# Standards for Technological and Engineering Literacy: Addressing Trends and Issues Facing Technology and Engineering Education

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# *Standards for Technological and Engineering Literacy:*

## addressing trends and issues facing technology and engineering education

by Johnny J Moye, DTE and
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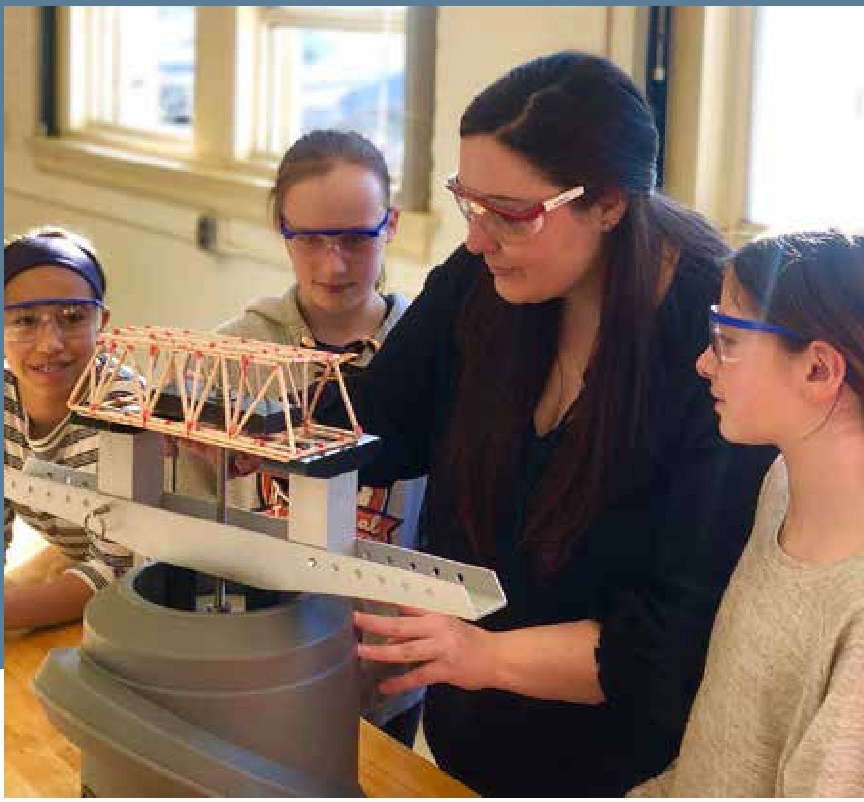
*Educating PreK-12 students to become technologically and engineering literate has never been so important.*

Every aspect of work and play involves technology and engineering knowledge, objects, and processes. Educating PreK-12 students to become technologically and engineering literate has never been so important. In order to face future challenges, students need to "have a broad conceptual understanding of technology and its place in society, enabling them to be active participants in the technological world and careful creators and users of technology" (ITEEA, 2020, p. viii).

For twenty years *Standards for Technological Literacy* (*STL*) (ITEA/ITEEA, 2000/2002/2007) provided technology education curriculum guidance. With *STL*'s aging content, an increased focus on technology and engineering education, and new emphasis on integrative STEM education, technology and engineering leaders realized *STL* needed to be updated. The International Technology and Engineering Educators Association (ITEEA) and its Council on Technology and Engineering Teacher Education (CTETE) led the creation of *Standards for Technological and Engineering Literacy: The Role of Technology and Engineering in STEM Education* (*STEL*) (ITEEA, 2020). While maintaining the epistemological foundation contained in *STL*, *STEL* addresses technological, engineering, ed-



dressed are therefore primarily from lead technology and engineering educators. This is important because it is these educators who understand the current and future trends and issues the technology and engineering education profession faces.

The trends and issues study collected 76 statements describing what participants felt were essential to address during future strategic planning for the profession. Those 76 points were grouped into eight major themes: critical teacher shortage; secondary and university program closures; program and teacher funding; curriculum; technology and engineering education identity and relevance; collaborative efforts; teacher certification/professional development; and student-centered foci. All themes are important, align with prior research (Wicklein, 1993, 2005), and are being addressed by ITEEA strategic planners. *Standards for Technological and Engineering Literacy* should be used as a foundation to address all eight themes but, due to limitations, this article will only address the curriculum theme.

ucational, and societal changes that have occurred since *STL* was last updated in 2007.

Change, however, is rarely easy. Educational leaders (rightly so) always have questions regarding change. There may be concerns about the time and expense to update curriculum or laboratory/classroom practice. Questions and concerns need discussion for any profession to progress. It is important to identify and discuss the purpose of technology and engineering courses and what those programs intend to do for PreK-12 students and society at large. The goal of *STEL* is to "broaden [students'] technological and engineering literacy so that people can make informed decisions about technology and better contribute to its design, development, and use" (ITEEA, 2020, p.3).

