EVOLUTION OF STEM IN THE U.S.

Technology and Engineering bring STEM to Life!

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&

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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

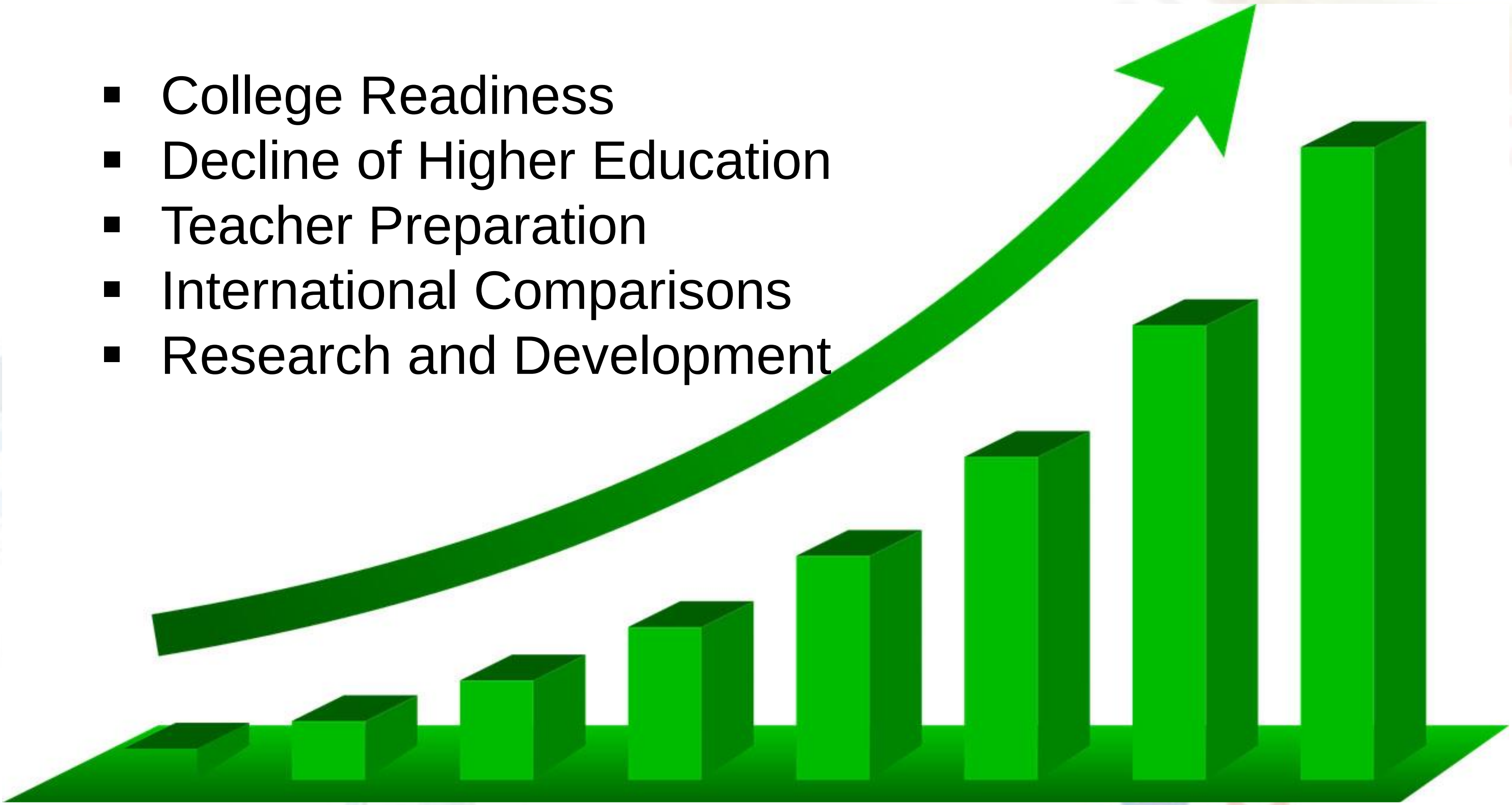
SMET *vs.* **STEM**

Science – Math – Engineering - Technology

