AC 2010-1140: 'EXPANDING TECHNOLOGICAL LITERACY THROUGH ENGINEERING MINOR

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(Due to the nature of this study, the names of the schools etc are not hidden from the reviewer, we apologize however, without the names the essence of this project could not be correctly captured)

This paper describes our effort to design, implement, and expand a valid platform for providing a technological literacy program that is adaptable for a wide range of engineering educational institutions. In order to achieve this we have established a synergetic collaboration between Iowa State University, Ohio State University, Hope College, and Rice University. Each school has initiated programs or classes in technological literacy and with this project we will be working to expand on the efforts and unify our activities and establishing working models for technological literacy in a form of engineering minor programs offered by engineering units. The minors are not intended to instill detailed engineering design-level abilities in non-engineers. Instead, the minor aims to develop the broad understanding and practical technological competence outlined by the National Academy of Engineering in reports such as *Technically Speaking*[1]. Thus decoupled from the engineering majors, the Minor in Engineering Studies at Iowa State for example has attracted students majoring in business, communications, journalism, and design. Minors can provide a recognized credential deemed attractive by many students. This paper will be introducing our goals and early effort in this research effort. The goal will be to develop the concepts and resources to support and define an appropriate minor structure that can be adopted efficiently and widely within American higher education.

Introduction

There is a national need for better technological literacy. Many studies show that future success of many nations are based on the infusion of technological literacy among the masses. Consequently, the goal for expanding technological literacy has become one of the most immediate focus of engineering educators, and the National Academy of Engineering. However, the effective way for engineering educators to educate non technical people with technological literacy is not an easy path. There have been many successful efforts to pave this path and there have been successful nationally known classes and in some cases programs that attempted to achieve technical education to non-technical students. As expected, there have been more than several US institutions that offer classes in this domain.[1-10].

Motivation

The structure of our institutions of higher education has made it difficult for non-engineers to develop any depth of understanding about engineering and technology. The engineering major has an elaborate curriculum, requires substantial prerequisite courses, and is a difficult pursuit to combine with another field of study[10-15]. Science courses emphasize knowledge of the natural world but provide little practical understanding of our complex human-built technological infrastructure. Non-engineers who complete a university natural science distribution requirement are hardly prepared to lead the world's largest economy through its present turmoil and to make informed decisions about topics such as supporting the automotive industry, developing fossil fuel alternatives, or appropriate regulation of nanotechnology[16-21].

Minors in the domain of technological literacy can provide an efficient and credible way for non-engineering majors to obtain a practical and meaningful degree of technological literacy. These minors are not intended to develop design-level engineering knowledge, but rather is based on the general competencies advocated by the National Academy of Engineering in such documents as *Technically Speaking*[1] and *Tech Tally*[21]. Minors can combine several courses, achieving a balance of depth and breadth that is not possible in a one- or two-course distribution requirement. A minor also provides a formal credential that students can use when entering the job market—a strong incentive and motivating factor for many students.

Our team builds on the promising results from the Minor in Engineering Studies at Iowa State University. Started in 2006, the Iowa State Minor in Engineering Studies has attracted many non-engineering students participating in the program. Thus far, eight students have graduated with the minor degree; of these, three are working in technology-related companies. One graduate, a female non-engineering major, completed the Minor in Engineering Studies, reevaluated her career plans, and is now pursuing a graduate degree in aerospace engineering.

The approach and goals

We are working on a collaborative approach to expand the Iowa State effort in technological literacy among a diverse set of institutions. This work involves four different schools with different strengths, sizes, emphases, and student populations to design, implement, and expand a successful platform for developing a technological literacy program at the collegiate level.

The intent of the proposed work is to bring the development of the minors to a state that one can be easily adopted by any engineering department. To achieve this objective, the collaborating institutions will be working in the areas of: developing consistent learning outcomes, creating learning materials and teaching strategies consistent with those outcomes, assessing student achievement, and developing faculty expertise. In addition, since the collaborators will be utilizing curriculum materials that have proven successful at the other schools, this work will involve a moderate degree of implementing educational innovations.

Due to the diverse nature of the institutions in order to develop the best collaboration, program development, and expansion, the members have created basic program objectives to be shared by all team members as a guideline for a sustainable development. All activities in the proposed program will be guided and focused by the following objectives. The basic objectives of the program can be summarized as follows (including the deliverables as well as relevant activities that will result).

1. Technological Literacy Outcomes. Establish a set of Technological Literacy Objectives and Outcomes for a Minor in Engineering Studies.
2. Technological Literacy Outcomes Assessment Methods. Develop a set of common assessment methods for the Technological Literacy Outcomes.
3. Course Curriculum Materials. Develop and share course curriculum materials appropriate for non-engineers.
4. Graduate Student as well as Regular and Adjunct Training. Develop materials and information to be used in selecting and training graduate students and adjunct faculty to teach technological literacy courses.
5. Non-Engineering Student Motivations and Interests. Determine the most significant factors that motivate and interest non-engineers in pursuing a Minor of this type
6. Example Minors. Establish specific course sequences and curricula for Minors at each participating institution, meeting the common technological literacy objectives.
7. Online Community. Establish an online community or discussion group to serve as a means for faculty from other institutions to obtain resources and to learn about the practical issues involved in creating the minors.

