Standards for Technological Literacy and STEM Education Delivery Through Career and Technical Education Programs

The domestic and international marketplaces are changing, developing new technology and processes to improve productivity in every sector, requiring people to have different skills and attitudes about work. Arguably, technology and the new literacies associated with it have transformed the workplace more quickly and more deeply than any of our other institutions (Mikulecky & Kirkley, 1998). With these improvements, some segments within the workforce have experienced technical obsolescence. Today's knowledge-based society that thrives on technological transformation has little room for those who cannot read, write, and compute proficiently; find and use resources; frame and solve problems; and continually learn new technologies and skills, as well as work in technical occupations (National Commission on Teaching and America's Future, 1996). According to the U.S. Department of Labor, technical occupations require knowledge of scientific, engineering, and mathematical theories, principles, and techniques that enable individuals to understand how and why a specific device or system operates (United States Department of Labor, n.d). Democratic governance in knowledge-based societies like the United States relies on the ability of the general populace to make informed choices about the options made available to them by responsible scientific and technological progress (Busquin, 2002). In such societies, it is commonplace to say that relationships between science, technology, engineering, and mathematics disciplines are becoming increasingly stronger, permeating the workplace and creating new literacy demands for solving daily work-related problems.

Career and Technical Education (CTE) has traditionally been viewed as the cornerstone of workforce preparation. CTE programs address aspects of science, mathematics, and most certainly technology, addressing STEM-related careers in auto technology, medical technicians, registered nurses, process control processors, machinists, financial managers, and many other kind of technical-related careers (Stone, 2011). The Association of Career and Technical Education (2009) stated that career and technical education (CTE) programs offer an important instructional approach that strengthens students understanding of STEM content and helps attract more individuals into STEM career pathways. In a culture that is increasingly embracing STEM concepts in the workplace, literacy in these disciplines and how they relate to each other is imperative. STEM requires cognitive comprehension, which enables the general

Paul A. Asunda (pasun07@siu.edu) is an Assistant Professor in the Department of Workforce Education and Development at Southern Illinois University-Carbondale.

populace to grasp how natural and designed worlds work, to think critically and independently, to recognize and weigh alternative explanations of events and design trade-offs, and to sensibly deal with problems that involve evidence, numbers, patterns, logical arguments, and uncertainties (American Association for the Advancement of Science [AAAS], 1993). Therefore, as the need for those with knowledge of technical work and critical thinking skills in the 21st century workplace continues to grow, policy makers, researchers, and educators alike believe that integration of STEM disciplines into CTE curriculum is a viable solution to meet some of these demands (Terrell, 2007; The President's Council of Advisors on Science and Technology, 2010).

Nevertheless, STEM integration into CTE curriculum faces unprecedented challenges. A search for CTE and STEM education curricula in academic databases will yield an insurmountable amount of documents and curricula. A more recent study by the Academic Competitiveness Council found 105 STEM education programs that experienced frequent programmatic changes with differing definitions of what constitutes STEM curricula and programs, in addition to multiple program goals (United States Department of Education, 2007). The National Science Board (2007) stated that the nation faces two central challenges to constructing a strong coordinated STEM education system: (a) ensuring coherence in STEM learning and (b) ensuring an adequate supply of well-prepared and highly effective STEM teachers. Further, the board stated that educators should strive to facilitate a strategy to define national STEM content and guidelines that would outline the essential knowledge and skills needed at each grade level, developing metrics to assess student performance that are aligned with national content guidelines, ensuring that assessments under No Child Left Behind promote STEM learning, improving the linkage between high school and higher education, and preparing individuals for the world of work (National Science Board, 2007).