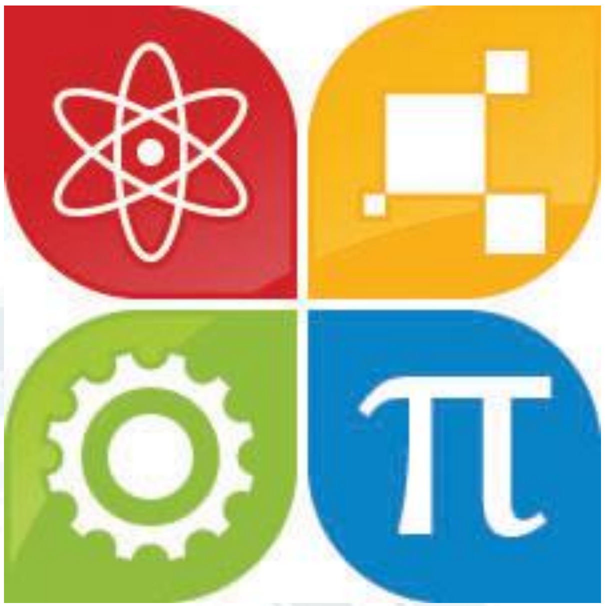
Science – Technology – Engineering - Math

There is a Growing Movement in the United States for STEM

- College Readiness
- Decline of Higher Education
- Teacher Preparation
- International Comparisons
- Research and Development



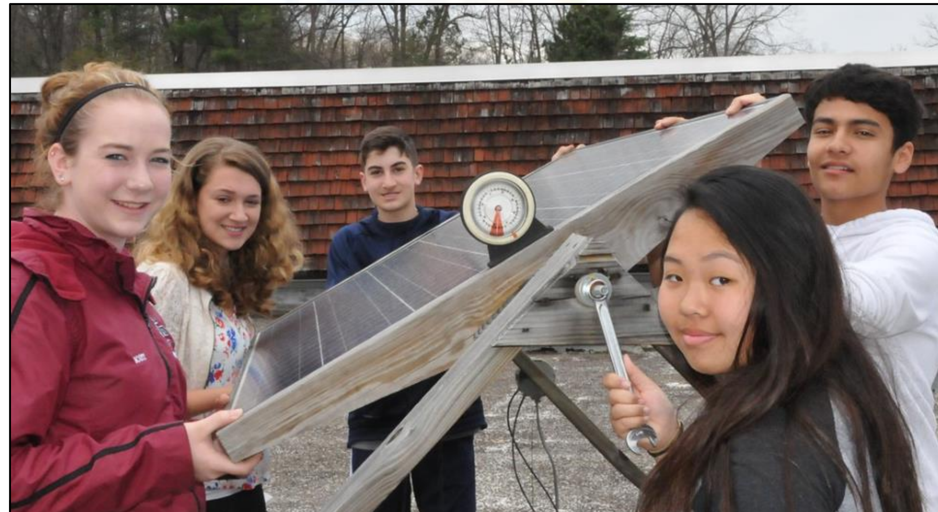
What is STEM Education?