The existing programs and the current efforts

Our work will utilize the findings primarily on the promising results achieved in the Minor in Engineering Studies Program at Iowa State. At Iowa state university Minor in Engineering Studies (MES) has been established since 2006 first students graduated from the program in 2008[14-16]. In addition, each participating school brings results from relevant prior work that will contribute to the project goal of refining and testing the Minor in Engineering Studies and reaching a conclusive state of development facilitating widespread adoption.

In a university-wide review of its general education requirements, Ohio State University has identified technological literacy as an insight area within general education. However, no satisfactory solutions as to how to address this insight area was established. Subsequently, the College of Engineering has completed the development and gained approval of two minors for this large state university[22]. In order to offer the most value in a minor and meet learning objectives in the most effective fashion, the conclusion was reached that it is best to view the potential audience for minors as two groups. The first group being those that will likely be working most directly with engineers in the future and who can be expected to have mathematics capability through beginning calculus. A minor for this group is termed *Engineering Sciences Minor*. The second group is those that are looking to the minor to build their technological literacy in a more general sense and who may not have as high a level of quantitative coursework background. A minor for this group is termed the *Technological Studies Minor* and is intended for the goal creating a more technologically literate citizen.

Hope College has a survey of modern technology course for non-engineers that has been cited by the National Research Council's Committee on Undergraduate Science Education as a course capable of engaging all students in science, mathematics, engineering, and technology.

Rice University has just established minors but has a long-running Introduction to Engineering Design course focusing on the construction of robots, which is taken by both engineers and non-engineers.

Each program has the effective focus that they established based on their experience and the type of historical needs for their particular students. In this program, we will work on utilizing the best efforts and the best finding, if something is working in one of the schools and the data shows the effectiveness, we will try to adopt it to other schools.

As of spring 2010, one of the introductory classes at ISU has been modified based on the findings of the efforts at Hope College. Hope College has been having a technological literacy class that introduces the concepts of engineering and helps students see the path of engineering process and how things work. The goal of the class is similar to the one at other school but in particular at ISU. Based on the success and the assessment at Hope College ISU will be modifying their class and include the approaches that have been tested by Hope College.

In addition for this program, Ohio State University is leading the efforts in identifying the Educational Outcomes and Objectives, in a form equivalent ABET definitions and Criterion 3 a-k, for technological literacy. This is one of the most significant goals of this project. We are now in the process of surveying experts for identification of the key terms, goals, definitions, expectation, and understandings of technological literacy.

Assessment

We are working on the possible assessments that can be utilized across the institutions. While there have been limited assessments in all schools we are planning to have a more modified assessment that can not only help assess the four participating universities, but also be available for those interested in developing new minor programs or classes in their institution. One of our goals is to identify the most effective and widely acceptable assessment instrument.

Outcomes accomplish part of the goal of establishing a means to create technological literacy among non-engineers. Assessment of the achievement of these outcomes is another essential component. The team is developing a set of assessment methods to accompany each of the outcomes. The existence of these methods will facilitate the establishment of engineering minors by reducing the effort needed to implement such programs.

The development of the assessment methods will proceed in the same fashion as the outcomes described above. One success full model exists and is being expanded for other school (Motivated Strategies for Learning Questionnaire, MSLQ). Items from this instrument are self-report items on a seven-point scale[19]. These measures are designed to be task-specific, that is, they measure motivation in a particular area of study. This is particularly appropriate in this project, since a focus of technological literacy is improvement in learning and motivation for engineering topics rather than learning strategies or motivational orientation for college in general. The MSLQ has been shown to be a reliable and valid measure of student motivation in higher education samples[20] as well as middle and high school samples[21].

Conclusions

This paper reports on the project definitions and plans developing national level programs for technological literacy. The goal of the project is to pilot an effort between four well established schools with different focuses and backgrounds. The schools include two large land-grant universities, a private research university and a private college. The paper introduces the study, the goals, and the process. This project is at its early infancy, the schools have been utilizing their best efforts to establish their strengths and help identify common platform for delivering technological literacy education to non-engineering students. By defining the best practices, and identifying what each program establishes, experiences, and discoveries, the project hopes to provide other interested institutions a practical platform for adopting their version of technological literacy well suited to their educational and academic needs and environment. Finally, one of the major outcomes of this project that will be useful for other programs is the better definition of the objectives and outcomes of technological literacy programs very similarly to ABET structure.

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