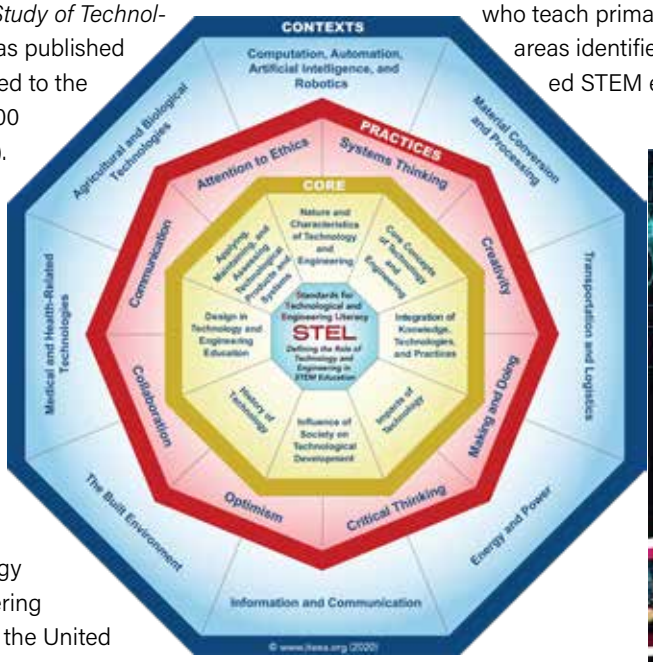
why the standards changed and what it means to you

by Michael Daugherty and Charlotte Holter

Most parents have a deep desire for their children to *do* well in school. While ***doing*** is a verb that encompasses all areas of academics, it has an even deeper meaning in STEM education. STEM education, particularly in the elementary grades, rests on a foundation focused on deeper, long-term, conceptual understandings—understandings accentuated greatly through learning by ***doing***. Moye, et al (2014) defined ***doing*** as "a tactical/hands-on process of technological problem solving starting with human needs and wants that leads to the principles of innovation such as designing, making/building, producing, and evaluating" (p. 24).

Standards for Technological Literacy: Content for the Study of Technology (*STL*) was published and presented to the public in 2000 (ITEA, 2000). These standards established content guidelines and benchmarks for learning across the K-12 spectrum for technology and engineering programs in the United States and beyond. These *STL* standards established a case for the study of technology and identified the big ideas that students should know and the things that students should be able to do with regard to technology and engineering.

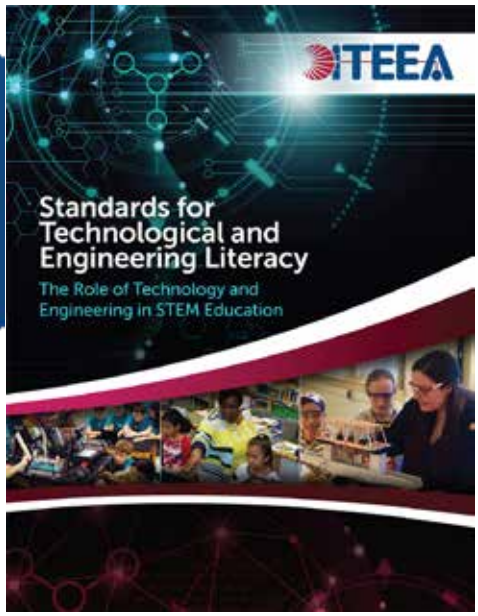


Due to immense changes in the educational landscape over the last 20 years, a call to action was made in 2018 to review the original 20 *STL* standards and identify methods by which they might be updated and/or improved. Concurrently, there was an effort to seek to identify methods by which these standards could provide greater assistance and usefulness to those teachers who teach primarily in subject areas identified as integrated STEM education.

Clearly, any revised or improved standards from our field needed to unmistakably address the "T" and the "E" in STEM education while also defining the field of technology and engineering education. Emphasis on design, particularly technology and engineering design throughout PreK-12 curriculum, was the driving force of this change.

core disciplinary standards, practices, and contexts

To accomplish the goal of moving the *STL* standards forward, an eight-member educational leadership team representing Pre-K to Grade 20 consistently met for a duration of two years. Through a comprehensive process of review, analysis, and critical assessment, a plan was created.



