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Technological Literacy and First Year Courses  
for Engineering and Engineering Technology Majors

Abstract  
Technological literacy courses and programs have the goal of educating people about technology. These courses do not focus on developing specific abilities to use some form of technology. Rather, these courses address broader questions and issues, such as the answer to the question of what is technology, and understanding how technology is developed and improved over time. A technologically literate person has learned to recognize the importance of technology in our lives, our collective ability to direct or restrict technological change, and the importance of economic, social, legal, and public policy considerations.

One thrust in technological literacy education has been to teach this subject to people who are not pursuing majors in engineering and technology. This has unique challenges, including the challenge of overcoming the sense of intimidation that seems to come with engineering courses. The topics being taught here are not only important for non-majors. Student pursuing degrees in engineering and engineering technology also need to develop technological literacy. While their major courses will focus on specific aspects of the student’s chosen area of engineering and technology, especially on developing the student’s abilities in analysis, design, and application of technology, these students also need to develop an understanding of the connections between technology and society.

Many institutions require new engineering and engineering technology students to take at least one first year course in the major. These courses are intended to introduce students to the subject of engineering and technology, to help them see the road ahead to the degree, and to assist the student in developing some basic abilities needed for future courses. This course is also likely to be expected to cover certain EAC or TAC of ABET program learning outcomes. This first year course often plays an important role in teaching prospective majors about engineering and technology, and may be more likely to cover broad issues of technology and society than upper level, major-specific courses.

The first year course is likely to include significant coverage of technological literacy in the course content. This link with technological literacy may or may not be recognized. The author has taught introductory level courses and an upper level course focusing on technological literacy for non-majors. This paper will explore links between the two types of courses and the concept of teaching technological literacy as a framework for material in first year courses. Finally, the paper will also discuss carrying the concept of teaching technological literacy throughout the curriculum.
Introduction
First year courses are an integral part of many engineering and engineering technology degree programs. These courses serve to introduce newly declared majors to careers in engineering and technology. A student taking such a course should come away with a foundation of knowledge about engineering and technology, about the different engineering disciplines, the work involved, and career prospects to be able to make an informed decision on whether they should pursue such a degree or not and what discipline would be the best match to their talents and interests. There is a strong correlation between the basic information about engineering and technology appropriate for first year courses and technological literacy. The perspective of teaching technological literacy can be useful in determining and framing content for first year courses. Likewise, a first year course may serve as a platform for developing a service course for non-majors in technological literacy. This paper will explore the common ground between first year and technological literacy courses.

First Year Courses – Content
The author teaches a first year course in an engineering technology program. Taken from the course syllabus, the course includes the following topics:
- Introduction to Technological Professions: Engineering Technology and Engineering
- Technological Careers: What to Expect in Today's Environment
- Getting to that Career: Surviving a Technological Major in College
- Technological Problem-Solving
- Overview of the History of Technology
- Ethics and Technology

At the end of this course, students should have met the following learning outcomes:
- have an understanding of engineering, engineering technology, and areas of technology,
- be able to solve basic technical problems using tools covered in this course, along with being aware of the limitations of the results, and
- through a discussion of topics from the history of technology and of issues in technological practice, students are exposed to the product development process, to physical, economic, social, and environmental issues, and will have a basic appreciation of professional issues and ethics in technology.

These lists of topics and outcomes were developed to meet the main goal of giving students information on which to base major and career decisions, and were done in reference to common first year textbooks\(^1\)\(^-\)\(^5\) and to accreditation criteria\(^6,7\).

In the process of introducing engineering and technology, the course covers many topics that are relevant to meeting Technology Accreditation Commission of the Accreditation Board for Engineering and Technology (TAC of ABET) criteria. These are also relevant to meeting the criteria for engineering programs (Engineering Accreditation Commission (EAC) of ABET). While later courses in the curriculum focus on capabilities needed for specific tasks, in this course there is more emphasis on broader issues involved in understanding technology including
how and why it is developed, the benefits and risks associated with technology, and how technological change affects society and how society directs technological progress. These topics are important in helping a first year student understand the function of engineers and technologists and the importance of their work to society. This understanding is also important to graduates in their careers as they deal with the development and use of technology within societal constraints. As noted in the literature on technological literacy, this understanding is important not only to graduates of engineering and engineering technology degree programs but also to the public at large.