To this end, some researchers have questioned the significance of STEM infusion into CTE without a clear curriculum, standards, or assessment procedures. Williams (2011) asserts that Sanders (2009) raised a lot of skepticism with regard to STEM education, specifically upon an examination of projects that have been developed for teachers and are available online to support teachers wishing to implement STEM activities into their school (e.g., projects found at http://www.stemtransitions.org). According to Williams (2011), these projects generally do not integrate science, technology, engineering, and mathematics but do offer bits and pieces of a couple of these disciplines. Pitt (2009) argued that such an approach as an education concept is problematic because there is little consensus as to what STEM education comprises and how it can be taught in schools—whether it needs to be taught as a discrete subject or whether it should be an approach to teaching the components.

The wide variation in STEM curricula and lack of coherence are two of the many factors that birthed the common standards initiative to examine what is taught, when it is taught, and how to test student performance. Bybee (2000) stated that standards influence the entire educational system because they are inputs, but they also define outputs. Similarly, Wulf (2000) noted that standards provide a much needed reference point for developers of curriculum and instructional materials. The question then arises: Which content standards should guide what students need to know with regard to comprehending principles that may lead to the goal of STEM literacy?

This paper seeks to address the first challenge identified by the National Science Board, "ensuring coherence in STEM learning" (2007, p. 1). Some thoughts about designing a set of content standards and a possible process that could contribute to the realization of this goal are presented. It should be noted that providing a clear set of standards is beyond the capabilities of this author. Nonetheless, clear standards for STEM literacy are very important to CTE profession because they provide direction for teachers to structure instruction methods to ensure students achieve a set of expected competencies. This essay contributes to ongoing discussions about STEM content standards that can guide instruction in order to realize the goal of STEM literacy. As a starting point, educators should comprehend literacy from a science, technology, engineering, and mathematics perspective and examine the categories for content standards from these disciplines for common themes that may guide STEM instruction and integration into the CTE curriculum. This essay presents a description of what science, technological, engineering, and math literacy entails and a process of identifying STEM literacy standards.

Math, Science, and Technological Literacy to STEM Literacy

Given the pressing needs for a high quality STEM workforce in 21st century economies, proposals for science, technology, engineering, and mathematics are being developed to meet and create pathways to a wide range of interesting and exciting career opportunities. The goal of this amalgation is to seek knowledge in science, technology, mathematics, and engineering in order to achieve STEM literacy. An examination of the content standards related to math, science, technology, and engineering disciplines describes the knowledge, skills, and proficiency students should acquire in each area of study. Content Standards guide the creation of goals and expected outcomes that are measurable by some form of assessment procedures that seek to examine the growth in students learning experiences (National Academy of Education [NAEd], 2009).

According to Kintgen, Kroll, and Rose (1988), the term *literacy* is usually interpreted as the ability to read and write. However, extensions of this term, to computer literacy, cultural literacy, political literacy, and of course STEM literacy, suggest that the semantic aspects of this term are very important. Although educators generally use literacy in its descriptive sense, it is the evaluative sense of the term—the mastery of a body of knowledge—that provides an understanding of the intended meaning. With advocacy to integrate STEM disciplines into CTE curriculum, it is imperative that we examine each discipline and what kind of literacy each advocates.

Science is a process of producing knowledge; the process depends on making careful observations of phenomena in the natural world and inventing theories for making sense out of those observations and therefore develop in students a set of predetermined beliefs about their natural environment (AAAS, 1989). Further, a scientifically literate individual is one that is able to sensibly deal with problems that often involve evidence, quantitative considerations, logical arguments, and uncertainty, not only with respect to decisions involving their own lives, but also with respect to issues that affect societies in general. Such a person has the ability to describe, explain, and predict natural phenomena as well as comprehend articles about science in the popular press and engage in social conversation about the validity of the conclusions (AAAS, 1989). In light of this view, Dani (2009) posited that scientific literacy is the knowledge and understanding of scientific concepts and processes required for: personal decision making, identification of scientific issues underlying economic productivity at the national and local level, as well as express positions that are scientifically and technologically informed. In other words, an individual can ask, find, or determine answers to questions derived from curiosity about everyday experiences.