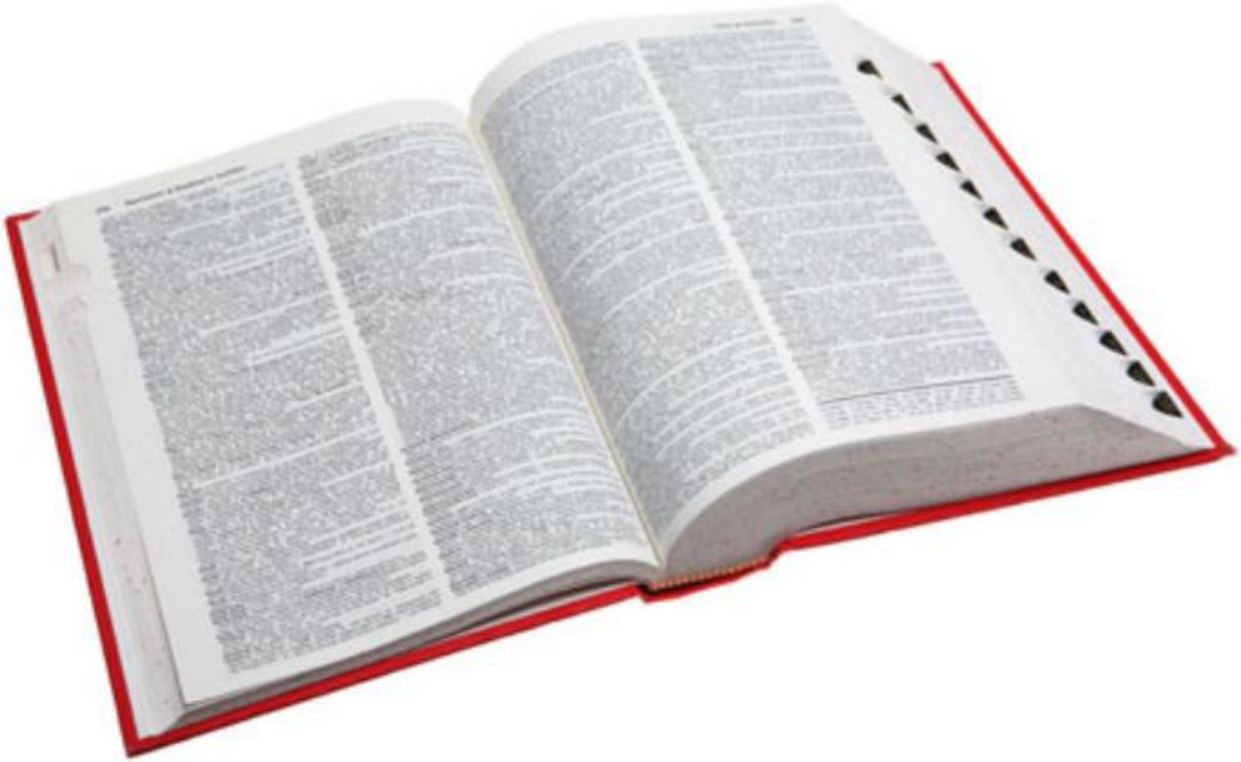
STEM is the integration of Science, Technology, Engineering, and Mathematics into a new transdisciplinary subject in schools.

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



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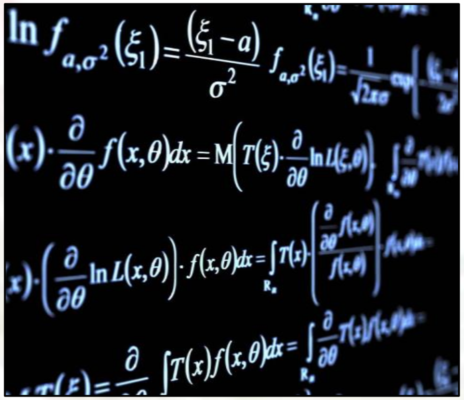
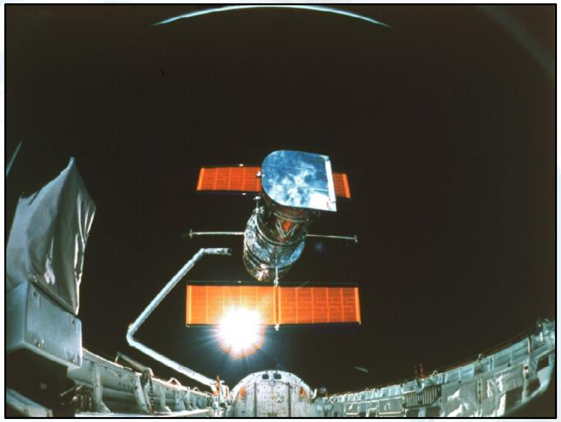
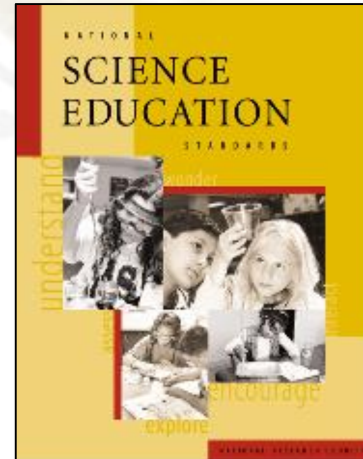


What is Science, Technology, Engineering, and Mathematics?



