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Two Minors in Technological Literacy for Non-Engineers

Abstract

University-wide review of General Education at Ohio State University brought forth the need for technological literacy as an insight area within general education. However, no satisfactory means to address this insight area was established. Therefore it has not been integrated into the general education requirements. This paper reports on subsequent work by the College of Engineering resulting in two minors that address technological literacy. The College has chosen to work from the basic description and general learning objectives developed by a recent reports of the National Academy of Engineering and National Standards for Technological Literacy. 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 in two groups. The first group being those that will likely be working 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 would be 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. This paper reports examples of these key audiences, learning goals for each minor, key curriculum components, and a proposed curriculum structure.

Development of the Minors

University review of General Education at Ohio State University has brought forth the need for technological literacy as an insight area within general education. However, to date no satisfactory solutions to address this insight area have been established. Therefore no technological literacy element has been implemented in the University's general education. In December of 2006, within the College of Engineering the Core Curriculum and College Services Committee and College Committee on Academic Affairs agreed to establish a joint six-member task force to consider what the College of Engineering could offer for non-engineering students in terms of one or more minors, with particular focus on the area of technological literacy. The task force members consulted several of the colleges with potential student interest (Business; Food, Agriculture and Environmental Sciences; Education and Human Ecology; and Colleges of Arts and Sciences), primarily through advisors and administrative representatives. Feedback received from the colleges was positive towards the concept of minors in this area. In March of 2007, the task force recommended the development of two minors. The recommendations of the report were endorsed by both college committees. The following outlines the objectives, audiences and content for two minors in the domain of technological literacy ultimately as approved at the University level in January 2009. The minors are scheduled for implementation in Autumn Quarter of 2009.

Working Definition for Technological Literacy

A review of literature and existing programs showed that there is no universally accepted definition of technological literacy. However the college chose to work from the basic description and general learning objectives developed by a recent Technological Literacy Task Force in the Colleges of the Arts and Sciences[1].

> "In the broadest sense, technology is the process by which we modify nature and society using knowledge of science and engineering to create new ways to meet our needs and wants[2]. Technology comprises the entire system of people and organizations, knowledge, and processes that go into creating and operating technological devices and systems[3]. An especially important area of knowledge is the design process, of starting with a set of criteria and constraints and working toward a solution – a device, say, or a process – that meets those conditions. Attempts to create new technology provide tests of scientific understanding, and some new technology enables new forms of scientific measurement and theorizing, so that science and technology are mutually reinforcing.
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> Understanding technology, technological literacy, encompasses three interdependent dimensions – knowledge, ways of thinking and acting, and capabilities[1]. Like literacy in other areas, the goal of courses on technological literacy is to provide people with the tools to participate intelligently and thoughtfully in the world around them. Although the kinds of things a technologically literate person must know can vary from society to society and from era to era, they are consistent with the goals of an educated person as expressed by the Ohio State University General Education model.
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> *General Learning Objectives*
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> The general learning objectives most relevant to the general education can be expressed within the knowledge and ways of thinking and acting as:
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> Knowledge
> • To recognize the pervasiveness of technology in everyday life.
> • To understand basic technological/engineering concepts and terms, such as systems, constraints, and trade-offs.
> • To be familiar with the nature and limitations of the design process in a technological system.
> • To know some of the ways technology shapes human history and people shape technology.
> • To know that all technologies entail risks, some that can be anticipated and some that cannot.
> • To appreciate that the development and use of technology involve trade-offs and a balance of costs and benefits.
> • To understand that technology reflects the values and culture of society.

Ways of Thinking and Acting
• Asks pertinent questions of self and others regarding the benefits and risks of technologies.
• Seeks information and hands-on skills related to existing and new technologies.
• Participates when appropriate in decisions about the development and use of technology.
• Can apply basic mathematical concepts related to probability, scale, and estimation to make informed judgments about technological risks and benefits."