Technology seeks to develop new knowledge by extending our abilities to change the world and cut, shape, or put together materials to satisfy our needs. In contemporary society, technological processes constitute a complex social enterprise that not only includes research, design, and crafts, but also includes finance manufacturing, management, labor, marketing, and maintenance (AAAS, 1989). Gagel (1997) suggested that technological literacy implied the ability to use, manage, understand, and access technology leading to four generalized competencies: (a) accommodate and cope with rapid and continuous technological change, (b) generate creative and innovative solutions for technological problems, (c) act through technological knowledge both effectively and efficiently, and (d) assess technology and its involvement with human life judiciously. The International Technology Education Association (ITEA/ITEEA) defined technological literacy as "the ability to use, manage, assess, and understand technology" (2000/2002/2007, p. 242). Garmire and Pearson (2006) provide a three dimensional view that includes (a) knowledge, (b) capability, and (c) critical thinking and decision-making. "First, a technologically literate person must have a certain amount of basic knowledge about technology…. Second, a technologically literate person should have some basic technical capabilities, such as being able to work with a computer and to identify and fix simple problems in the technological devices used at home and in the office. More generally, he or she should be able to employ an approach to solving problems that rely on aspects of a design process…. And third, a technologically literate person should be able to think critically about technological issues and act accordingly" (Garmire & Pearson, 2006, p. 21).

Engineering is the profession in which knowledge of the mathematical and natural sciences gained by study, experience, and practices are applied to develop ways to economically utilize the materials and forces of nature for the benefit of humanity (Jones, 2000). The knowledge needed to solve an engineering problem is pre-defined by the context. This context determines relevant knowledge that requires the integration of mathematical principles and scientific knowledge for the purpose of solving or meeting societal needs. Engineering integrates the principles of science and the fundamentals of mathematics for the purpose of meeting societal needs. Heywood (1993) stated that engineering literary requires that we understand how individuals, organizations, and society interact at a variety of levels of technology in an engineered world, and how in this process we can exercise purposive control over the changes that technology creates in our lives. For example, a course that includes basic engineering will help students unravel some of the mysteries of technology necessary to succeed in the workforce of a technological society. The idea of engineering literacy is synonymous with technological literary, since it is difficult to differentiate between the two, though engineers may argue differently. However, engineering serves as the connection between scientific and mathematical theory and the technology we use in our everyday lives. For example, a certified nursing assistant in laboratory health care systems uses technology to gather information, compute gathered data, and make critical decisions based on this information from various products that have been engineered. Therefore, it's a profession devoted to designing, constructing, and operating structures, machines, and other industry devices. This is characteristic of 21st century work environments, which are a mosaic or collage of solutions to engineering problems.

Mathematics is the study of any patterns or relationships (AAAS, 1993). Mathematics explores the possible relationships among abstractions, which can be anything from a string of numbers to geometric figures to a set of equations. Because of its abstractness, mathematics is universal in a sense that other fields of human thought are not. It finds useful applications in business, industry, music, history, politics, sports, medicine, engineering, and social and natural sciences. According to the Organization for Economic Co-operation and Development (2003), mathematical literacy is an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments, and to engage in mathematics in ways that meet the needs of that individual's current and future life as a constructive, concerned, and reflective citizen. Therefore, mathematics plays a central role in modern culture, and some basic understanding of the nature of mathematics is requisite for a better understanding of the world.

Although each of these disciplines has a character and history of its own, they are interdependent and reinforce each other. New insights from science often catalyze the emergence of new technologies and their applications, which are developed using engineering principles. In turn, new technologies create opportunities for new scientific investigations (National Research Council, 2011). It is the union of science, mathematics, and technology that forms the scientific endeavor, which is further reinforced by engineering principles that reflect our modern designed world and the quest for STEM literacy (AAAS, 1989).

