Pre-College Engineering Education and *Standards for Technological Literacy*

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Abstract
Pre-college engineering and technology programs are not immune from the increased demands that advances in technology have placed upon them. The International Technology Education Association (ITEA), and its Technology for All Americans Project, has recently published *Standards for Technological Literacy: Content for the Study of Technology*[1]. These standards provide critical guidance for all pre-college engineering and technology programs. In addition, the focus of *Standards for Technological Literacy* and the focus of the ABET Criteria 2000 are closely related. Pre-college engineering and technology curricula would benefit by adopting and implementing the standards for technological literacy into their curricula.

Background
In 1989, the National Governors Association endorsed the National Education Goals Panel recommendations for improving education in the United States. The publications of *Everybody Counts: A Report to the Nation on the Future of Mathematics Education* by the National Research Council (NRC) and *Curriculum and Evaluation Standards for School Mathematics* by the National Council of Teachers of Mathematics (NCTM) marked the beginning of current educational reform and the development of standards in other fields of study. The American Association for the Advancement of Science (AAAS), through its Project 2061, published *Science for All Americans* in 1989 resulting in a clear call to action and the need for scientific literacy for all students. This publication paved the way for future developments of science standards. The National Science Teachers Association (NSTA) made a formal request of the National Academy of Sciences (NAS) and the National Research Council (NRC) to coordinate the

development of *National Science Education Standards* (NSES) in content, teaching, and assessment resulting in the publication of NSES in 1996. In the 1990's, over 16 subject areas created nationally developed standards; currently 49 of the 50 states have developed and are using educational standards.

Standards for Technological Literacy were published in April 2000 by ITEA. The vision of *Standards for Technological Literacy* is to promote the study of technology and to encourage the development of technological literacy by all students in grades kindergarten through 12. The document provides an argument for the need for students to develop technological literacy and explores in detail the twenty standards for technological literacy (See Figure 1). The final chapter recommends what interested parties may do in order to join in advancing the cause of technological literacy as laid out in the standards and encourages the adoption of the standards for technological literacy in states, provinces, and localities.

Standards for Technological Literacy	
Standard 1:	Students will develop an understanding of the characteristics and scope of technology.
Standard 2:	Students will develop an understanding of the core concepts of technology.
Standard 3:	Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
Standard 4:	Students will develop an understanding of the cultural, social, economic, and political effects of technology.
Standard 5:	Students will develop an understanding of the effects of technology on the environment.
Standard 6:	Students will develop an understanding of the role of society in the development and use of technology.
Standard 7:	Students will develop an understanding of the influence of technology on history.
Standard 8:	Students will develop an understanding of the attributes of design.
Standard 9:	Students will develop an understanding of engineering design.
Standard 10:	Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.
Standard 11:	Students will develop the abilities to apply the design process.
Standard 12:	Students will develop the abilities to use and maintain technological products and systems.
Standard 13:	Students will develop the abilities to assess the impact of products and systems.
Standard 14:	Students will develop an understanding of and be able to select and use medical technologies.
Standard 15:	Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.
Standard 16:	Students will develop an understanding of and be able to select and use energy and power technologies.
Standard 17:	Students will develop an understanding of and be able to select and use

	information and communication technologies.
Standard 18:	Students will develop an understanding of and be able to select and use transportation technologies.
Standard 19:	Students will develop an understanding of and be able to select and use manufacturing technologies.
Standard 20:	Students will develop an understanding of and be able to select and use construction technologies.

Figure 1: ITEA. (2000). ***Standards for Technological Literacy: Content for the Study of Technology*****. Reston, VA: Author.**

The development of *Standards for Technological Literacy* involved the participation of several groups, including the Advisory Group and the National Academy of Engineering (NAE) Focus Review group. The Advisory Group consisted of representatives of associations who had developed standards, including Rodger Bybee, former Executive Director, Center for Science, Mathematics, and Engineering Education and James Rutherford, Education Advisor, Project 2061. In addition, other concerned parties, including William Wulf, NAE President and Gerald Wheeler, Executive Director, National Science Teachers Association (NSTA).

The NAE Focus Group was formed to help provide input and guidance from a professional point of view. The NAE Focus Group consisted of Alice Agogino, Professor, University of California, George Bugliarello, Chancellor, Polytechnic University, New York, Samuel Florman, Chairman, Kreisler Borg Florman Construction Company, New York, Elsa Garmire, Professor, Dartmouth College, New Hampshire, Carl Hall Engineer, Engineering Information Services, Virginia, and John Truxal, Professor, State University of New York at Stony Brook.