Another useful description related to technological literacy can be found through the International Technology Education Association (ITEA) documents[4,5,6] which can be summarized as:

- A technological literacy is the ability to use, manage, assess, and understand technology. (ITEA)
- A technological literate person is a person who understands – with increasing sophistication – what technology is, how it is created, how it shapes society, and in turn is shaped by society. (ITEA)

Construct of Two Minors

In order to offer the most value in a minor and meet learning objectives in the most effective fashion, the conclusion was reached by the task force that it is best to view the potential audience for minors as two groups. The first group would be those who will likely be working 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 would be those who 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 of creating a more technologically literate citizen. In the following section, examples of key audiences, learning goals for each minor, key curriculum components, and a proposed curriculum structure are identified. Students enrolled in degree programs within the College of Engineering would not be eligible for either of the two minors.

Table 1 summarizes and differentiates audience and learning objectives for the two minors. In each case the Learning Goals are defined in a manner appropriate to the intended audience.

Table 1. Construct for Engineering Science and Technological Studies Minors

Engineering Sciences Minor	Technological Studies Minor
Key Audience	

Students who have an interest in working with technology experts/engineers and in technology based industry/environments. *Examples:* Business, Economics, Science, and Math majors *Assumptions:* Competence in mathematics through beginning concepts of calculus	Students who have interest in understanding technology at a level that will help make them be more informed citizens and perhaps more attractive to employers. *Examples:* Humanities and Arts majors *Assumption:* No particular prerequisites
Learning Goals - At the completion of the minor, students will be able to:	
1 - demonstrate a basic understanding of the engineering design process	1 - appreciate the importance of methods and underlying assumptions used in cost-benefit analysis and risk-benefit analysis by engineers.
2 – perform simple analysis and estimation using engineering methodology	2 - achieve a survey-level understanding of why particular materials and processes are used to produce simple engineering devices and systems
3 – understand the capabilities and limitations of basic manufacturing processes and engineered systems	3 - better understand the role of technology (engineering) in society and the interactions of technology (engineering) with their major field
4 – make informed decisions about the desirability of engineering activities by weighing the benefits of those activities against the risks.	4 – understand how to access and interpret reliable information to make informed decisions regarded technological issues
5 – work effectively as a member of a team including technological experts.	
Key Curriculum Components	
Understand fundamentals of engineering science and design (beginning calculus prerequisite)	"How it works" (minimal level of prerequisites)

• Introduction to Engineering
  o Design process
  o Communication with graphics tools
  o Numerical approaches to problem solving
• Science base and complimentary engineering science base
• Computational technology competence
• Appreciation of interaction of technology and society
• Capstone interdisciplinary teamwork experience.
	• Introduction to Engineering
	  o Design process
	  o Communication with graphics tools
	  o Quantitative approaches to problem solving
	• Science base
	• Computational technology competence
	• Appreciation of interaction of technology and society

Prerequisites: First Calculus; and Natural Science Dependent on Engineering Science selected.	Prerequisites: Any Gen Ed approved Natural Science course.

Curriculum Structure for Two Minors

The curriculums shown in Table 2 are structured appropriately to the background and needs of the audience. (Note: All course credits are in units of quarter system hours.)

Engineering Sciences

The two core courses for the Engineering Sciences minor are two first courses currently taken by all engineering majors. These courses form foundational knowledge and skills that are important to the engineering profession and following courses. Since teamwork, communications and a design experience are included as significant elements of these courses, they will no doubt contribute to the ability of the non-engineering students to work with those oriented towards engineering and understand the engineering design process. The minor adds more depth by the requirement of an Engineering Science course and a Computation Technologies course. These courses will give the student exposure to technical knowledge engineers use through the design process. Criteria for engineering science courses includes that the course must be available to the students without prerequisites beyond selection of an appropriate natural science course and a basic calculus course. The minor is enhanced by an element reflected by a course in the domain of Technology and Society. The capstone class for the minor gives the student direct experience working as part of an engineering design team. This should directly build their skills towards the objective of being able to work effectively with technological experts.

Technological Studies

Two options are available for the core element of the Technological Studies minor. For the first core option, two new courses are included specifically to introduce technological concepts for a non-engineering audience. Technical and practical aspects of several technology areas will be explored. A prerequisite of one science course from Biology, Chemistry or Physics, as these are considered fundamental sciences, is required. The natural science requirement assures at least some exposure in this area. The second core option may appeal to those who have the higher mathematics prerequisite and want a quantitatively more rigorous approach. Facility with computational technology is needed for technology considerations, leading to the curriculum requirement in this area for both minors. Students also need to be able to place technological development in a societal context, which is the focus of the Technology and Society course requirement for both minors. A capstone seminar focusing on current technological topics of broad interest will complete the minor package.