So, what is STEM literacy, and how can it be attained? Leon Lederman, a renowned physicist, posited that STEM literacy implied that an individual operating in a knowledge–based economy has the ability to adapt to and accept changes driven by the new technology, work with others across borders, anticipate the multilevel impacts of their actions, communicate complex ideas effectively to a variety of audiences, and find measured yet creative solutions to problems that are today unimaginable (National Governors Association, 2007). On the contrary, Williams (2011), Sanders (2009), and Pitt (2009) have argued that there seems to be little clear discussion about the similarities, differences, and relationship between science, technology, engineering, and mathematics as school subjects; the idea of STEM literacy is a vague idea that is laudable but problematic with regard to educational outcomes, scientific literacy, and technological literacy—although reasonably well researched and defined, an amalgam of the three has not been developed nor tallied.

Standards and the School System

Subramanyam (1981) described standards as "fundamental to many aspects of modern life including science, technology, industry, commerce, health, and education. Standards and specifications are documents that stipulate or recommend: (1) minimum levels of performance and quality of goods and services, and (2) optimal conditions and procedures for operations in science, industry, and commerce" (as cited by Erdmann, 2010). According to NAEd (2009), a standards-based vision was enacted in federal law under the Clinton administration with the 1994 reauthorization of the Elementary and Secondary Education Act (ESEA) and carried forward under the Bush administration with the No Child Left Behind Act (NCLB) of 2001. In recent years, conversations about the importance of standards in our school systems have intensified. In 2008 the National Research Council of the National Academies produced a summary report titled *Common Standards for K-12 Education? Considering the Evidence.* By 2009, the National Governors Association, the National Association of Secondary School Principals, the Council of Great City Schools, and the American Federation of Teachers all publicly supported national standards. Further, in a recent survey of policy makers, standards were acknowledged as the central framework guiding state education policy (Massell, 2008). Today, discussions around education reform are focused on developing common core standards. The mission statement of the standards directly relates to CTE: “relevant to real word, reflecting the knowledge and skills that our young people need for success in college and careers” (Bray, 2011, p. 6). Although these statements seem to support taking action and designing standards for integrating STEM disciplines into CTE curriculum, most are sparse on the details of what to do and how to do it.

Could Technological Literacy Standards Be a Common Approach to STEM Literacy Standards?

The study of technological process provides students with opportunities to learn about the processes of design, fundamental concepts of technology and engineering, and the limits and possibilities of technology in society. *Standards for Technological Literacy: Content for the Study of Technology*, national standards released by the International Technology Education Association (ITEA/ITEEA) in 2000, identifies and defines 20 standards that every student should know and be able to do to be technologically literate. Widespread acceptance of technological literacy as a desirable outcome for both academic and vocational education has led to the development and implementation of a variety of curriculum innovations in the field of career and technical education (Prime, 1998).

In 2009, ITEEA proclaimed that the delivery of STEM education content is closely aligned with the same core content as the *Standards for Technological Literacy* (STL). The organization stated that the content contained within the STL standards was the foundation for students to develop 21st Century STEM literacy—the very core of abilities needed for students to become advanced problem solvers, innovators, technologists, engineers, and knowledgeable citizens. ITEEA believes that all true STEM programs must include STL as a ladder to help students achieve STEM literacy (ITEEA board of directors, 2009). Gorham, Newberry, and Bickart (2003) offered a starting point for such a discussion by illustrating the connection between the *Standards for Technological Literacy* and *Engineering Criteria 2000*, criterion 3. They further stated that STL provided a focused guide for improving technological literacy and the standard will provide a much needed reference point for developers of curriculum and instructional materials in addition to laying a foundation for building a technologically literate society (Gorham, Newberry, & Bickart, 2003).