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)

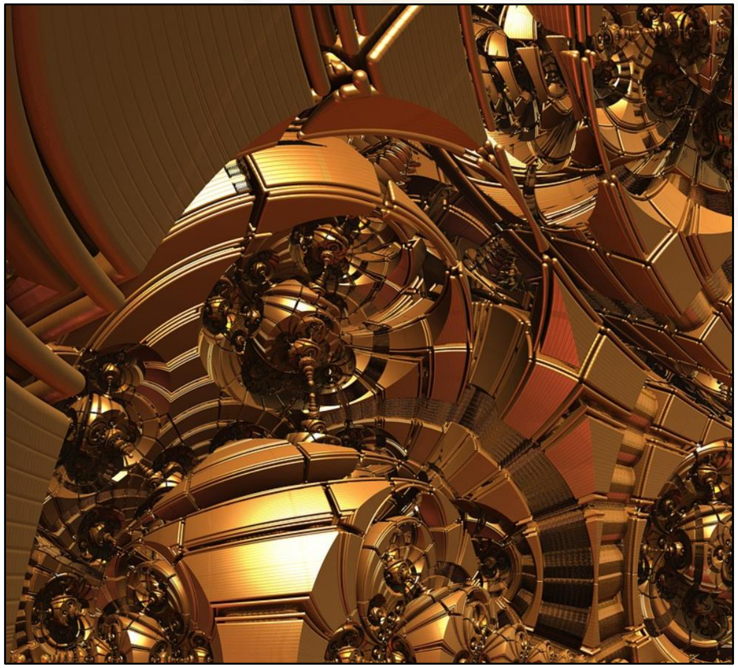
- In the broadest sense, technology extends our abilities to change the world: to cut, shape, or put together materials; to move things from one place to another; to reach farther with our hands, voices, and senses. (*Benchmarks for Science Literacy*, AAAS, 1993)
- Technology is the process by which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

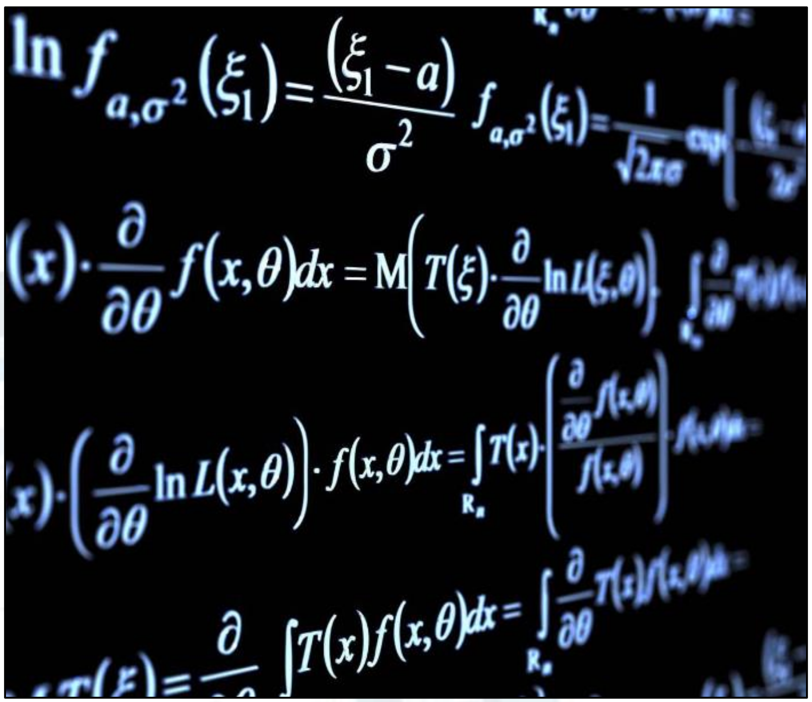
What is Engineering?

- "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?

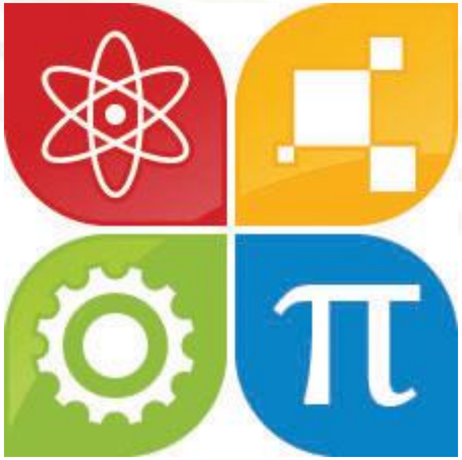
- The study of any patterns or relationships (AAAS, 1993)



- 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?

"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.