The purpose of this article is to demonstrate how *STEL* addresses concerns found in the recent project *Current and Future Trends and Issues in Technology and Engineering Education* (Moye et al., 2020). The trends and issues project identified topics impacting the technology and engineering education profession and should not be confused with trends and issues that might be taught in a Technology and Engineering Education (TEE) laboratory classroom (i.e., current events such as emerging technologies, socio-technological issues, etc.). Specifically, this article looks at how *STEL* addresses curriculum trends and issues. The correlation between the two projects provides additional justification for technology educators to adopt *Standards for Technology and Engineering Literacy.*

The majority (73%) of the stakeholders who participated in the trends and issues study were PreK-12 technology and engineering (TEE) teachers and TEE teacher educators. The concerns ad-

Participants identified six technology and engineering curriculum items that the profession needs to address. Foremost, participants felt that technology and engineering standards needed to be updated. Second, respondents felt there is a need for guidance on course/curriculum content to indicate what they should be teaching. Third, there was concern of technology and engineering's role in teaching integrative STEM. A fourth finding of the study revealed that technology and engineering education needs to focus on teaching methodology. Specifically, survey respondents felt that technology and engineering students should be doing more hands-on learning in the classroom. Finally, determining technology and engineering's role in preparing students for occupations and college was a sixth item found to be important in the trends and issues study. The organization of *STEL* into eight standards, eight practices, and eight contexts provides appropriate levels of specificity to address each of the six curriculum items (figure, pg. 11).

Study participants felt that technology and engineering standards **needed to be updated**. *Standards for Technological Literacy* (ITEA/ITEEA, 2000/2002/2007) provided excellent curriculum guidance for twenty years. However, extensive educational, technological, and societal changes have occurred since it was initially published in 2000. Six years after *STL* was published, ITEEA updated the *Rationale and Structure* document (2006) that suggested reducing the number of standards and benchmarks as well as "adding new content such as crosscutting concepts to mirror the practices of contemporary standards developed for other disciplines" (ITEEA-STEL Revision FAQ, n.d., p. 1). The process to create *STEL* utilized these recommendations, and *STEL* now "provides a map for teachers, administrators, and other education professionals to create rigorous and relevant PreK-12 technology and engineering programs" (ITEEA, 2020, p. 4).

*Standards for Technological and Engineering Literacy* was designed to provide "an updated vision of what [PreK-12] students should know and be able to do in order to be technologically and engineering literate" (ITEEA, 2020, p. ix). Reduction of standards was accomplished by compressing the original 13 *STL* (2000) engineering design standards that were similar or overlapping, resulting in what could be termed as eight *power standards*. The seven Designed World standards (*STL* Standards 14-20) were formed into *contexts*, in which the core *STEL* standards may be applied. This combination resulted in a reduction of benchmarks from 288 to 142. Standards and benchmarks define enduring "ideas and abilities that will withstand technological changes over time" (ITEEA, 2020, p. ix). The eight standards and 142 benchmarks provide teachers with manageable direction needed to prepare technologically and engineering-literate students. The *STEL* document also "outlines technological and engineering *practices* that identify key attributes and personal qualities that all technology and engineering students should exhibit" (ITEEA, 2020, p. ix). Adapted from contemporary educational practices (i.e., domains of learning, 21st Century Skills, Engineering Habits of Mind), the eight *STEL* practices "reflect the knowledge, skills, and dispositions students need in order to successfully apply the core disciplinary standards in the different context areas" (ITEEA, 2020, p. 14).