Overview of Technological Literacy
The concept of technological literacy has received significant attention in recent years. A technologically literate person has the knowledge necessary to understand, make informed decisions, and think critically about technology. In the National Academy of Engineering publication “Technically Speaking,” this is described as having three major components: knowledge, ways of thinking and acting, and capabilities. As stated in “Technically Speaking,”

*Characteristics of a Technologically Literate Person*

A technologically literate person has knowledge of technology and is capable of using it effectively to accomplish various tasks. He or she can think critically about technological issues and acts accordingly. Technological literacy can be visualized in three dimensions.

**Knowledge**
- Recognizes the pervasiveness of technology in everyday life.
- Understands basic engineering concepts and terms, such as systems, constraints, and trade-offs.
- Is familiar with the nature and limitations of the engineering design process.
- Knows some of the ways technology shapes human history and people shape technology.
- Knows that all technologies entail risk, some that can be anticipated and some that cannot.
- Appreciates that the development and use of technology involve trade-offs and a balance of costs and benefits.
- Understands 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 about new technologies.
- Participates, when appropriate, in decisions about the development and use of technology.
Capabilities

Has a range of hands-on skills, such as using a computer for word processing and surfing the Internet and operating a variety of home and office appliances.

Can identify and fix simple mechanical or technological problems at home or work.

Can apply basic mathematical concepts related to probability, scale, and estimation to make informed judgments about technological risks and benefits.\textsuperscript{22}

Much of this attention has been focused on efforts to develop greater technological literacy in the general population. From the perspective of faculty in colleges and universities, discussion of this topic has focused on courses aimed primarily at people who are not majoring in engineering or engineering technology. While these dimensions are important for majors as well, expectations for specific attributes of technological literacy for majors are likely to go beyond expectations for the public at large.

Technological Literacy and First Year Courses

Whether it is recognized or not, it is likely that most if not all first year courses teach technological literacy to some degree. A study by Atman and Nair of first year students that compared engineering and non-engineering majors showed that both groups were similar in their understanding of technology, and that the same course could be used to teach technological literacy to both groups.\textsuperscript{23} For each dimension, there are aspects that are relevant for first year students being introduced to engineering and technology. While some time spent on capabilities is appropriate here as well, this is likely to be relatively limited, and in-depth development by students of specific capabilities will be done in later major courses. At this point, some time spent on relatively basic capabilities that both serve to set a foundation for later work and to give students the sense of the type of work expected of them is important.

Compared to other courses in the curriculum, the first year course is likely to be uniquely suited to a broad discussion of technology issues listed under the categories of both knowledge and ways of thinking and acting. While these topics should be revisited in later courses once the student has developed more academic maturity, discussion at this point can lay a solid foundation for later work.

In a course endeavoring to help students better understand engineering and technology, each of these items is relevant and worthy of discussion. A prospective major should recognize the broad scope of technology (i.e., technology is not just information technology). They should recognize the importance of technology in our lives and how many important technological marvels are so commonplace as to be ignored. While recognizing the benefits of technology, the students also need to recognize the downside to technology and the risks inherent in technological developments. Failure to recognize that there are negative as well as positive consequences and that a poorly chosen or managed technological project may promise benefits but also cause great harm. Later in their career, this recognition should help the person recognize risks and make decisions that will minimize risks. It is also quite appropriate for them to know
that risks of negative consequences can be minimized but never eliminated, and that there are also negative consequences in a failure to accept reasonable risks and pursue development of a potentially beneficial technology.

The student should also recognize that, whether we are fully conscious of it or not, we as a society make decisions that direct the development of technology. While it is very easy to believe in technological determinism, students should be helped to see that society does shape and control the development of technology.

All of this information should help students better understand career they are considering and the major necessary to enter that career. Whether they pursue this career or not, having this content in the course will help the student in later life when faced with questions about technology. The main focus of the technological literacy movement is to foster literacy in the general population, so that people are better prepared in their private lives, as members of the workforce, and as citizens in a democracy to make informed decisions about technology. Whether a student pursues a career in engineering and technology or switches to another major, technological literacy is important, and a course that helps the student develop in this area has been of value to them and to society.