Table 2. Curriculum Structure

Engineering Sciences Minor	Technological Studies Minor
Core (6-8 credits) ENG 181 (3) Introduction to Engineering I ENG 183 (3) Introduction to Engineering II Or ENG 191H (4) Engineering Fundamentals and	**Core** (9 -11 credits) Option 1: ENG 201 (5) Technological Studies I: Analyzing Our World, (New Course) and ENG 202 (5) Technological Studies II: Analyzing Our World, (New Course)

Laboratory I ENG 193H (4) Engineering Fundamentals and Laboratory III	Or Option 2: ENG 181 (3) Introduction to Engineering I, ENG 183 (3) Introduction to Engineering II ISE 504 (3) Engineering Economic Analysis Or ENG 191H (4) Engineering Fundamentals and Laboratory I ENG 193H (4) Engineering Fundamentals and Laboratory III ISE 504 (3) Engineering Economic Analysis
Engineering Science (3 credits minimum): AERO 200 (5) Introduction to Aerospace Engineering CE 410 (3) Environmental Pollution and Control CE 511 (3) Introduction to Environmental Engineering Educ: T&L 220 (3) Design of Constructed and Manufactured Goods FABE 481 (4) Introduction to Food Process Engineering II&VCD 230 (3) Basic Design Concepts for Non-majors ISE 311 (3) Manufacturing Engineering ISE 406 (4) Industrial Quality Control ISE 504 (3) Engineering Economic Analysis MSE 205 (3) Introduction to Materials Science and Engineering MSE 281 (1) Materials Processing Laboratory WE 300 (3) Survey of Welding Engineering WE 350 (1) Introduction to Welding Laboratory Other Engineering courses by permission of the Minor Coordinator	
Computation Technologies (4 – 5 credits) CSE 200 (5) Computer Assisted Problem Solving for Business CSE 201 (4) Elementary Computer Programming CSE 202 (4) Introduction to Programming and Algorithms for Engineers and Scientists CSE 203 (4) Computational Thinking in Context: Interactive Video and Games CSE 204(4) Computational Thinking in	**Computation Technologies** (4 – 5 credits) CSE 200 (5) Computer Assisted Problem Solving for Business CSE 201 (4) Elementary Computer Programming CSE 202 (4) Introduction to Programming and Algorithms for Engineers and Scientists CSE 203 (4) Computational Thinking in Context: Interactive Video and Games CSE 204(4) Computational Thinking in

Context: Digital Images and Sound or Higher Level CSE class	Context: Digital Images and Sound or Higher Level CSE class
Technology and Society (5 credits) Comparative Studies 272 (5) Science and Society Comparative Studies 597.01 (5) Global Studies of Science and Technology ENG 360.02 (5) History of American Technology (New course) ENG 367 (5) American Attitudes about Technology History 362 (5) History of Technology Physics 367 (5) Use of Science in Solving Problems of Society Sociology 302 (5) Technology and Global Society	**Technology and Society** (5 credits) Comparative Studies 272 (5) Science and Society Comparative Studies 597.01 (5) Global Studies of Science and Technology ENG 360.02 (5) History of American Technology (New course) ENG 367 (5) American Attitudes about Technology History 362 (5) History of Technology Physics 367 (5) Use of Science in Solving Problems of Society Sociology 302 (5) Technology and Global Society
Capstone Experience (4 - 8 credits): ENG 581 (4-8) Engineering Capstone Collaboration (New course)	**Capstone Seminar** (2 credits) ENG 582 (2) Technology Issues Seminar (New Course)
22 credits minimum	20 credits minimum

Core and Capstone Course Descriptions

This section gives a brief description of the required and core courses for both minors.

ENG 181 (3) Introduction to Engineering I -- Visualization and sketches, introduction to spreadsheets and CAD, working drawings, experimental design and data analysis, problem solving approaches, hands-on lab, reporting, and production dissection. Prereq or concur: Math 150 or higher

ENG 183 (3) Introduction to Engineering II -- Team building, design/build project; project management, introduction to MATLAB, written and oral reports, preparation of visual aids, hands-on lab and reporting. Prereq: ENG 181 or H191.