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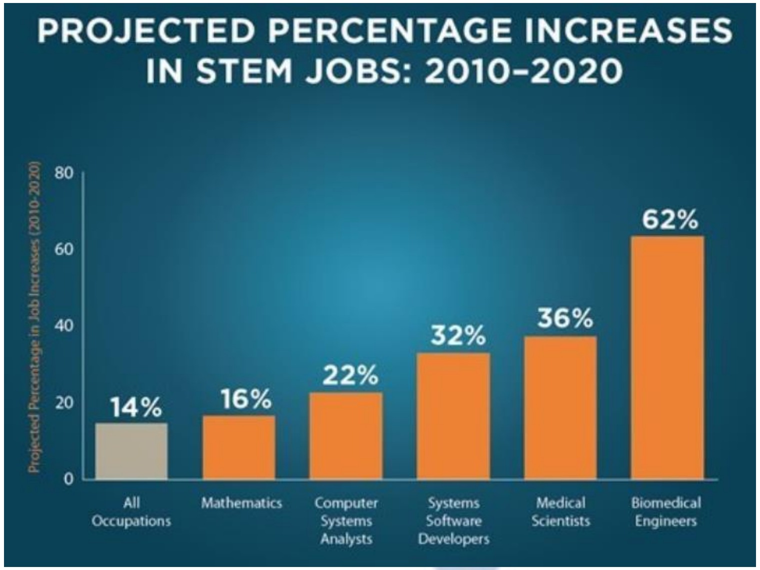
Schooling is Not Relevant to Many of Our Youth Today:

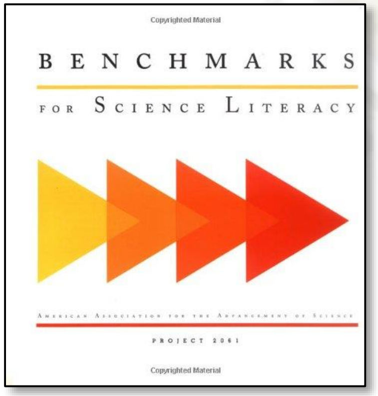
In 2014, 7% of the nation's 18 to 24 year olds had dropped out of high school, continuing a steady decline in the nation's dropout rate since 2000, when 12% of youth were dropouts.

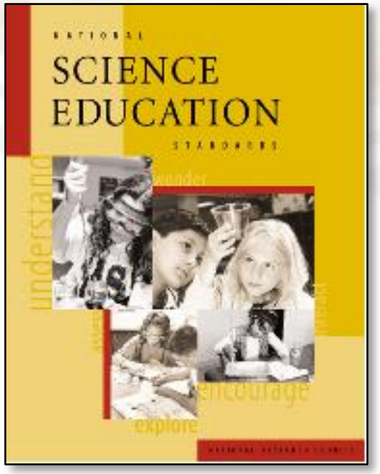
The National Science Board in 2008 reported that the U.S. is currently experiencing a chronic decline in homegrown STEM talent and is increasingly dependent upon foreign scholars to fill the workforce and leadership voids.

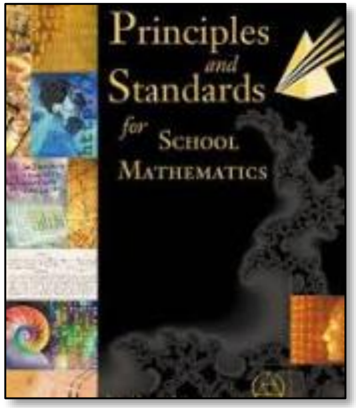


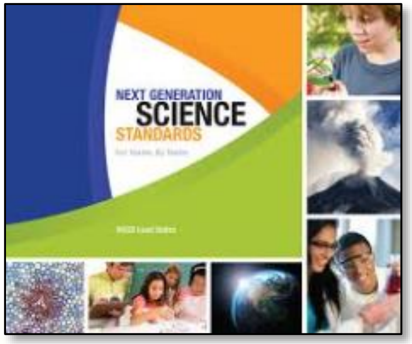
National Content Standards for STEM

- 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)

