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The Power and Promise of Technology and Engineering Education

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Introduction

It is a pleasure to have this opportunity to talk with you today about technology and engineering as a part of your schools' efforts toward integrating STEM through interdisciplinary instruction. ITEEA (The International Technology and Engineering Educators Association) embraces the concept that "Technology and Engineering bring STEM to Life"! We believe this captures the essence of **interdisciplinary STEM instruction**. Focusing on the integration of science, technology, engineering, and mathematics while using technology and engineering as a catalyst allows teachers to engage students in meaningful real-life contexts! These technological and engineering contexts bring attention to the increasingly important role that STEM plays in our society and emphasizes how it affects our everyday existence.

Technology and technological literacy have been described in many ways—but most definitions concur that technological literacy is used to make our lives better, more productive, or more enjoyable. In itself, technology can be rigid and inhuman. It offers no solutions. However, when managed, technology is flexible. When understood, it can be adapted and changed as needed—or wanted. Many educators think of technology and technological literacy as applied mathematics and science for specific purposes. Those purposes have also been described as the use of knowledge, tools, and skills to increase our potential, to solve problems, and to modify our world.

The issue is not whether technology or engineering is good or bad; not whether it should or shouldn't be offered; and not how it is to be taught. The pertinent issue here is whether any nation can maintain a worldwide competitive edge without appropriate understandings and education pertaining to technological literacy—understandings that result in raising the level and quality of living that we desire. Therefore, the information being shared in this presentation is about providing a type of education that will help our citizens live optimally in an advanced technological society. It is becoming more evident through the integrative STEM movement that we can no longer teach in silos, locked inside each educational discipline. It is imperative that students are given the opportunity to connect the content they are learning in the academic core subjects, as well as the arts, to outside learning experiences, in rich and meaningful ways. Using an integrative STEM delivery through interdisciplinary instruction is a vital key to unlocking a unique learning experience that children will experience and apply in circumstances beyond the classroom and long into their future.

Focusing on the "T" of STEM - Defining Technological Teaching

Educators often only associate technology and technological literacy with the use of computers and educating **with** technology. Technological literacy is teaching **about** technology. We must consider all types of technologies that relate to our designed world. That designed world may include medical, agricultural and related bio-technologies, energy and power technologies, information, environmental, communication, transportation, manufacturing, construction, and more. To think of technology only in terms of delivering instruction is a narrow and short-sighted instructional delivery view.

Technological literacy has its own content base. That content base has to do with the nature of technology, technology and society, design, abilities for a technological world, and the designed world. We like to refer to this delivery of interdisciplinary content in context in an acronym titled "T.I.D.E." (**T**echnology-**I**nnovation-**D**esign-**E**ngineering)!

Defining the teaching of science and technology is also important when delivering interdisciplinary instruction. Science education has traditionally been known to include teaching about the natural world through observation, identification, description, experimental investigation, and theoretical explanations. Scientific inquiry is a key method of learning about our world through the use of questioning and close examination using the science methodology.

Technology and Engineering Bring STEM to Life

Technology and engineering education provides opportunities to learn about the processes and knowledge related to technologies that are needed to solve problems and extend human capabilities. Technology has been defined as human innovation in action that involves the generation of knowledge and processes to develop systems that solve problems and extend human capabilities. Design is the key method used in teaching about technology (ITEA/ITEEA, 2000/2002/2007).

Science education does not automatically teach about technology any more than technology and engineering education automatically teaches about science. The two subjects have distinct differences in their ways of thinking, the content addressed, and their importance as a part of the general educational background of all students. Interdisciplinary teaching requires a thoughtfully implemented and interconnected curriculum that should produce synergistic results in terms of student learning.

Technological Literacy Content

We (ITEEA and the T&E profession) are currently working to advance science, technology, engineering, and mathematics (STEM) teaching with an emphasis on technology and engineering. We see the subjects working together to create an education that will produce the next generation of technology and engineering thinkers in order to benefit 100% of our citizenry!

