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Standards for Technological and Engineering Literacy (STEL):

Turning Silos into Bridges!

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Introduction

ITEEA published the Standards for Technological and Engineering Literacy (STEL) in July 2020, explaining what all PreK-12 students should know and be able to do to achieve technological and engineering literacy. The goal of these standards is to develop individuals who are adequately prepared to actively participate in our technological world, address existing and minimize future challenges created by technology, and appropriately consider social, ethical, economic, environmental, and technical factors in decision making. These standards are innovative and versatile and can be used to develop curricula that can be effectively applied in any educational setting.

This paper will explore the evolution of technology and engineering standards, explain the necessary emphasis on social emotional learning and diversity, equity and inclusion practices, and introduce resources that make the STEL easy to use and apply. It will demonstrate how the core standards of technology and engineering can be achieved through different practices and in various contexts, and how they can be embedded in courses and activities across multiple subjects. We hope classroom teachers, district supervisors, administrators, and curriculum developers will feel empowered to integrate the STEL into their program development, curriculum design, and lesson plans, regardless of their unique needs, constraints, and goals.

STEL Development and Content

Background

Standards Based Education

Standards-based education reform emerged in the United States in the 1980s and became a focus of the federal government into the 1990s and 2000s (Apex Learning, 2017). The intent of this initiative was to establish a common set of educational expectations that all students could be measured by, instead of measuring students' capabilities against each other. Teaching and aligning assessments to these standards also provided a level of confidence that students are proficient in certain basic knowledge areas and have attained relevant skill sets at specific milestones in their educational journey.

Early standards-based education in the United States was mostly focused on reading, writing, and mathematics and was essentially silent on technological literacy. At that time, we had no idea the impact technology would have on our society. However, through the digital revolution, understanding and knowing how to use and apply technology became more important than ever through and technology education gained relevance. The first standards for technology education, ITEEA's Standards of Technological Literacy (STL), were published in 2000, then updated in 2003 and 2007. The STL was fully focused on the content - the knowledge and abilities - students need to acquire then apply to realize the vision of a technologically literate society.

The Evolution of Technology

Thinking back to 2000 when the STL was first published, technologies that we now use every day including broadband internet, mobile phones, home robots, artificial intelligence, and more were either unimaged or brand new and yet to reach widespread use. Since then, we have all experienced the rapid advances of technology, and with that, we have also seen its positive and negative effects on our society. These advances and experiences were the catalyst for re-envisioning technological literacy, including its integral relationship to engineering literacy, and revising the STL accordingly.

While technology is the human modification of the natural environment to satisfy needs and wants, engineering allows us to optimize technologies to meet those needs under defined constraints (STEL, 2020). Incorporating engineering literacy into the STEL emphasizes the importance of both technological and engineering literacy in developing solutions to human wants and needs while also considering the corresponding effects technology has on both society and the environment. The STEL defines literacy in the disciplines of technology and engineering as requiring a strong emphasis on "process and action, including designing and making" (STEL, 2020, p. 2). ITEEA's role in standards development is pivotal to ensuring today's students become informed consumers and producers of technology in our world.

The STEL Framework

The original STL included 20 core content standards, each with supporting benchmarks that specify what students should know and be able to do to meet the standards. The revised STEL includes only eight core content standards with fewer total benchmarks. However, new to the STEL are eight technological and engineering practices, aligned with the broadly accepted 21st century skills, that identify the necessary attributes and qualities all students should exhibit, plus eight diverse technological and engineering contexts, or educational settings, in which the eight core content standards might typically be applied.

The switch to this framework of eight content standards, eight practices, and eight contexts highlights that it's not just about what students need to know and be able to do; it is also about the attributes students should aim to exhibit and the range of disciplinary contexts in which the content and practices might be applied. The standards' 8x8x8 framework also strikes a balance of structure and flexibility, providing educators the autonomy to develop standards-based curricula that can be effectively implemented within the constraints of their own local environment. .

Beyond the Technical Skills

When people hear the word technology, many immediately think of computers and technical skills, which represent a very narrow view of the discipline. Technology is all around us, enabling us to communicate, learn, experience, and engage with one another.

To ensure technological literacy, we have to think well beyond the traditional skills, including how we integrate social emotional engagement into technology education and promote the need for responsible decision making, self-management, and social awareness. Further, we have an opportunity to incorporate diversity, equity, and inclusion practices into technology education through hands-on learning, teamwork, and iterative problem solving, which relates directly to how we define and teach engineering as a verb.