Most often educators have developed integrated STEM programs around shared themes based on existing national standards, such as the National Council of Teachers of Mathematics’ *Principles and Standards for School Mathematics* (2000), the National Research Council’s *National Science Education Standards* (1996), the *Standards for Technological Literacy (*2000), the Accreditation Board for Engineering and Technology’s *Engineering Criteria 2000* (1997), and most recently the *Common Core State Standards Initiative for Mathematics* (2011). Utilizing the work of Gorham, Newberry, and Bickart (2003) as a basis toward the development of STEM literacy is a viable strategy that will provide coherence and a robust foundation toward development of the standards. This will enable instructional practices that will enable all students to achieve both academic and technological abilities in all career pathways and future leadership in technical occupations. Table 1 details the correlation of ideas and concepts in both standard and outcome between the twenty *Standards for Technological Literacy* (STL) and the eleven Accreditation Board for Engineering and Technology (ABET) *Engineering Criteria* outcomes.

Table 1
Comparison of Standards for Technological Literacy with ABET Engineering Criteria

ABET	A	B	C	D	E	F	G	H	I	J	K
STL 1	●	●	●	●	■	●	✓	■	●	✓	■
STL 2	●	●	■	■	■	●	✓	■	●	✓	■
STL 3	■	■	●	●	✓	■	■	■	●	✓	✓
STL 4	■	●	●	●	✓	■	✓	■	●	✓	✓
STL 5	●	●	●	●	✓	■	✓	■	●	■	✓
STL 6	●	●	●	●	■	■	✓	■	●	■	✓
STL 7	■	●	●	●	✓	■	✓	■	●	■	✓
STL 8	✓	■	■	●	■	●	■	■	●	✓	■
STL 9	✓	■	■	●	■	●	■	■	●	✓	■
STL 10	✓	■	■	●	■	■	■	■	●	✓	■
STL 11	✓	■	■	■	■	●	■	■	●	✓	■
STL 12	✓	✓	■	■	✓	●	■	■	●	✓	■
STL 13	✓	■	■	■	✓	■	■	■	●	✓	■
STL 14	✓	■	■	✓	■	●	■	■	●	✓	■
STL 15	✓	■	■	✓	■	●	■	■	●	✓	■
STL 16	✓	■	■	✓	■	●	■	■	●	✓	■
STL 17	✓	■	■	✓	■	■	■	■	●	✓	■
STL 18	✓	■	■	✓	■	●	■	■	●	✓	■
STL 19	✓	■	■	✓	■	●	■	■	●	✓	■
STL 20	✓	■	■	✓	■	●	■	■	●	✓	■

Table Key:
■ = denotes a correlation in ideas and concepts in both standard and outcome
✓ = denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both standard and outcome
● = denotes an implied idea or concept that may be used in both standard and outcome

Source: Accreditation Board for Engineering and Technology's *Engineering Criteria 2000* (ABET) and International Technology Education Association's *Standards for Technological Literacy* (STL); a modification of table from Gorham, Newberry, and Bickart (2003).

Table 2 details the correlation of ideas and concepts in both standard and outcome between the twenty *Standards for Technological Literacy* (STL) and the eight *National Science Education Standards*.

Table 2
Comparison of Standards for Technological Literacy with the National Science Education Standards

NSES	A	B	C	D	E	F	G	H
STL 1	✓	✓	✓	✓	✓	●	●	✓
STL 2	✓	✓	✓	✓	✓	●	●	✓
STL 3	●	●	✓	✓	✓	●	●	✓
STL 4	✓	✓	✓	✓	✓	●	●	✓
STL 5	✓	●	✓	✓	●	●	●	✓
STL 6	✓	●	✓	✓	✓	●	●	✓
STL 7	✓	●	✓	✓	●	●	●	✓
STL 8	✓	●	■	✓	●	●	✓	✓
STL 9	✓	●	■	✓	✓	●	✓	✓
STL 10	✓	●	✓	●	✓	✓	✓	✓
STL 11	✓	●	■	●	✓	●	✓	✓
STL 12	✓	●	✓	●	✓	●	✓	✓
STL 13	✓	●	■	●	✓	✓	●	✓
STL 14	✓	●	✓	●	✓	✓	●	✓
STL 15	✓	●	■	●	✓	●	●	✓
STL 16	✓	●	●	✓	●	●	●	✓
STL 17	✓	●	✓	✓	✓	●	✓	✓
STL 18	✓	●	●	✓	✓	●	✓	✓
STL 19	✓	●	●	✓	✓	●	✓	✓
STL 20	✓	●	●	✓	✓	●	✓	✓