Imagine a simple three-legged stool with the legs representing the subject areas of mathematics, technology, and science, and with the seat of the stool representing engineering. This practical way of thinking about the interaction and relationship of these school subjects also shows us that each subject is important for the content and way of thinking that it presents to the student.

ITEEA has used these foundational ideas as a launching pad to develop a curriculum for technological literacy to be taught as a separate, but interdisciplinary subject in our schools starting at the earliest levels and continuing through high school. The curriculum was developed as a result of several steps that included a major national project to create *Standards for Technological Literacy: Content for the Study of Technology.*

The first step was the creation of *A Rationale and Structure for the Study of Technology* (ITEA/ITEEA, 1996). This work allowed ITEEA to examine and study in detail such topics as the need for technological literacy in our schools, the processes of technology, what technology teaching would look like, and a call for action across our country.

A complete set of content standards followed the development of the *Rationale* that described what all students should know and be able to do pertaining to technology at grade levels K-2, 3-5, 6-8, and 9-12. The resulting standards have been translated into the Chinese, Japanese, Estonian, German, and Finnish languages. The Table of Contents shows five major areas that have been identified, with 20 major standards noted as important to the study of technology. The chapters are as follows:

- Preparing Students for a Technological World
- Overview of *Standards for Technological Literacy*

- The Nature of Technology
- Technology and Society
- Design
- Abilities for a Technological World
- The Designed World
- Call to Action

A subsequent major effort resulted in the creation of three additional sets of standards in a publication titled *Advancing Excellence in Technological Literacy: Student Assessment, Professional Development, and Program Standards* (ITEA/ITEEA, 2003). These standards developed research-based principles, practical contexts, students as learners, curricula and programs, instructional strategies, and continued professional growth and learning environments, and were designed to assist teachers in becoming better educators of technological literacy.

A Curriculum to Reflect Technological Teaching

At this point in our effort to create a pathway to technological literacy, we found it necessary to build courses that were based upon the standards. Today, we have a comprehensive set of K-16 courses that reflect standards in science, technology, engineering, and mathematics called **Engineering byDesign™** (www.engineeringbydesign.org).

The goals of this curriculum are to:

- Provide a standards-based K-12 program that ensures that all students are technologically literate.
- Provide opportunities for ALL students.
- Provide clear standards and expectations for increasing student achievement in STEM subjects.
- Provide leadership and support that will produce continuous improvement and innovation.
- Provide a program that constructs learning from a very early age and culminates in a capstone experience that prepares students to become the next generation of engineers, designers, innovators, and technologists.

Believing in the importance of early exposure to technological literacy, ITEEA has units for elementary students containing standards-based content, suggested testing, and the ability to refine and assess technological designs.

A few selected topics and descriptions are as follows:

- **Invention**: Students develop an idea for an invention by designing and constructing a working model or prototype of a gadget.
- **Communication**: Students examine communication processes, and design and develop a commercial project promoting school spirit.

- **Power and Energy**: Students gain an understanding of wind energy as they construct a device that captures wind energy and converts it to electricity.
- **Mechanical Toys**: Students investigate two mechanical devices and design a toy that uses both to create movement.

Today, ITEEA has numerous courses and complete curriculum guides that are used by teachers around the world (www.iteea.org).

Engineering byDesign™ (EbD): A Standards-Based Model Program
(http://www.iteea.org/EbD/ebd.htm)

CORE PROGRAM	K–2		EbD-TEEMS™ *Technology Starters/KITS*	
	3–5		EbD-TEEMS™ I^{3*}/KITS	
	6		*Exploring Technology*	18 weeks
	7		*Invention and Innovation*	18 weeks
	8		*Technological Systems*	18 weeks
	9		*Foundations of Technology*	36 weeks
	10–12	HS Choices	*Technology and Society*	36 weeks
	10–12	HS Choices	*Technological Design*	36 weeks
	11–12	HS Choices	*Advanced Design Applications* *	36 weeks
	11–12	HS Choices	*Advanced Technological Applications* *	36 weeks
	11–12		*Engineering Design (Capstone)*	36 weeks

ITEEA's **STEM*Center for Teaching and Learning** ™ has developed the only standards-based national model for Grades K-12 that delivers technological literacy in a STEM context. The model, **Engineering byDesign™** is built on the Common Core State Standards at both the high school and middle school levels, Standards for Technological Literacy (ITEEA); Principles and Standards for School Mathematics (NCTM); Project 2061, Benchmarks for Science Literacy (AAAS), and has plans in place to align with the Next Generation Science Standards (NGSS). Additionally, the Program K-12 has been mapped to the National Academy of Engineering's Grand Challenges.