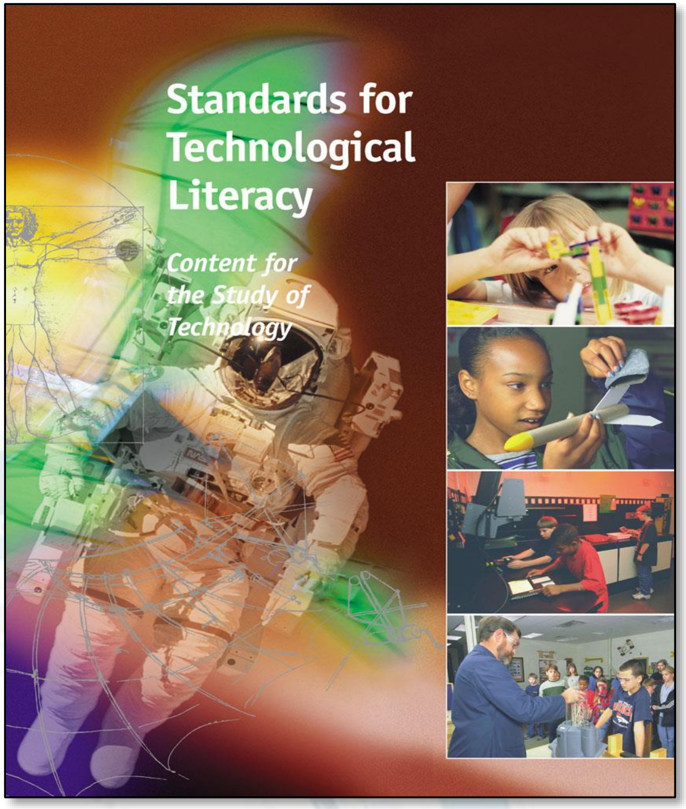








Individual Standards
(Continued)

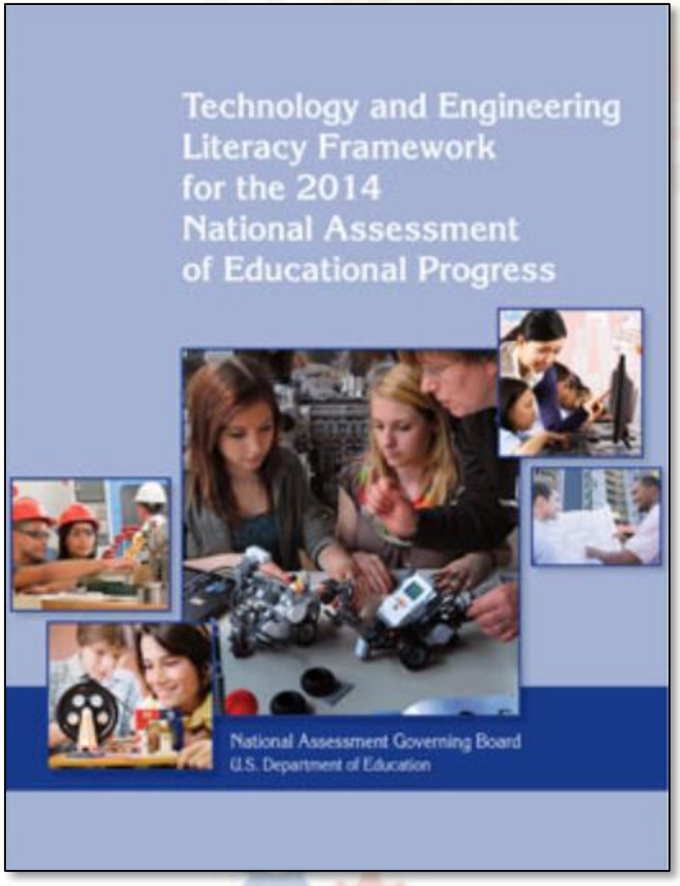


- Engineering (None)
- Technology
  - Standards for Technological Literacy (STL)(ITEA/ITEEA, 2000/ 2002/2007)
  - Technology and Engineering Standards (maybe in future)
- Common Core Standards
  - State Standards – vary by state