Table Key:
■ = denotes a correlation in ideas and concepts in both standard and outcome
✓ = denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both standard and outcome
● = denotes an implied idea or concept that may be used in both standard and outcome

Source: International Technology Education Association's *Standards for Technological Literacy* (STL) and National Research Council's *National Science Education Standards* (NSES); a modification of table from Gorham, Newberry, and Bickart (2003).

Table 3 details the correlation of ideas and concepts in both standard and outcome between the twenty *Standards for Technological Literacy* (STL) and the eight *Common Core State Standards Initiative for Mathematics*.

Table 3
Comparison of Standards for Technological Literacy with the Common Core State Standards Initiative for Mathematics

CCSSI	1	2	3	4	5	6	7	8
STL 1	✓	✓	✓	✓	●	■	✓	✓
STL 2	✓	✓	✓	✓	●	■	✓	✓
STL 3	●	✓	✓	✓	●	■	✓	✓
STL 4	●	✓	✓	✓	■	✓	✓	✓
STL 5	✓	✓	✓	✓	■	✓	✓	✓
STL 6	✓	✓	✓	✓	■	✓	✓	✓
STL 7	●	✓	✓	✓	✓	■	✓	✓
STL 8	✓	✓	●	●	●	●	■	✓
STL 9	✓	✓	●	●	●	●	■	✓
STL 10	✓	■	■	●	●	●	■	■
STL 11	✓	✓	●	●	●	●	■	■
STL 12	✓	✓	✓	●	●	●	■	■
STL 13	✓	■	■	●	●	✓	■	■
STL 14	✓	✓	✓	●	●	✓	■	✓
STL 15	✓	✓	✓	●	●	✓	■	✓
STL 16	✓	✓	✓	●	●	✓	■	✓
STL 17	✓	✓	✓	●	●	●	■	✓
STL 18	✓	✓	✓	●	●	✓	■	✓
STL 19	✓	✓	✓	●	●	✓	■	✓
STL 20	✓	✓	✓	●	●	✓	■	✓

Table Key:
■ = denotes a correlation in ideas and concepts in both standard and outcome
✓ = denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both standard and outcome
● = denotes an implied idea or concept that may be used in both standard and outcome

Source: International Technology Education Association's *Standards for Technological Literacy* (STL) and National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM); a modification of table from Gorham, Newberry, and Bickart (2003).

Key Concepts and Principles That May Support STEM Literacy in Career and Technical Education

As educators, school districts, and stakeholders continue to advocate for integration of STEM disciplines into the curriculum, it should be noted that, ideally, students learn better in a standards-based environment because everybody is working towards the same goal (U.S. Department of Defense, Domestic Dependent Elementary & Secondary Schools, 2008). This author hopes that by using STL standards as a basis for interacting with STEM disciplines anticipated learning outcomes, as depicted in tables 1-3, students will be able to develop lifelong learning skills that will help to impart in them STEM competencies required for 21st century workplace. Building further on Gorham, Newberry, and Bickart's (2003) work, Table 4 (next two pages) depicts some of the major concepts and principles covered in CTE courses, specifically technology education. According to the Association of Career and Technical Education (2009), a thoughtful integration of STEM concepts into CTE curriculum can help students become more STEM literate and increase the chances that these students consider STEM-related careers. It then can be argued that if students understand more about the concepts and principles of technology incorporating science, engineering, and mathematics standards, then their overall level of STEM literacy will be enhanced. An increase in STEM literacy will very likely result in a workforce that is capable of assuming technical occupations in a knowledge-based society.