Comparing ABET and STL

ABET is widely recognized as the agency responsible for accrediting educational programs leading to degrees in engineering. ABET has recently adopted Engineering Criteria 2000. Criterion 3 — Program Outcomes and Assessment[2] is evidence of a new focus on what students are expected to know and be able to do upon graduation (See Figure 2).

Engineering programs must demonstrate that their graduates have:	
Criterion A:	An ability to apply knowledge of mathematics, science, and engineering
Criterion B:	An ability to design and conduct experiments, as well as to analyze and interpret data
Criterion C:	An ability to design a system, component, or process to meet desired needs
Criterion D:	An ability to function on multi-disciplinary teams
Criterion E:	An ability to identify, formulate, and solve engineering problems
Criterion F:	An understanding of professional and ethical responsibility
Criterion G:	An ability to communicate effectively
Criterion H:	The broad education necessary to understand the impact of engineering solutions in

	a global and societal context
Criterion I:	A recognition of the need for, and an ability to engage in life-long learning
Criterion J:	A knowledge of contemporary issues
Criterion K:	An ability to use techniques, skills, and modern engineering tools necessary for engineering practice

Figure 2: Accreditation Board for Engineering and Technology (ABET). 1997. *Engineering Criteria 2000, 3rd ed.* Baltimore, MD.

Table 1 compares *STL* concepts and principles that are recommended to be addressed in technology education courses (K-12) with those criterion specified in the ABET Criteria 2000-Criterion 3 — Program Outcomes and Assessment.

A code sequence of ABETA through ABETK correlates to the ABET Criterion 3 —, while STLS1 through STLS20 correlates to the ITEA technology education standards. A check mark refers to the topic being mentioned or covered in some manner but may not be directly stated.

CONCEPTS AND PRINCIPLES	ABET Criterion 2000 (Post-Secondary)	*Standards for Technological Literacy* (K-12)
Understand and use mathematics, science, and technology	ABETA	STLS3, STLS4, & STLS7
Understand technological knowledge	✔	STLS1 & STLS2
Understand the history of technology	✔	STLS7
Understand the historical significance of previous advances in technology and engineering	✔	STLS3 & STLS7
Understand about engineering and technology in society	ABETF, ABETH, & ABETJ	STLS 4, STLS5, STLS6, & STLS7
Understand systemic principles	ABETC & ABETH	STLS11, STLS12, & STLS13
Understand ecological principles	ABETJ	STLS5
Use and recognize inquiry skills, apply knowledge in retrieving information, and recognize and analyze major limitations in the usefulness of information	ABETB, ABETF, ABETG	STLS3, STLS10, STLS13 & STLS 17
Understand and use abilities of engineering design • Define a problem • Brainstorm, research, and generate ideas • Identify criteria and specify constraints • Develop and propose designs and choose between alternative solutions • Implement a proposed solution • Make a model or prototype • Evaluate a solution and its consequences • Refine the design • Create or make the design • Communicate the processes and results	ABETB, ABETC, ABETE, ABETG, & ABETK	STLS8, STLS9, STLS10, &STLS11
Identify, formulate, and solve engineering problems	ABETE	STLS8, STLS9, STLS10, & STLS11
Employ tools and equipment and use appropriate tools and techniques	ABETK	STLS1, STLS11, & STLS12

CONCEPTS AND PRINCIPLES	ABET Criterion 2000 (Post-Secondary)	*Standards for Technological Literacy* (K-12)
Understand properties of objects and materials	✔	STLS2, STLS15, STLS18, STLS19, & STLS20
Understand about risks and benefits of design solutions	✔	STLS2, STLS5, & STLS13
Understand resources: ➢ Understand properties of earth materials, such as building materials & sources of fuel ➢ Understand resources and human use	✔	STLS2, STLS14, STLS15 STLS16, STLS17, STLS18 STLS19, & STLS20
Work as a team or individually to solve problems	ABETD	STLS2, STLS11, STLS12, & STLS13
Assess impact and consequences of products and systems and assess impact and consequences of actions.	✔	STLS13
Communicate solutions in portfolios, design sketches and drawings, journals, logs, multi-media presentations, and audio-visual presentations	ABETG	STLS12 & STLS17
Recognize the need for, and ability to engage in life-long learning	ABETI	✔

