Evolution of STEM in the U.S.

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Outline of Presentation

- What is STEM?
- Definitions Related to STEM
- Why is STEM Gaining Importance?
- Integration vs. Isolation of STEM
- Why is STEM so Important?
- STEM and Nationally Developed Standards
- National Assessment of Educational Progress (NAEP)
- Summary
Where Did STEM Come From in the U.S.?

- National Science Foundation coined the acronym “STEM” in the early 1990s.
  - SMET vs STEM
  - Integration of Science with other Related School Subjects

SMET vs. STEM

Science – Math – Engineering - Technology

Science – Technology – Engineering - Math
There is a Growing Movement in the United States for STEM

- College Readiness
- Decline of Higher Education
- Teacher Preparation
- International Comparisons
- Research and Development
What is STEM Education?

STEM is the integration of Science, Technology, Engineering, and Mathematics into a new transdisciplinary subject in schools.
STEM Integration in K-12 Education
STEM Education offers a chance for students to make sense of the world rather than learn isolated bits and pieces of phenomena.
Some Basic Definitions
What is Science, Technology, Engineering, and Mathematics?
Science Seeks to Understand the Natural World

- National Science Education Standards, National Research Council (1996)
- Next Generation Science Standards (2013)
What is Technology?

- It is the innovation, change, or modification of the natural environment in order to satisfy perceived human wants and needs. (*Standards for Technological Literacy*, ITEA/ITEEA, 2000/2002/2007)

- The goal of technology is to make modifications in the world to meet human needs. (*National Science Education Standards*, NRC, 1996)
What is Technology?
(Continued)

- In the broadest sense, technology extends our abilities to change the world: to cut, shape, or put together materials; to move things from one place to another; to reach farther with our hands, voices, and senses. (*Benchmarks for Science Literacy*, AAAS, 1993)

- Technology is the process by which humans modify nature to meet their needs and wants. (*Technically Speaking: Why All Americans Need to Know More About Technology*. (NAE/NRC, 2002).
Updated Definition of Technology

- Technology is the modification of the natural world to meet human wants and needs. It helps us to:
  - improve our health
  - grow and process food and fiber better
  - harness and use energy more efficiently
  - communicate more effectively
  - process data faster and accurately
  - move people and things easier
  - make products to enhance our lives
  - build structures that provide shelter and comfort.
What is Engineering?

- “Design under constraint.” Engineers design solutions to problems. However, there are a set of constraints that we have to satisfy – size, weight, reliability, safety, economic factors, environmental impact, manufacturability, and a whole list of “abilities.” (Wulf)

- The profession in which a knowledge of the mathematical and natural sciences gained by study, experience, and practices are applied with judgments to develop ways to economically utilize the materials and forces of nature for the benefit of mankind. (Accreditation Board for Engineering and Technology (ABET, 2002)
What is Mathematics?

- The study of any patterns or relationships (AAAS, 1993)
- The science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations (Webster’s Ninth New Collegiate Dictionary)
STEM: Integrated or Separated?

- Integrated STEM (iSTEM): The principles of science and the analysis of mathematics are combined with the design process of technology and engineering in the classroom.
- Separated S.T.E.M.: Each subject is taught separately with the hope that the synthesis of disciplinary knowledge will be applied. This may be referred to as STEM being taught in “silos.”
Engineering byDesign (EbD) Overview
Why is STEM Education so Important?

Learn to think
“For a society so deeply dependent on technology and engineering, we are largely ignorant about technology and engineering concepts and processes, and we have largely ignored this incongruity in our educational system.”

(Roger W. Bybee, 2000)
Some Educational Problems

Our educational system can be enhanced to appropriately function for a new world reality according to Thomas Friedman in his frequently cited book, *The World is Flat*.

He wrote that “the world may be flat, but our educational system is as mountainous as ever.”

(McComas and McComas, ITEA, 2009)
STEM Jobs

In the U.S., it was reported by “Change the Equation,” a research group, that one-half of all STEM jobs don’t require a four-year college degree and pay an average of $53,000 per year, which is 10% higher than non-STEM jobs with similar educational requirements.
Schooling is Not Relevant to Many of Our Youth Today:

In 2014, 7% of the nation’s 18 to 24 year olds had dropped out of high school, continuing a steady decline in the nation’s dropout rate since 2000, when 12% of youth were dropouts.
The National Science Board in 2008 reported that the U.S. is currently experiencing a chronic decline in homegrown STEM talent and is increasingly dependent upon foreign scholars to fill the workforce and leadership voids.
National Content Standards for STEM

- No integrated STEM standards
- Individual Standards
  - Science
    - Benchmarks for Science Literacy (AAAS, 1989)
    - National Science Education Standards (NRC, 1996)
    - Next Generation of Science Standards (NGSS, 2013)
  - Mathematics
    - Principles and Standards for School Mathematics (NCTM, 2000)
Individual Standards ( Continued )

• Engineering (None)

• Technology
    o Technology and Engineering Standards (maybe in future)

• Common Core Standards
  o State Standards – vary by state
National Assessment of Educational Progress (NAEP)

2014 Technology and Engineering Literacy Framework

Results released in May, 2016
NAEP 2014 Technology and Engineering Literacy Framework

- What is NAEP?
- Evolution and Background
- Process of Framework Development
  - Steering Committee
  - Planning Committee
Overall Purposes

1. Develop the recommended framework and specifications for NAEP Technology and Engineering Literacy 2014 in Grade 8 (ages 13-14).