Social Emotional Learning and Diversity, Equity, and Inclusion

The intersection of discipline-focused STEM education and the softer side of social emotional learning presents an exciting opportunity to develop well rounded citizens of society. We know that the inclusion of personal agency, social emotional learning, and diversity, equity, and inclusion practices are critical for all of today's learners. This has been more evident than ever as a result of recent events, including the civil unrest and the pandemic. These events also revealed that learners have a desire and an ability to take agency of themselves and their education, even at an early age. This finding is exciting because, according to Hannon and Peterson (2021), agency, which relates to recognizing one's social responsibility to be an engaged citizen, results in "learners who…are purposive, reflective, invested, and action oriented" (p. 168). We know that social awareness and social management skills are lifelong skills that learners can develop and hone at an early age (Dearden & Childress, 2021). As such, we must find opportunities to integrate the development of social-emotional skills into all subjects and teaching strategies, including technology and engineering education.

Technology and engineering education actually provide a unique opportunity to integrate social emotional learning strategies and promote a culture of diversity, equity, and inclusion because, in these disciplines, STEM learning is approached from a hands-on perspective that emphasizes learning by doing. For example, think about the engineering design process of iterative design cycling through the steps to develop a workable solution. A learner's back-and-forth steps promote taking a perspective on others' ideas, developing empathy, and growing skills in interpersonal communications and conflict resolution (Dearden & Childress, 2021). The engineering design process also promotes the need for responsible collaborative decision-making from the entire team. Further, reaching a team decision requires each learner to practice inclusion and equity and value different viewpoints and perspectives. Working in a group requires culturally effective listening, empathy, and effective communication skills (Talbott, 2019).

This importance of considering a wide range of perspectives, preferences, and challenges in the evaluation of problems and formulation of solutions is embedded throughout the STEL and explicit in many benchmarks. In fact, all eight of the STEL practices promote the dispositions that learners need to succeed in tomorrow's world (STEL, 2021). Learners equipped to apply these practices gain cultural capital that helps remove cultural divides such as gender, ethnicity, and race (Jones, 2016). The STEL highlights that it is about more than what students know and can do, but also about how they approach problems and evaluate solutions, which is critical to ensuring diversity and equity for all in our society as technology continues to change and advance.

Engineering as a Verb

The use of the noun engineering and its inherent definition as a disciplinary field of study is broadly understood and accepted. However, the STEL focuses on the use of engineering as a verb, or the application of engineering habits of mind and the use of engineering design concepts (STEL, 2021). This focus led to the rebranding of ITEEA's standards to include *technological and engineering literacy* [emphasis added]. This helps us operationally define the intent of the STEL by stating empirically that it is not just for future Technicians, Technologists, or Engineers, but for all students no matter their career aspirations.

Teaching engineering as a verb engages the whole learner by immersing them in real-world situations with real-world problems to achieve trade-offs that benefit all of society. Grubbs et al. (2018) states, "[engineering education] also covers the focal points of technology education, (i.e., design, problem solving, ethics, cultural and societal effects, and good consumers) and industrial arts (tool usage, material selection and testing, and industry connections)" (p. 34). At the same time, it provides greater alignment to science and math and a variety of college and career pathways. Further, learners who apply engineering as a verb understand they create things that can and will change the world, developing "social capital" through these experiences and opportunities to develop broader networks through real world learning (Jones, 2016).

This capital gives students a “toolkit of skills to understand, manage, or resolve concerns encountered while learning” (Jones, 2016, p. 17). As Funk states “STEM learning helps develop the skills and mindset needed to navigate life. Perseverance is key. We all fail at times. It takes character to learn from our mistakes and to try again” (National Afterschool Association, 2016, para. 4).

Implementing the STEL

The pandemic hit our world in early 2020 causing all industries, especially educators, to reframe how they deliver their services. During the height of the pandemic, ITEEA released the new standards. While this presents some challenges with promotion and adoption, the STEL reinforces that it is possible for teachers to offer engaged, real-world learning regardless of constraints, an encouraging and empowering message during an otherwise chaotic time. The eight benchmarks and related contexts and practices provide a comprehensive blueprint for how students can progress through the grade levels and standards to graduate with a firm understanding of technological and engineering literacy. The flexibility afforded by the 8x8x8 framework allows teachers to adapt and apply the STEL to any situation, including virtual learning, and the supplemental resources provided by ITEEA take some of the burden off teachers to develop curricula, lesson plans, and assessments from scratch.