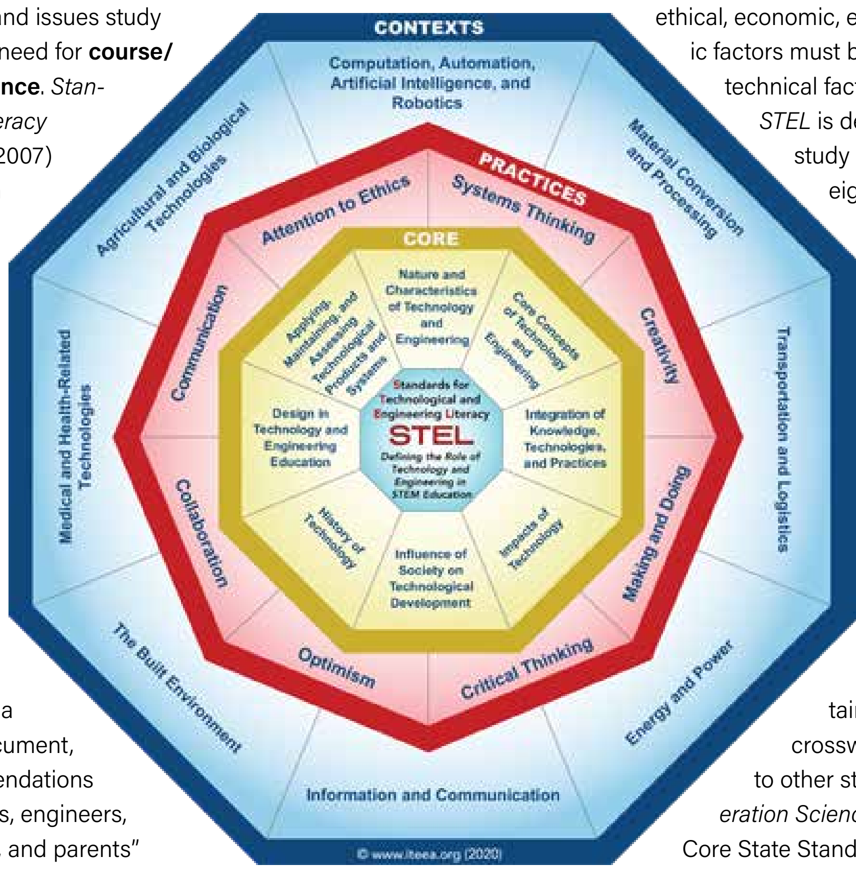
Participants in the trends and issues study (Moye et al., 2020) felt the need for **course/curriculum content guidance**. *Standards for Technological Literacy* (ITEA/ITEEA, 2000/2002/2007) provided sound curriculum guidance, but with age, some of the content became dated. A survey conducted at the outset of the *STEL* project confirmed that many states broke from using *STL* and began creating their own technology and engineering education standards (ITEEA, 2019).

*Standards for Technological and Engineering Literacy* is not a curriculum. As a thoroughly researched document, *STEL* is based on recommendations of "educators, technologists, engineers, scientists, mathematicians, and parents" (ITEEA, 2020, p. 10). The document went through a rigorous developmental process that resulted in the standards, contexts, and practices needed to develop PreK-12 technology and engineering curricula and courses relevant to future educational needs. Appendix B of *STEL* provides the history and timeline of the standards revision project.

Trends and issues (Moye et al., 2020) study participants expressed concern about technology and engineering's role in teaching integrative STEM. The full title of *STEL*, *Standards for Technological and Engineering Literacy: The Role of Technology and Engineering in STEM Education*, was deliberately selected to answer that concern.

STEM education is a means to integrate science, technology, engineering, and mathematics, as well as other content (e.g., research and communication skills) in the classroom. STEM education is incomplete without the T&E, yet many view STEM education as merely *more* mathematics and science since they are core subjects (Reed, 2018). *STEL* clarifies the role of technology and engineering within STEM education because it "describes what the content and practices of technology and engineering education should be in Grades PreK-12" (*STEL*, 2020, p. ix).

By providing specific standards and benchmarks that technologically and engineering-literate students should possess, *STEL* also provides real-world contexts in which these standards are encountered. This approach allows technology and engineering educators to address the "larger interdisciplinary nature of study in technology and engineering, in which social, ethical, economic, environmental, and aesthetic factors must be considered alongside technical factors" (*STEL*, 2020, p. ix). *STEL* is designed for all students to study all eight standards and all eight practices but provides flexibility for how states/provinces and local school divisions implement the contexts.



*STEL* standards, practices, and contexts.

ITEEA has dedicated web pages for integrative STEM and *STEL* (see www.iteea.org/STEL.aspx and www.iteea.org/IntegrativeSTEMEducation.aspx). The "*STEL* Resources" tab on the *STEL* page contains documents that provide crosswalks of *STEL* benchmarks to other standards (i.e., *Next Generation Science Standards*, Common Core State Standards Mathematics and Language Arts). This document reveals benchmark-specific connections between science, technology and engineering, mathematics, and English language arts standards. (ITEEA, n.d.)

The trends and issues study (Moye et al., 2020) also revealed that technology and engineering education needs to focus on a common **teaching methodology**. There are many teaching methods and practices in TEE and, rather than expecting students to learn discrete facts, *STEL* suggests that teachers focus "more time on the broad dimensions of knowing, thinking, and doing in the context of technology and engineering" (ITEEA, 2020, p. 4). *Standards for Technological and Engineering Literacy* stresses the symbiotic nature of the knowing, thinking, and doing dimensions in fostering technological and engineering literacy. *STEL* is structured to help educators teach and assess students' abilities in the cognitive, affective, and psychomotor domains of learning. To accomplish this, the *STEL* benchmarks are written with active verbs that measure the different levels of student growth within the cognitive, affective, and psychomotor domains.