Using constructivist's models, students participating in the program learn concepts and principles in an authentic, problem-/project-based environment. Through an integrative STEM environment, EbD™ uses all four content areas as well as English-Language Arts to help students better understand the complexities of tomorrow.

Mission

We live in a technological world. Living in the twenty-first century requires much more from every individual than a basic ability to read, write, and perform simple mathematics. Technology and engineering affect every aspect of our lives, from enabling citizens to perform routine tasks to requiring that they be able to make responsible, informed decisions that affect individuals, our society, and the environment.

Citizens of today must have a basic understanding of how technology affects their world and how they exist both within and around technology. Technological literacy is fundamentally important to all students. Technological processes have become so complex that communities and schools collaborate to provide a quality technology program that prepares students for a changing world—one that is progressively more dependent on an informed, technologically literate citizenry.

EbD™ is also linked to the National Academy of Engineering's Grand Challenges for Engineering. Through these real-life engineering issues/problems/challenges, students begin to envision their future beyond the school building.

Vision

The ITEEA model STEM program is committed to providing technological study in facilities that are safe and that facilitate creativity, enabling all students to meet local, state, and national technological literacy standards. Students are prepared to engage in additional technological study in the high school years and beyond. Technology students will possess the knowledge and abilities to help them become informed, successful citizens who are able to make sense of the world in which they live. The technology program also enables students to take advantage of the technological resources in their own community. The EbD™ program also enables students to be wise consumers, advocates, and change agents of the technological resources in their own community.

Goals

- Provide a standards-based K-12 program that ensures that all students are technologically literate.
- Provide opportunities for all students without regard to gender or ethnic origin.

- Provide clear standards and expectations for increasing student achievement in science, technology, engineering, and mathematics.
- Provide leadership and support that will produce continuous improvement and innovation in the program.
- Restore America's status as the leader in innovation.
- Provide a program that constructs learning from a very early age and culminates in a capstone experience that leads students to become the next generation of engineers, technologists, innovators, and designers.

Using the Little "e" for engineering - Organizing Principles

The program is organized around ten principles—overarching concepts that identify major content organizers for the program. In order of importance, the organizing principles are:

1. Engineering through design improves life.
2. Technology and engineering have affected, and continue to affect, everyday life.
3. Technology drives invention and innovation and is a thinking and doing process.
4. Technologies are combined to make technological systems.
5. Technology creates issues and impacts that change the way people live and interact.
6. Engineering and technology are the basis for improving on the past and creating the future.
7. Technology and engineering solve problems.
8. Technology and engineering use inquiry, design, and systems thinking to produce solutions.
9. Technological and engineering design is a process used to develop solutions for human wants and needs.
10. Technological applications create the designed world.

All of these materials can be accessed online once the teacher or his or her school becomes a part of a purchased funding source. Approximately 20 of the 50 U.S. states are involved in this effort, which includes online learning, assessments, and a community of learners.

Building Ongoing Success

Building ongoing success in student learning is the result of key educational components that strengthen the school subject. Such success is no different when it comes to teaching interdisciplinary STEM instructional experiences. The following are key components that offer a path to establishing technological literacy as a vital ingredient that is essential to the education of all students.