Table 4 (continued on next page)
Depiction of Some of the Major Concepts and Principles Covered in Technology Education Courses Across Science, Technology, Engineering, and Mathematics Standards

Concepts and Principles	NSES	STL	ABET	CCSSI
Understand and use mathematics, science, and technology	✓	3, 4, & 7	A	1 through 8
Understand technological knowledge	F	1 & 2	✓	1, 2, & 5
Understand the history of technology	✓	7	✓	✓
Understand the historical significance of previous advances in technology and engineering	H	3 & 7	✓	✓
Understand about engineering and technology in society	J & H	4, 5, 6, & 7	F, H, & J	1 through 8
Understand systemic principles	A & C	11, 12, & 13	C & H	1 through 8
Understand ecological principles	E & D	5	J	✓
Use and recognize inquiry skills, apply knowledge in retrieving information, and recognize and analyze major limitations in the usefulness of information	B	3, 10, 13, & 17	B, F, & G	1, 2, 3, 5, 6, & 7
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 chose 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	A, B, & F	8, 9, 10, & 11	B, C, E, G, & K	1 through 8

Table Key:
A checkmark ✓ refers to the topic being mentioned or covered in some manner, but it may not be directly stated.

Table 4 (continued from previous page)
Depiction of Some of the Major Concepts and Principles Covered in Technology Education Courses Across Science, Technology, Engineering, and Mathematics Standards

Concepts and Principles	NSES	STL	ABET	CCSSI
Identify, formulate, and solve engineering problems	B & F	8, 9, 10, & 11	E	1 through 8
Employ tools and equipment and use appropriate tools and techniques	B	1, 11, & 12	K	5 & 6
Understand properties of objects and materials	C	2, 15, 18, 19, & 20	✓	✓
Understand about risks and benefits of design solutions	G	2, 5, & 13	✓	1 through 6
Understand resources: • Understand properties of earth materials, such as building materials & sources of fuel • Understand resources and human use	E, C, & H	2, 14, 15, 16, 17, 18, 19, & 20	✓	✓
Work as a team or individually to solve problems	✓	2, 11, 12, & 13	D	3, 4, & 6
Assess impact and consequences of products and systems and assess impact and consequences of actions	A & G	13	✓	✓
Communicate solutions in portfolios, design sketches and drawings, journals, logs, multi- media presentations, and audio-visual presentations	A & F	12 & 17	G	3, 4, 5, & 6
Recognize the need for, and ability to engage in life-long learning	H	✓	I	✓

Source: Accreditation Board for Engineering and Technology's *Engineering Criteria 2000* (ABET), International Technology Education Association's *Standards for Technological Literacy* (STL) , National Council of Teachers of Mathematics' *Principles and Standards for School Mathematics* (NCTM), and National Research Council's *National Science Education Standards* (NSES); a modification of table from Gorham, Newberry, and Bickart (2003).

Conclusion

At a minimum, employers rely on career and technical education (CTE) and workforce training systems to supply workers able to perform in their jobs (Rojewski 2002). In CTE classes that seek to integrate STEM concepts, it falls to the instructors to design and sequence the learning experiences that will promote such a deliberate practice. Instructors must also arrange learning experiences that help students learn to identify the knowledge and skills needed for expert practice, as well as to develop that knowledge and skill set. This paper provided a standards-based framework based on the STL to lay a foundation for

STEM instruction supporting the goal of STEM literacy. It is the intent of this paper to contribute to ongoing discussions among educators, employers, parents, and all those concerned, to seek coherence in STEM instruction through a common standards-based approach. This will serve as the benchmark for accomplished teaching of STEM disciplines in CTE programs preparing individuals for the jobs of the 21st century, consequently requiring that CTE teacher education programs be organized around STEM literacy standards.

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