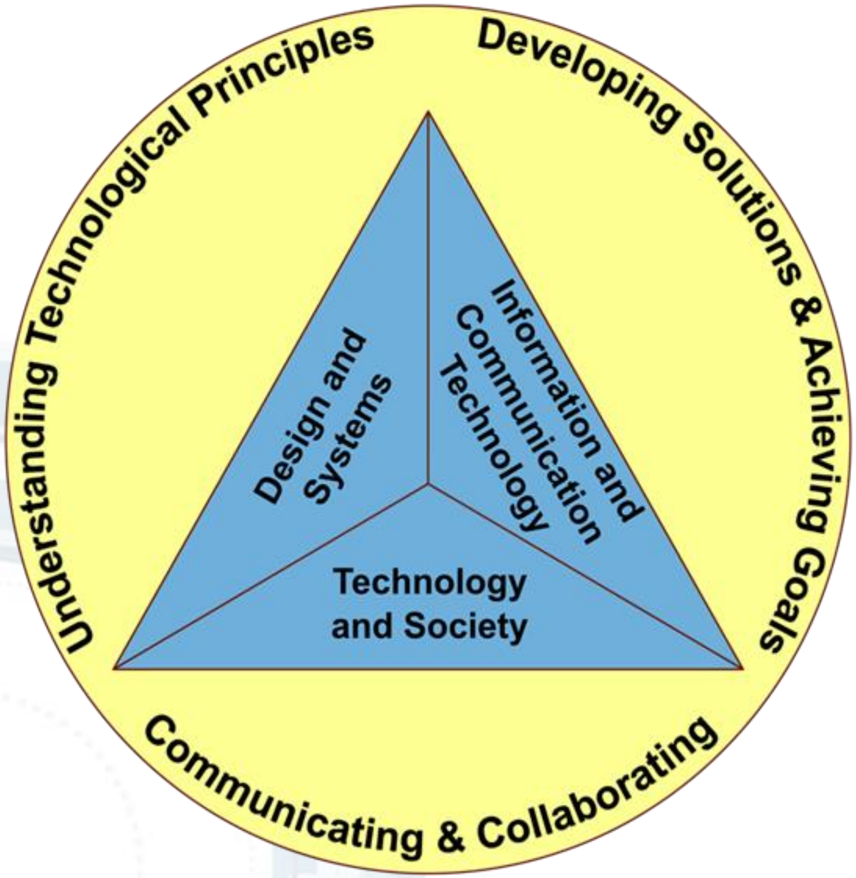
National Assessment of Educational Progress (NAEP)

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

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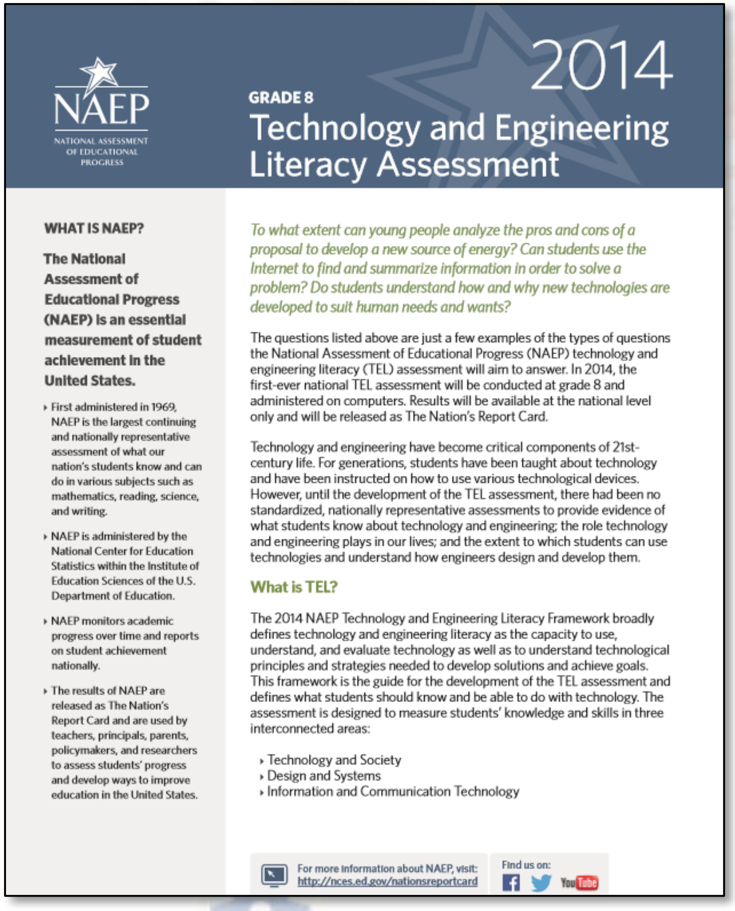
Overall Purposes

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.



