students.

The design of accessible environments has roots in Universal Design (UD), a concept largely developed in architecture by Ron Mace for the design of public spaces to be accessible for the broadest range of users to the greatest degree possible^{1,2}. The underlying concept in UD is to incorporate accessibility into the design process from the start, rather than a posteriori. The goal of this approach is to increase the usability and potentially the functionality of a design for a diverse population. In addition to promoting usability, it has the potential to increase inclusivity for a greater number of users as well. UD in engineering is now generally widespread: ramps originally intended for wheelchair users are also usable by strollers and delivery-people, and text-messaging on cellphones assist both the hearing-impaired and those who want a silent conversation, and so forth. Additionally, the importance of this approach has played a role in the development of legislation (Americans with Disabilities Act³, Telecommunications Act⁴) to mandate increased accessibility for a greater number of users. The principles of universal design advocate flexibility in use, intuitive design, and among others, equitability¹.

The applicability of UD in educational settings has also been explored to some degree. Universal Design in Education (UDE) is an offshoot that aims to develop a learning environment that is inclusive and accessible for a broad range of students. Various authors^{5,6,7} have discussed the implications of UDE in terms of standardization, testing, creation of social relationships, and effective learning, among other ideas. Although it may be easy to see how UD benefits physical spaces, the application and effectiveness of UDE is more difficult to assess. In an engineering design we seek to achieve measurable objectives; in UDE however, the ever-changing diversity of the learning population demands that the learning environment be dynamic and inclusive. The challenge is to create a flexible environment while maintaining the integrity of the learning objectives, and measure the effectiveness of changes in terms of achieving accessibility.

Engineering education is also a designed system – it follows a design process, has a specified user-group, contextualizes problems into manageable quantities, etc. – and thus, it should also benefit from a universal design approach to increase inclusivity. The applicability of such pedagogy in instruction has been investigated in the fields of higher education and disability studies, but not in an engineering context⁸. The importance of understanding UDE in engineering is high because educators routinely contextualize problems to increase authenticity for the purposes of instruction and assessment. If the context of an engineering problem is not clear to the students, then it renders the instruction inaccessible.

THE RESEARCH

Our research aims to identify potential accessibility barriers in engineering education, and use UDE principles, and other information on accessibility, to mitigate these barriers. Ideally mitigation strategies can benefit many students, not just those with identified disabilities (i.e. the “curb cut” effect). The goal is to minimize barriers to learning by promoting accessibility and inclusivity, and to facilitate an approach similar to UD currently used in other areas of engineering to maximize usability: or, in this case, learn-ability. Although there are many aspects of accessibility that can be explored, our current research is examining the validity of engineering assessment instruments (tests and exams). Specifically, our preliminary study⁹ assesses whether language used to contextualize problems on exams compromises the validity of the assessment by testing colloquial vocabulary instead of course-related material. For example, consider the following engineering problem: Calculate the magnitude and directions of the centripetal force acting on

an F-1 car while cornering through a chicane. Here, the contextualization of the problem creates difficulty for students who do not know what the terms ‘F-1 car’, and ‘chicane’ mean. This type of contextualization difficulty arises from colloquial cultural, technical, and linguistically-difficult terminology and phrasing: all of which are learning barriers.

In a preliminary study participants were given ten colloquial words that are typical of what could be found on engineering exams. The participants were asked to score their understanding of each word: this is called the “perceived-understanding” score. They were also asked to provide a written definition. The definitions provided were compared against a dictionary definition to formulate an “observed understanding” score. Comparing these two scores for each word, it was found that culturally-based words generally could be classified as “visible” learning barriers: there was a relatively high degree of correlation between the perceived- and observed-understanding scores. Essentially, if a student did not know the word, they were aware of the deficiency. For other words, however, the correlations were weaker and the overall scores were lower indicating that these were inaccessible invisible barriers. Using an adaptation of the Johari window concept (Figure 1), these words represent a blind spot for students that is neither teachable nor learnable because both the teacher and the student are unaware of the deficiency. Ideally, we would like to expand the window to make these linguistic barriers visible to both the instructor and student thereby creating the opportunity for mitigation.

We are currently in the process of collecting more data to fully elucidate the problem. In future work we plan to explore several universal design approaches to mitigate these learning barriers. We will be investigating the efficacy of information system tools that could be used to improve the accessibility of assessment instruments in engineering while maintaining the integrity of the learning objectives in a course or program.

Figure 1: Adapted Johari Window.

REFERENCES

1. North Carolina State University. Center for Universal Design. Available at: <http://www.design.ncsu.edu/cud/univjdesign/ud.htm>. Accessed: March 11, 2010.
2. Wilkoff, W. L., and Abed, L. W. (1994). *Practicing universal design: An interpretation of the ADA*. New York: Van Nostrand Reinhold.
3. Americans with Disabilities Act of 1990, P.L. 101-336, 104 Stat. 327, 42 U.S.C. 12101 et seq.
4. Telecommunications Act of 1996, P.L. 104-104, 110 Stat. 56.
5. McGuire JM, Scott SS, Shaw SF. Universal design and its applications in educational environments. *Remedial and Special Education*. 2006;27(3): 166-75.
6. Pliner SM, Johnson JR. Historical, Theoretical, and Foundational Principles of Universal Instructional Design in Higher Education. *Equity & Excellence in Education*. 2004;37(2): 105-113.
7. Chickering AW, Gamson ZF. Seven Principles for Good Practice in Engineering Education. *AAHE Bulletin*. 1987;40(7): 3-7. Available at: <http://catedraunesco.es/modeloeducativoupm/documentos/2.pdf>
8. Variawa C, McCahan S. Design of the Learning Environment for Inclusivity. *Proc. of ASEE Annual Conference and Exposition*. 2010. ASEE Paper No. AC 2010-1195.
9. Variawa C, McCahan S. Balancing Content Contextualization and Accessibility in Engineering Assessment. *Proc. of 21st ACM Conference on Hypertext and Hypermedia*. 2010.