AC 2008-805: TECHNOLOGY COURSES FOR UNDERGRADUATES: DEVELOPING STANDARD MODELS

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The Technological Literacy of Undergraduates:
Developing Standard Models

Abstract

This paper reports the results of a workshop on the technological literacy of undergraduates convened at the National Academy of Engineering (NAE) on March 26-27, 2007. The NAE advocates that all Americans become more knowledgeable about technology. Here technological literacy is defined as the broad understanding of all types of technological devices and process not just computers. Educators in Computer Science, Engineering and Technology have a responsibility to educate all students not just those intending technical careers. Despite the need for all Americans to become technologically literate, technical literacy is not likely to gain wide acceptance until the scholarly community develops standard courses that are supported by textbooks and other course materials. This National Science Foundation (NSF) sponsored workshop sought to identify and define several models of technological literacy courses. Based on a review of courses already developed and comparisons to other disciplines, four candidate standard models were identified:The Technology Survey Course, The Technology Focus or Topics Course, The Technology Creation Course (Design Course), The Technology Critique, Assess, Reflect, or Connect Course. The technology survey courses offer a broad overview of a number of areas of engineering and technology. The technology or topics or focus course is narrower in scope and develops one well-defined area. The engineering design course, or technology creation, places an emphasis on the engineering design process to develop technological solutions to problems. The last model to emerge is concerned with assessing technological impacts, connecting technological developments to other areas of society, history and culture, or reflecting on engineering in a broader context.

Introduction

In publishing "*Technically Speaking* [1]," The National Academy of Engineering has emphasized the need for all Americans to understand and appreciate our technological infrastructure. The National Science Foundation's "*Shaping the Future*" challenged science and engineering faculty to insure that: "All students have access to supportive, excellent undergraduate education in science, mathematics, engineering and technology [2]."

This call for technological literacy has resulted in some action; however, the national efforts are thus far directed largely toward the pre-college population. The International Technological Education Association (ITEA) with support from the NSF and NASA has produced a set of standards that help define the concept of technological literacy [3]. These are intended for K-12 students. The ITEA is also working to develop program and assessment standards and curriculum materials for the K-12 audience [4]. The engineering community has responded enthusiastically to the need to increase the awareness and understanding of engineering as a career, by initiating a number of programs aimed at the K-12 students.

To achieve widespread impact, standard classes must be taught at many institutions around the country. To accomplish this, standard models of technological literacy courses must be

developed. As a beginning to this process, a workshop was convened at the NAE of representative individuals with experience relevant to improving the technological literacy of undergraduates. Participants included individuals who successfully implemented courses on technological literacy for undergraduates, representatives other disciplines such as Science Technology and Society (STS), history of technology, education, and the humanities, and representatives of the National Science Foundation and the National Academy of Engineering. Participants are listed below.

Developing Standard Models: Participants from Academic Institutions

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At the workshop, groups defined several models of technological literacy courses. An eventual goal is to create materials for both students and instructors with the intention of easy adoption and widespread use.

Candidate Models for Standardized Technological Literacy Courses.

Based on a review of courses already developed and comparisons to other disciplines, four candidate standard models were identified:
1. The Technology Survey Course.
2. The Technology Focus or Topics Course.
3. The Technology Creation Course (Design Course).
4. The Technology Critique, Assess, Reflect, or Connect Course.

The technology survey courses offer a broad overview of a number of areas of engineering and technology. The technology or topics or focus course is narrower in scope and develops one well-defined area. The engineering design course, or technology creation, places an emphasis on the engineering design process to develop technological solutions to problems. The last model to emerge is concerned with assessing technological impacts, connecting technological developments to other areas of society, history and culture, or reflecting on engineering in a broader context.

1. Technology Survey Courses.
- Address a range of technologies.
- May include social and historical dimensions.
- May include lectures, demonstrations, laboratories.
- Scientific principles usually a major component.
- Includes "How Things Work" courses
- Includes Physics courses that emphasize everyday technology.
- Could include some introduction to engineering courses.

Examples:

Bloomfield.	How Things Work: Physics of Everyday Life [8,10]
DeGoode	How Things Work [14]
Disney	Science at Work: Technology in the Modern World [15,16]
Hammack	The Hidden World of Engineering [19]
Kim	Introduction to Electro-Technology [21]
Krupczak	Science and Technology of Everyday Life [24-26]
Lienhard	Engines of our Ingenuity [29-31]
Oakley	Everyday Engineering [38]
Ollis	How Things Work [39-42]

Technology Focus or Topics Courses
- These courses tend to address a single technological topic or issue.
- Subject matter is intentionally focused rather than intentionally broad.
- May have a substantial technical or quantitative component.
- May include laboratories or projects.
- May include some social and historical aspects of the topic.