An Integrative Approach

Education should not be segmented, or siloed, but integrated across all subjects to help learners make meaning of the content. The STEL is designed to broaden its application to include all letters of the acronym STEM, and more. “What passes for ‘STEM education’ involves an unbalanced focus on science and mathematics, with marginal attention to technology and engineering (STEL, 2020, p. 5). The STEL is designed to help educators understand the interconnectedness of *all* [emphasis added] disciplines learners’ study and to instill in all learners the need to connect these disciplines into a meaningful learning experience that has a real-world application for their future learning and growth. The STEL is designed to encapsulate the broad field that is technological and engineering literacy into a set of inclusive essential knowledge areas, skills, and dispositions that are widely applicable across all education disciplines (STEL, 2020).

The STEL provides opportunities to offer cross-curricular integrative learning for all grade levels. For many, the connections between the sciences, mathematics, and engineering are easy to make. However, because the STEL promotes understanding the history of technology, impacts on society and its influences, the benchmarks also easily correlate with learning standards for U.S. history, world history, economics, and other social sciences. Further, the design applications and applying and maintaining technological products and systems tie in nicely into arts and civics education.

To maximize the use of the STEL and rid ourselves of the working in silos, collaboration with our academic peers is important. Collaboration between teachers can be achieved through having a common vision and goals, building of community, setting up norms and expectations, and working through disagreements. (Davis 2020). Professional Learning Communities, collaborative planning time, and opportunity for reflection are necessary to create an environment where teachers can plan integrated lessons together. The STEL are written to be cross curricular having eight contexts, practices that align with the Engineering habits of mind, and standards that are inclusive of technology, engineering, and the academic sides of education which opens the possibilities for collaboration across academic areas.

Supplemental STEL Resources

With integration top of mind, several resources are available to assist in implementing STEL so that educators from all academic areas can work collaboratively with technology and engineering educators.

Crosswalks to Other Standards

Educators can easily integrate the STEL with existing standards they are already using by referencing ITEEA's crosswalks. During March, April, and May of 2021, ITEEA created and provided standards crosswalks for National Common Core State Standards (NCCSS) for English Language Arts and Math, Next Generation Science Standards (NGSS), International Society for Technology in Education (ISTE), and National Assessment of Educational Progress (NAEP). There is also a crosswalk to the STL to assist teachers and administrators who had implemented the STEL's predecessor in aligning the new benchmarks to their instructional plans.

Curriculum

ITEEA offers an integrative curriculum Engineering byDesign™ (EbD™) curriculum, which is aligned to the STEL, as well as national standards for science and math as well as Common Core and the National Academy of Engineering's Grand Challenges for Engineering (Engineering by Design, n.d.). EbD™ includes courses in PreK through grade 12 that can be taught independently or comprehensively and integrated into all four STEM disciplines, plus English Language Arts (Engineering by Design, n.d.). Further, ITEEA offers professional learning and training for teachers, so they are better equipped to use the curriculum in the classroom.

STEL eTool and Lesson Planner

ITEEA recognized the need for resources to aid teachers in the application of STEL. As such the STEL eTool (https://iteea-stel-etool.github.io/) and the STEL Lesson Planner (https://www.surveymonkey.com/r/ITEEASTELLP) were created. The eTool allows educators to select a benchmark or keyword, a standard, and or a grade level to detail the benchmark, performance band, standard, crosswalks to core standards, practices, and a description of the benchmark. The lesson planner allows educators to submit STEL aligned lesson plans to ITEEA to be shared with others. These lesson plans, once submitted and reviewed by ITEEA, can be found on the ITEEA website. ITEEA has created a STEL Benchmark Verb Alignment to Cognitive, Affective, and Psychomotor Domains. This document assists educators in aligning these domains with each of the 142 benchmarks or outcomes.

Conclusion

The STEL is a powerful tool with countless supplemental resources that teachers can apply in any educational setting to prepare students that are technologically and engineering literacy, which will benefit us all. However, releasing the STEL is only the first step in building bridges between the STEM disciplines and beyond via integrative, cross-curricular application. A strong statement from the president of the National Academy of Engineering about the STL still rings true today and should remain a focus for our teaching and learning – “Indeed, the standards cannot succeed without the concerted effort of many stakeholder groups” (Wulf, 2000, p. vi). The statement emphasizes a call to action to ITEEA and its related organizations, teachers, administrators, and other educational leaders that remains true today. It is dependent on the education community to explain, promote, and implement the STEL so today’s students become the leaders our world needs tomorrow.

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