Table 1: A table depicting major concepts and principles covered in technology education courses and recommended engineering accreditation criteria.
Source: Accreditation Board for Engineering and Technology (ABET) Criteria 2000 and International Technology Education Association's (ITEA) *Standards for Technology Education* (Draft 5). NOTE: A code sequence of ABETA through ABETK correlates to the ABET's Criterion 3 — Program Outcomes and Assessment statements, while STLS1 through STLS20 correlates to the ITEA's technology standards. A check mark, ✔, refers to the topic being mentioned or covered in some manner and may not be directly stated.

Impact of STL on Engineering Education

The engineering profession can serve society and itself by encouraging and supporting the implementation of the standards for technological literacy. The National Research Council publication *Engineering Education: Designing an Adaptive System*[3] (1995) comments on the status of the engineering profession:

> "The nation's engineering education system includes not just higher education but also K-12, community colleges, and continuous (lifelong) engineering education. These elements are embedded in the larger society, whose political and economic influences typically affect engineering schools through the academic institution of which they are a part. Those socioeconomic and political factors also drive demand for engineers, as well as the supply, recruitment, and retention of engineering students" (p. 40).

Rodger W. Bybee, Executive Director, Biological Sciences Curriculum Study (BSCS) adds, "In reviewing contemporary scientific research, one cannot escape the reality that most advances in science are based on technology…Yet, as a society, we know little about technology and engineering"[4] (Bybee, 2000, p. 23).

As school districts adopt and implement the standards for technological literacy increased numbers of pre-college students will be exposed to the various aspects of engineering. This exposure is likely to result in more students understanding engineering principles and choosing engineering as a career. This increase in understanding is likely to translate into pre-college graduates with a higher overall level of technological literacy as well as more students entering into the formal study of engineering. This will result in more efficient and effective engineering education programs and most likely in a higher quality of student graduating.

What Role Can Engineering Play?

Schools and school districts are not mandated to adopt and implement the standards for technological literacy. The engineering community can serve as a catalyst by supporting and encouraging schools and school districts to embrace the standards for technological literacy.

Individual engineers working or retired, can assist in this venture in a variety of ways including:

a) Serve as a member of a school/district technology committee. As technological literacy becomes increasingly important to our pre-college education systems the need for schools/districts to plan for technology purchases and training will be crucial to the academic progress of students in the technical areas.
b) Become a member of a school's PTO/PTA, or School Advisory Council. Parents need guidance in understanding the issues surrounding the standards for technological literacy and the effects on their children.
c) Serve as a reviewer when schools/districts are considering adopting new curricular materials, e.g., science or technology textbooks, workbooks, or equipment. New curricular materials should be aligned with the standards for technological literacy.
d) Become involved in the school's Career and Technical Student Organization. Engineers working with students and their teachers on technologically oriented projects and programs can only enhance the level of technological literacy.
e) Become a local school board member. There is no faster way to impact academic change.
f) Become an advocate for the standards for technological literacy. Request the opportunity to make presentations on the need to implement the standards for technological literacy to school boards, faculty, principals, booster groups, and parent organizations.

In addition, schools of engineering can support degree programs in technology teacher education. Engineering educators can initiate interdisciplinary collaborations with technology and science faculty to promote the standards for technological literacy. Engineering schools can develop partnerships with individual schools and assist them in developing technologically oriented curricula, including engineering projects and laboratory activities. Engineering societies through local sections can develop collaborations with school districts to develop practical, applicable engineering activities for K-12 teachers.

Summary

STL provides a focused guide for improving technological literacy at the pre-college level. There are clear connections between the standards for technological literacy and the ABET 2000 Criteria. William A. Wulf goes further in describing the potential impact of the standards for technological literacy when he wrote, "The standards will provide a much-needed reference point for developers of curriculum and instructional materials. Most important, the standards lay the foundation for building a technologically literate citizenry"[5] (Wulf, 2000, p. 10). The movement to improve technological literacy in K-12 education and the new ABET guidelines have the potential to improve engineering — resulting in a more technological society and stronger economy. Engineers, engineering educators, and their professional societies, are encouraged to support the implementation of *STL* at the pre-college level.

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