Examples:

Klein and Balmer: ....Converging Technologies at Union [7,22]
Billington, Littman et. al ....Civil Infrastructure. [8]
George ....Fuel Cells [17]
Mechtel ,Korzeniowksi et al. ....Electrical Engineering for Non-Engineers [23]
Kuc: ....Information Technology [27-28]
Norton and Bahr ....Materials [36,37]
Orr, Cyganski, and Vaz: ....Information Technology [43,44]
Pisupati, Mathews, and Scaroni ....Energy Conservation [45]
Walsh, Demmons, and Gibbs.............Materials [48]
Shraibati ....Intro to Computer Graphics Tools.[47]

In developing and teaching these courses, instructors are often working from their area of research expertise. Topical courses focused on one area of technology were characteristic of many of the courses developed under the Sloan Foundation New Liberal Arts .

3. Engineering Design for Everyone (Technology Creation or Application Courses)
- These courses focus on the engineering design process.
- May include engineering majors along with non-engineering majors
- Also includes some of the work being done with K-12 teachers.
- Includes some introduction to engineering courses.

Examples:

Baish ....Designing People, Form and Function [6]
DeGoode ....How Things Work [14]
Mahajan. and McDonald....................Exploring Technology [32]
Mikic and Voss ....Engineering for Everyone [33]
Nocito-Gobel.....................................Project-based Introduction to Engineering [35]
Whitman...Engineering for Non-Engineers [50]
J. Young ....Introduction to Engineering [20]

4. Technological Impacts, Assessment, and History Courses.
(Critique, Assess, Reflect, and Connect Courses)
- These courses emphasize the relation between technology and culture, society, history.
- May include technological policy assessment or analysis.
- Well represented in Science Technology and Society (STS) programs but not many examples offered by engineers or jointly taught.

Examples:
Carlson and Gorman, UVa: ....Invention and Innovation
Cutcliffe, Lehigh ....Technology and Human Values
Klein and Balmer. ....Converging Technologies Courses at Union [6,22]
Neeley UVa....................................Engineering in Context.
Rosa...Technology 21 [46]

Comparison to of Course Formats Across Disciplines.

All of the existing courses on technology for non-engineers were developed in the absence of any formal organizational scheme. However, the four standard models appear to be in a consistent format that can be applied to other disciplines. A comparison of the technology course models with a sampling of other disciplines is given in Table 2. Also included in the table are some example courses names in each category.

Table 2: Comparison of Technology Literacy Courses to Other Disciplines Including Example Course Names.

Activity	Engineering for Everyone (Technology Literacy)	English	Psychology
Survey	Technology Survey Courses	English 101: *Intro to Literature*	Psychology 101: *Intro to Psych*
Focus	Technology Focus Courses *Fuel Cell Systems* *Materials: Foundation of Soc.*	Focus or Topics Courses *British Literature* *American Literature*	Focus or Topics Courses *Developmental Psych* *Organizational Psych*
Create Apply	Technology Creation Courses (Engineering Design) *Intro. to Engineering Design* *Designing People*	Writing Courses *Creative Writing: Nonfiction* *Creative Writing: Poetry*	Creation or Application Courses *Research Methods in Psych* *Clinical Assessment*
Critique Assess *Reflect Connect*	Technology Critique Courses *Converging Technologies* *Engineering in Context*	Critique Course Examples: *Literature and Cultural Difference* *Literary Forms and Reformulations*	Critique, Assess, History Ex: *History of Modern Psychology* *The Psychology of Everyday Things*

Basic similarity in course models exists across disciplines. All disciplines have survey courses that are open to all undergraduate students with limited or no prerequisites. Theses courses help to define the scope and breadth of the discipline. All areas also have a focus or topics course model. Courses of this model are of narrower scope but greater in depth than survey courses. The third category of engineering design courses are analogous to English courses focusing on writing or Music courses in composition or performance.

The fourth category is the broadest in scope and possibly the most difficult to define. However all disciplines have a course model that examines activity in some type of context external to itself. This model includes discipline-specific history courses and courses focusing on critique or assessment.

One notable difference between the engineering for everyone courses and the other disciplines listed in Table 2, is that courses in each of the other disciplines are mostly located in on one department. The technology courses can be dispersed through a range of departments including: chemical engineering, civil engineering, electrical engineering, physics, history, or STS departments.

While the boundaries between categories are by no means rigid, these four standard models appear to approximate the organization of courses that has persisted in other disciplines. This provides some confidence that these models of technology courses could endure into later eras of course development.

Acknowledgement

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