There are (or should be) higher expectations on engineering and engineering technology majors in regards to technological literacy. This is obvious in the area of capabilities. For example, while a citizen should have a basic understanding of the design process, the major must be prepared on graduation to become a productive part of the design team and should be prepared to lead a team later in their career. A citizen should be prepared to participate in debates about technology. They should be prepared to understand and thoughtfully weigh the arguments of the expert. A graduate should be expected to do more. They should have greater knowledge in their area of expertise, and they should be the experts and take a leading role in these debates.

The need for engineering and engineering technology majors to recognize and understand these broad questions of technology and society is reflected in accreditation criteria. In lists of outcomes for both types of degrees, the accrediting bodies include specific criteria that relate these aspects of technological literacy. This has been demonstrated by Gorham et al, who have mapped the EAC of ABET criteria to technological literacy standards developed by the International Technological Education Association (ITEA).\textsuperscript{11}

For engineering degrees, the relevant EAC of ABET accreditation criteria items include:

\begin{itemize}
  \item [(c)] an ability to design … within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
  \item [(f)] an understanding of professional and ethical responsibility
  \item [(h)] the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
  \item and
  \item [(j)] a knowledge of contemporary issues.\textsuperscript{24}
\end{itemize}
For engineering technology degrees, the relevant TAC of ABET accreditation criteria items include:

- an ability to … adapt to emerging applications of … technology
- an ability to understand professional, ethical and social responsibilities
- a respect for diversity and a knowledge of contemporary professional, societal and global issues

Programs are expected to document not only that their curriculum covers these items but also to show that students are able to make use of knowledge. Some of these topics are covered directly in texts for first year courses. It may be helpful both to faculty designing and teaching courses and to students to approach these topics from the perspective of teaching technological literacy.

First Year Courses and Technological Literacy Courses

As noted earlier, it is likely that technological literacy is being taught already in existing first year courses. An established first year course for majors may be a useful starting point for faculty and programs that wish to develop technological literacy courses for non-majors. The National Science Foundation (NSF) and the National Academy of Engineering (NAE) have promoted efforts to teach technological literacy. A technological literacy community has been formed within the American Society for Engineering Education (ASEE) which has presented workshops on developing technological literacy courses and a number of ASEE conference sessions where papers have been presented that document a variety of approaches to teaching technological literacy. In addition to providing a service to the community through the promotion of technological literacy, these courses can be beneficial to the program offering the course by bringing non-majors into programs that normally only serve majors. This results in additional enrollment in the program’s courses and can help justify additional funding for faculty lines. A program that has an established first year course that covers topics relevant to technological literacy is well positioned to develop a course for non-majors. While it may be possible to use the same course for both purposes, it is likely that there will be differences in the goals for majors and non-majors, resulting in a need for two different courses. In that case, the faculty experienced in teaching that course would be well positioned to develop the course for non-majors by using the existing first year course as the foundation for the new course.

Given the common ground between first year and technological literacy courses, it is apparent that many good ideas developed for first year courses should be of interest to people developing technological literacy courses, and that good ideas developed for technological literacy courses would likewise be applicable in first year classes.

It is unlikely that topics related to program accreditation would only be discussed in a first year course. However, the elements of technological literacy that best fit first year classes may not fit well in traditional engineering subject area courses. Accreditation considerations have forced
faculty to include such topics in other classes. Often, these are worked in as examples or case studies, and only a limited amount of time can be spent on these topics. These efforts in later courses need to be coordinated with and to build on the foundation from the first year class. The perspective of teaching technological literacy may serve well as a common framework for these efforts and can help faculty coordinate these activities.

Conclusions
There is a great deal of common ground between material relevant for first year courses and for courses in technological literacy. People who teach first year courses are likely to be teaching technological literacy whether this is recognized or not. They are likely to find helpful material and a useful perspective in the literature on technological literacy. Also, people who have worked to teach technological literacy are likely to find valuable ideas and material in the work done by those focusing on teaching first year courses. For those who teach first year courses, they may be able to adapt work done for the first year class to new courses designed to teach technological literacy to non-majors. This would meet a critical need for society and may be beneficial to the faculty member and their program as well. A focus on teaching technological literacy in the first year course may aide in efforts to document outcomes for accreditation. Finally, the perspective of teaching technological literacy may be very valuable as faculty attempt to coordinate material included in different courses at different levels to meet accreditation criteria.

Bibliography
24. Criteria for Accrediting Engineering Programs, pg 3
25. Criteria for Accrediting Engineering Technology Programs, pg 2