Standards for Technological and Engineering Education: The Role of Technology and Engineering in STEM Education (*STEL*) was born. These new standards represent a significant refinement and adaptation of the original 20 technological

Table 1. CORE Disciplinary Standards (STEL)	
1.	The Nature and Characteristics of Technology and Engineering
2.	Core Concepts of Technology and Engineering
3.	Integration of Knowledge, Technologies, and Practice
4.	Impacts of Technology
5.	Influence of Society on Technological Development
6.	History of Technology
7.	Design in Technology and Engineering Education
8.	Applying, Maintaining, and Assessing Technological Products and Systems

literacy standards. Most importantly, the new *Standards for Technological and Engineering Education* include a refined eight CORE disciplinary standards (ITEEA, 2020). These eight core standards represent those ideas and concepts that are central and pivotal to deep understanding in the fields of technology and engineering within STEM fields and courses of study. These eight CORE standards (Table 1) are critical to engaging in the study and comprehension of technology and engineering regardless of the context within which the given study takes place.

These eight Core standards are followed by the *Technology and Engineering Practices* that comprise the abilities and dispositions that are seen as fundamental to student success in technology and engineering, as well as STEM education (ITEEA, 2020). These *Practices* include abilities and dispositions like systems thinking, creativity, making and doing, critical thinking, optimism, collaboration, communication, and attention to ethics. You will note that these *Practices* hold a relationship to the 21st Century Learning Skills (Brusic & Shearer, 2014).

Finally, *Standards for Technological and Engineering Education* (*STEL*) includes *Technology and Engineering Contexts*. These eight *Contexts* represent areas or units of study through which the *CORE* standards and the *Practices* can be applied and expanded upon. The Technology and Engineering Contexts are outlined in Table 2 below.

the developmental process

Standards for Technological and Engineering Education (*STEL*) was adapted, developed, and refined and edited by hundreds of professionals within technology and engineering education, adjoining STEM fields, and experts from associated fields of study. To complete a close examination and refinement of these standards, a team of 40 international leaders, covering the technology, engineering, and STEM educational landscape, came together in Chinsegut, Florida during the summer of 2019. It was during this collaborative retreat that these new standards were closely examined and scrutinized by the leadership team, writers, and reviewers. These teams collaborated and brought clarity and contextual examples to each standard, practice, context, and benchmark for the new *Standards for Technological and Engineering Education* (Figure 1).

conclusions and recommendations

So, what do these new standards for technological and engineering education mean to you as an educator? These new standards represent guideposts to which content, classroom applications, instructional strategies and student assessments can be tethered. They represent the most current international wisdom about the critical knowledge and applications that assist in developing a baseline of knowledge and abilities with regard to the "T" and the "E" in STEM education. Finally, they provide the technology and engineering or STEM education teacher with assurances that they are delivering important, vital, and justifiable content and practices in the classroom. By implementing *Standards for Technological and Engineering Education*, the teacher may be able to apply technological and engineering context to your already existing curriculum, assist students understand engineering design processes, prepare the next generation of students to become technologically and engineering literate, address all types of learning modal-

Table 2. Technology and Engineering Contexts (STEL)	
1.	Computation, Automation, Artificial Intelligence, and Robotics
2.	Material Conversion and Processing
3.	Transportation and Logistics
4.	Energy and Power
5.	Information and Communication
6.	The Built Environment
7.	Medical and Health-Related Technologies
8.	Agriculture and Biological Technologies

Figure 1. The Leadership Team and Reviewers/Writers at Chinsegut, August 2019.

ities: cognitive, affective, and psychomotor; and, draw vital connections with other adjoining and complementary disciplines in the school. *Standards for Technological and Engineering Education* is designed to be practical, and we believe that you will find this document to be easy to read and very pertinent to your classroom practices.

By implementing these standards in your classroom, we believe that you will be able to build motivation and optimism, increase creativity, critical thinking, and communication among your students as they learn by doing and become technologically and engineering literate. Please review the new *Standards for Technological and Engineering Education* at the following site: www.iteea.org/STEL.aspx.

references

Brusic, S. A. & Shearer, K. L. (2014). The ABCs of 21st century skills. *Children's Technology and Engineering, 18*(4), 6-10.

International Technology Education Association (ITEA/ITEEA). (2000). *Standards for technological literacy: Content for the study of technology.* Reston, VA: Author.

International Technology and Engineering Educators Association (ITEEA). (2020). *Standards for technological and engineering education: The role of technology and engineering in STEM education.* Downloaded from www.iteea.org/STEL.aspx

Moye, J. J, Dugger W. E., & Starkweather, K. N. (2014). "Learning by doing" research—introduction. *Technology and Engineering Teacher, 74*(1), 24-27.

Michael Daugherty, Ed.D., is a Distinguished Professor of STEM Education at the University of Arkansas. He can be reached at mkd03@uark.edu.

Charlotte Holter, Ed.D., is Professor for the School of Education at Liberty University, Lynchburg, VA. She can be reached at cholter1@liberty.edu.