The ITEEA *STEL* web page (www.iteea.org/*STEL*.aspx) contains a resource titled the *STEL Benchmark Verb Alignment to Cognitive, Affective, and Psychomotor Domains*. This resource provides educators with an overview of the relationships between the domains of learning, dimensions of technology and engineering, and *STEL* student outcomes as measured by the benchmark verbs. Table 1 provides a visual of these relationships.

The trends and issues study (Moye et al., 2020) participants felt that students should **do more hands-on activities**. *STEL* explicitly reflects TEE's history of making and doing: "completing hands-on activities to solve real-world problems is the cornerstone of technology and engineering education" (ITEEA, 2020, p. 83). Challenged with project- and problem-based learning, students use minds-on, hands-on knowledge, skills, and dispositions to solve problems. Such instructional methods are excellent when assessing students' achievement in the three domains of learning.

When students perform minds-on, hands-on activities they are doing more than just building. Students engaged in this type of learning are taught through a range of well-researched processes. *STEL* refers to these processes as *Practices*. Chapter Four of *STEL* outlines eight interconnected *Technology and Engineering Practices* and, like the standards, students should study all eight. The chapter also provides examples of challenges teachers could use to teach and assess each standard and practice. The examples should not be viewed as prescribed activities; rather, they are ideas teachers could use to consider how each standard and practice could be taught and assessed.

Determining technology and engineering's role in preparing students for **occupations** and **college** were two additional items found in the trends and issues study. The purpose of an education is to prepare students for life, continued education, and the workforce. "All occupations require the use of technological products, systems, and processes, and therefore people with higher levels of technological and engineering literacy are better prepared for the workforce" (ITEEA, 2020, p. 3). *STEL* continues, "…there is societal recognition of the role played by science, technology, engineering, and mathematics (STEM) education in preparing students for college and career readiness, including high-skill careers" (ITEEA, 2020, p. viii).

People will better serve themselves and others if they understand that everything in the human-designed environment they purchase, possess, or engage in was designed by someone using technology and/or applying engineering design. With this thought in mind, *STEL* was not created in a vacuum. Business and industry leaders participated in the development and writing of the standards, practices, and contexts students need to understand and be able to do in the workplace. *STEL* provides the core disciplinary standards, contexts, and practices everyone needs to be productive citizens.

## Conclusion

It is important that all people learn and understand science, technology, engineering, mathematics, and liberal arts to become productive citizens. Trends and issues have been a longstanding line of research to keep the field of technology and engineering education moving forward. *STEL* addresses six recently identified trends and issues impacting the profession.

The ancient Greek philosopher Heraclitus once said, "There is nothing permanent except change." That was true 2,500 years ago; it remains true today. The courses we teach are a result of years of change, from manual arts, industrial arts, and technology education. The profession has, in name, evolved to technology and engineering education. Changing the name is simple, changing the content focus is not.

**Table 1.** Relationships among domains of learning, dimensions of technology and engineering, and student outcomes.

| Domains of Learning | | Technology and Engineering Dimensions | | Student Outcomes (as defined by Benchmark verbs) |
|---|---|---|---|---|
| Cognitive | → | Knowing and Thinking | → | Knowledge |
| Psychomotor | → | Doing | → | Skills |
| Affective | → | Knowing, Thinking, and Doing | → | Dispositions |

*Standards for Technological and Engineering Literacy: The Role of Technology and Engineering in STEM Education* provides the content teachers need to prepare students for an ever-evolving technological world. *STEL* is based on logical research that determined what future technologically and engineering-literate students should know and be able to do. As *STEL* was being written, technology and engineering educators participated in a study defining the current and future trends and issues facing technology and engineering education in the United States. When comparing the study results to *STEL* content, it is evident that *STEL* addresses current and future trends and issues facing technology and engineering education.

The literature shows that *STEL* provides the content and direction needed to develop valid technology and engineering programs. The proof, however, is "in the pudding." Technology and engineering educators must accept and use these standards to continue the evolution of our programs. Charles Darwin's theory of evolution purports, "It is not the strongest of species that survives, not the most intelligent that survives. It is the one most adaptable to change."

The United States is in the midst of educational reform. *Standards for Technological and Engineering Literacy* is now a part of that reform. Never before has the T&E (technology and engineering) in STEM been defined. *STEL* provides the technology and engineering standards, contexts, and practices students need to become technologically and engineering-literate citizens.

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