ENG 201 (5) Technological Studies I: Analyzing Our World -- An introduction to technology concepts for students without extensive math or science backgrounds. Technical and practical aspects of several technology areas will be explored including design, communications, energy, and manufacturing. This course is intended for non-engineering students who want to better understand how technology impacts their lives.

ENG 202 (5) Technological Studies II: Analyzing Our World -- This is the second course in a two-course sequence which serves as an introduction to technology concepts for students without extensive math or science backgrounds. Technical and practical aspects of several technology

areas will be explored including nanotechnology, bio-related technology, transportation, and construction. This course is intended for non-engineering students who want to better understand how technology impacts their lives.

ISE 504 (3) Engineering Economic Analysis -- Economic analysis of engineering projects and methods of operation; the analysis of public investments, and introduction to analysis of engineering decisions. Prereq: 3rd yr standing or concur with 500 or written permission of instructor.

ENG 581 (4, repeatable to 8) Engineering Capstone Collaboration -- This is a new course being developed. It is anticipated that students enrolled in this course will contract to collaborate with an existing capstone design team (within any program of the College expressing willingness to collaborate). The students will be expected to bring a disciplinary expertise outside of engineering to the project. This course is to be managed by the Engineering Education Innovation Center. A proposed course syllabus is appended.

ENG 582 (2) Technology Issues Seminar -- This is a new course being developed. This course is intended as a culminating seminar experience for non-engineering students who are completing the Technological Studies Minor. A series of current technological issues within areas of focus of the college, (e.g. energy, transportation, environment, biomedical technologies, advanced materials) will be addressed by leading technologists. This should directly build their skills towards understanding issues of the day.

Additional Requirements

To be consistent with requirements of similar minors at the University, the following additional requirements are to be included.

1. No grade below a C- will be permitted in courses comprising the minor; the minimum overall CPHR of the minor shall be 2.00 (4.0 system).
2. No more than 10 hours of transfer credit may be applied to the minor.
3. Variations in the program are generally not permitted; any variation must be approved by the Chair of the Minors Oversight Committee.
4. Although the College of Engineering places no restrictions on use of course both in a minor and major program (double counting), students should consult their major program for any constraints that might be applied there.
5. A minor program form, to be available on College of Engineering website, must be filed at least by the time the graduation application is submitted. It requires signature by the student and student's major program advisor. This is then submitted to the advisor for the minor program for approval. Once the minor has been filed, any changes must be approved by the Chair of the Minors Oversight Committee.

Administration and Advising

The two minors offered by the College of Engineering will be administratively supported by the Engineering Education Innovation Center (EEIC). The EEIC Director (or designee of the Director) will chair a Minors Oversight Committee which will assure the advising of students, certification of completion, review of courses and be responsible for on-going development of the minor. This oversight committee will report to the Core Curriculum and College Services Committee of the College (acting as curriculum committee for both minors.)

Estimates of Student Interest and Needed Instructional Resources

The minors are scheduled for implementation in Autumn Quarter of 2009. Although difficult to anticipate, demand for the two minors is initially projected at 50 to 75 students per year for each minor. It is anticipated that space and laboratory needs for the additional sections of ENG 181/183 and the new courses will be accommodated through the EEIC. Addition of any of the new courses within general education remains an issue to be addressed in the future.

Student Learning Outcome Assessment Plan

The Minors Oversight Committee will be charged with assuring the assessment of student learning outcomes. The EEIC will administer a minor completion survey. The survey will explore student perceptions of: 1) the attainment of the learning goals indicated for the minor, and 2) structure, availability, and appropriateness of courses in the minor. This data, along with enrollment data, will be reviewed annually by the oversight committee.

Bibliography

[1]Extracted from "Proposed Supplement to "A Model Curriculum Developed by the Special Committee for Undergraduate Curriculum Review in Arts and Sciences and Approved by the Faculty of the Colleges of the Arts and Sciences, June 8, 1988" _____ _____ University, 12/12/06.
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[5]ITEA. 2005. Technological Literacy for All, International Technology Education Association, Reston, VA.
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