Understandings of Technological and Design Thinking

Most U.S. educators fail to understand that to have a population of next-generation technological thinkers and innovators, one must teach more than just mathematics and science. Technology and engineering put mathematics and science into action—causing human innovation to take place. While mathematics and science rely on facts and principles, technology and engineering are dynamic in nature, always changing as new ideas are created and better ways to advance technology are applied. Design is the key factor in understanding the application of technology and engineering. The design and engineering processes offer different ways of thinking about content that is not taught in any other school subject. Science, technology, engineering, and mathematics need to be considered a single unit because their interaction necessitates the use of each subject, while each has a unique aspect to bring to the total relationship.

Dynamic Technological Content

As noted in *Standards for Technological Literacy,* humans have been called the animals that make things, and at no time in history has that been as apparent as the present. Today, every human activity is dependent upon various tools, machines, and systems—from growing food and providing shelter to communication, healthcare, and entertainment. Technological literacy addresses content that is like water. It can be slow or fast-moving, used in work or recreation, helpful or harmful to your health, and be simultaneously simple and sophisticated in nature. Similarly, we are dealing with perpetually-in-motion content that is created by humans who are involved in "human innovation in action." No other school subject deals with content that is as dynamic as this subject area. The result is open-ended learning that allows for maximum creativity on the part of the student—where the teacher is the manager of activities rather than the administrator of limited exercises, and where the student is not constrained by what the teacher knows. The dynamic nature of this subject area is why we have so many people involved in creating devices, making new things possible, and doing what humans have never been able to do before.

Research-Supported Teaching/Learning

We cannot advance excellence in technological literacy unless there is an assessment of student learning that is consistent with the goals or standards that are to be attained. Restated, we must have student learning assessment that aligns with its intended purpose. This necessitates the establishment of a specific statement of purpose related to the content for the study of technological literacy. The purpose must be followed with fair and equitable student assessment methods and with valid and reliable data measurements that are reflective of classroom experiences. Teaching and learning assessments must be systematic and derived from research-based assessment practices found to be successful with other educational subjects. However, due to the unique character of technology and engineering courses, a variety of technological assessment- and performance-based methods must be utilized.

Facilities that Allow the Ability to Design and Construct

The majority of school systems in the United States have facilities or student learning environments in which to practice design and construction. These facilities are supportive of student interactions and the abilities to question, inquire, design, invent, and innovate. The facility helps to promote student development of knowledge and abilities and provides for the safe application of appropriate technological tools, machines, materials, and processes. Therefore, technology students have a learning environment that allows them to practice the design and engineering processes that enable them to create and construct.

Student Co-Curricular STEM Opportunities

A perfect example of a co-curricular program that can engage students at the middle and high school grades is the "TEAMS" (Tests of Engineering Aptitude, Mathematics, and Science) competition program managed by the Technology Student Association (http://www.TSAweb.org). This one-day competition is an opportunity for middle and high school students to apply their knowledge of STEM in a real-world engineering challenge. In 2014 the competition theme is based on the Academy of Engineering National Challenge "restore and improve urban infrastructure."

The TEAMS Competition specifically targets students interested in pursuing engineering as a career. Students compete in teams of four to eight and work to find solutions to issues that engineers face every day. The competition highlights the application of math and science to these real-world issues.

Summary

I hope that this information has provided you with ideas to consider during and after your Summer Institute! One of humankind's biggest challenges is to make our world work in a way that sustains everything that is wonderful about this planet. To do so will take a special kind of skill. Some call it design and technological problem-solving. It is the ability to create real solutions for the real world. We say: Technology and Engineering Bring STEM To Life!

The challenge to implement the appropriate technology and engineering curriculum into our school systems is a difficult one regardless of where you live. I wish you success with your efforts to improve your ability to teach STEM through an interdisciplinary approach and hope that we can continue our conversation in the future.

References

International Technology Education Association (ITEA/ITEEA). (1996). *Technology for all Americans: A Rationale and structure for the study of technology.* Reston, VA: Author.

International Technology Education Association (ITEA/ITEEA). (2000/2002/2007). *Standards for technological literacy: Content for the study of technology (STL)*. Reston, VA: Author.

International Technology Education Association (ITEA/ITEEA). (2003). *Advancing excellence in technological literacy: Student assessment, professional development, and program standards (AETL)*. Reston, VA: Author.

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