   – The assessment is entirely computer-based.

2. Recommend important background variables associated with student achievement in Technology and Engineering Literacy that should be included in NAEP Assessment.
## Major Assessment Areas

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<th>Technology and Society</th>
<th>Design and Systems</th>
<th>Information and Communication Technology (ICT)</th>
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<td>A. Nature of Technology</td>
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<td>B. Effects of Technology on the Natural World</td>
<td>B. Engineering Design</td>
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<td>C. Effects of Technology on the World of Information and Knowledge</td>
<td>C. Systems Thinking</td>
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<td>D. Ethics, Equity, and Responsibility</td>
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Reporting NAEP Scores

• The NAEP Technological Literacy Assessment is an assessment of overall achievement, not a tool for diagnosing the needs of individuals or groups of students.
• By law, scores are not produced for individual schools or students. NAEP scores have been reported at the national, state, and district levels.
• The probe for the 2014 NAEP Technological Literacy Assessment is not designed to inform instruction—to guide how technological literacy is taught—only to measure a representative sample of the American student population at one grade and students’ performance within the assessment context outlined in the framework.
For More Information

NAEP Technological and Engineering Literacy Assessment:

https://nces.ed.gov/nationsreportcard/tel/
STEAM

STEAM is Science and Technology interpreted through Engineering and the Arts, all understood with elements of Mathematics.

(Georgette Yakman, #STEAMeducation, 2016)

www.steamedu.com
Learn Better by Doing Research

International Technology and Engineering Educators Association (ITEEA) and the Foundation for Technology and Engineering Educators (FTEE)

LEARNING BY DOING RESEARCH

WHAT IS "DOING"?

The United States has long been known as a nation of doers. In this new era of learning, as we become a nation of computer users, we are more likely to learn through hands-on experience, project-based learning, and other forms of active involvement. Such involvement—rather than being passive listeners—is the learning by doing.

The word "doing" is used in many ways in the English language. To "do" something means to engage in a meaningful action, performance, or activity. "Doing" is an essential part of our daily lives, and we cannot imagine a world without it. The English language is rich with examples of "doing." "Doing" is a verb that means "to perform an action or activity." "Doing" is also a noun that refers to the act of doing something.

The research in this Learning by Doing study focuses on a special type of doing that applies to science, technology, engineering, and mathematics (STEM) education. This initiative will use the term "doing" as defined above.

DOING: "A significant component of the process of technology problem solving, starting with human needs and ends that leads to the principles of innovation such as designing, making, building, producing, and evaluating."

The ability to do and use the tools of doing is an essential part of the human experience. The ability to do and use the tools of doing is an essential part of the human experience.

WHY IS LEARNING BY DOING IMPORTANT?

In the early stages of humankind, the act of doing was essential for survival and paved the way for the evolution of technology. For example, the earliest prehistoric technology used by humans was the use of shapen sticks. These shaped sticks were used to cut meat, to prepare food for cooking, and to make tools for hunting, as well as for digging and other uses. Chip-based technologies have been used to create tools such as axes, arrows, and spears. The development of these technologies required knowledge of the manipulation of materials and the ability to use that knowledge to create essential tools for the survival of the human race.

As was true in ancient times, knowledge and the ability to use that knowledge to do remains essential for survival of the human race.

* This research article is a result of an ITEEA-FTEE jointly underwritten research project.
Purpose of Study

- To determine the extent to which U.S. public school elementary and secondary education science, technology, engineering, and mathematics (STEM) students are doing activities in their classrooms.

- Research involved elementary, middle school, and high school STEM teachers in U.S. from 2013-2017 (four-year longevity study).
Definition of “Doing”

A tactile/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.
**Importance of Study**

- *Doing* in the classroom prepares students for life.
- Determine where learning by doing is occurring.
- Integrate the importance of doing as a learning method.
- Relationship and repositioning of content within STEM subject areas.
General Statement 1

“I believe that students benefit from doing activities to support learning.”

(Percent Yes)

Overwhelmingly teachers feel that students benefit from doing activities to support learning.
General Statement 2

“If given the time and resources, I would assign my students more projects to do in class.”

(Percent Yes)

Vast majority of STEM teachers also state that if given the time and resources they would assign students more projects in class.
Doing in Courses – Interesting Findings

• Teachers responded to same standards-based statements.
• Technology and engineering students do the same types of standards-based projects and activities (more frequently) than do science and mathematics students.
• Technology and engineering students do more hands-on activities focusing on societal needs and wants than do science and mathematics students.
What is the Future of STEM?

- Depending on acceptance in the future, STEM could grow and flourish
- OR
- It could remain as it is today and remain an integrated curricular effort in an already crowded set of school offerings
- OR
- It could not be accepted and slowly pass away.
“A wealth of natural resources, innovation, and hard work provided the mechanisms that transformed nations during the 20th Century. National and international transformations during the 21st Century will be driven by those who want to invest in and advance comprehensive STEM educational programs.” (Daugherty, 2009)
Thank You!

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and

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