NAEP
NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

2014
GRADE 8
Technology and Engineering Literacy Assessment

WHAT IS NAEP?

The National Assessment of Educational Progress (NAEP) is an essential measurement of student achievement in the United States.

- First administered in 1969, NAEP is the largest continuing and nationally representative assessment of what our nation's students know and can do in various subjects such as mathematics, reading, science, and writing.
- NAEP is administered by the National Center for Education Statistics within the Institute of Education Sciences of the U.S. Department of Education.
- NAEP monitors academic progress over time and reports on student achievement nationally.
- The results of NAEP are released as The Nation's Report Card and are used by teachers, principals, parents, policymakers, and researchers to assess students' progress and develop ways to improve education in the United States.

To what extent can young people analyze the pros and cons of a proposal to develop a new source of energy? Can students use the Internet to find and summarize information in order to solve a problem? Do students understand how and why new technologies are developed to suit human needs and wants?

The questions listed above are just a few examples of the types of questions the National Assessment of Educational Progress (NAEP) technology and engineering literacy (TEL) assessment will aim to answer. In 2014, the first-ever national TEL assessment will be conducted at grade 8 and administered on computers. Results will be available at the national level only and will be released as The Nation's Report Card.

Technology and engineering have become critical components of 21st-century life. For generations, students have been taught about technology and have been instructed on how to use various technological devices. However, until the development of the TEL assessment, there had been no standardized, nationally representative assessments to provide evidence of what students know about technology and engineering; the role technology and engineering plays in our lives; and the extent to which students can use technologies and understand how engineers design and develop them.

What is TEL?

The 2014 NAEP Technology and Engineering Literacy Framework broadly defines technology and engineering literacy as the capacity to use, understand, and evaluate technology as well as to understand technological principles and strategies needed to develop solutions and achieve goals. This framework is the guide for the development of the TEL assessment and defines what students should know and be able to do with technology. The assessment is designed to measure students' knowledge and skills in three interconnected areas:

- Technology and Society
- Design and Systems
- Information and Communication Technology

For more information about NAEP, visit: http://nces.ed.gov/nationsreportcard
Find us on:

Major Assessment Areas

Technology and Society	Design and Systems	Information and Communication Technology (ICT)
A. Interaction of Technology and Humans B. Effects of Technology on the Natural World C. Effects of Technology on the World of Information and Knowledge D. Ethics, Equity, and Responsibility	A. Nature of Technology B. Engineering Design C. Systems Thinking D. Maintenance and Troubleshooting	A. Construction and Exchange of Ideas and Solutions B. Information Research C. Investigation of Problems D. Acknowledgement of Ideas and Information E. Selection and Use of Digital Tools

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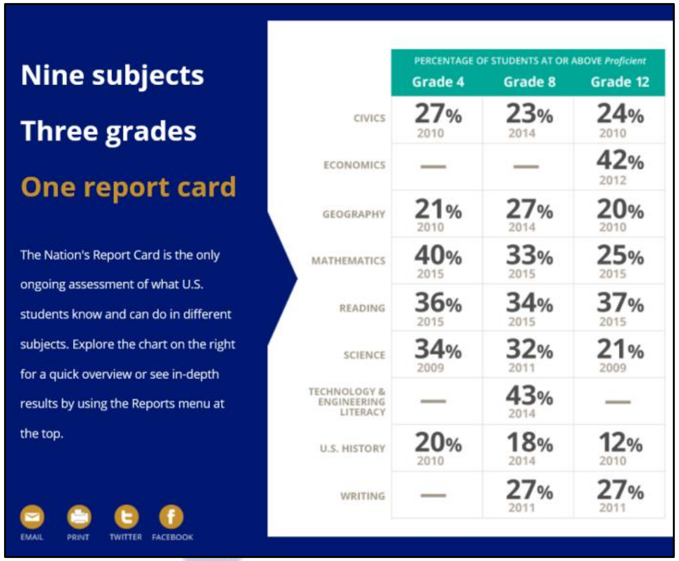
Reporting NAEP Scores

- 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.



PERCENTAGE OF STUDENTS AT OR ABOVE *Proficient*	Grade 4	Grade 8	Grade 12
CIVICS	27% 2010	23% 2014	24% 2010
ECONOMICS	—	—	42% 2012
GEOGRAPHY	21% 2010	27% 2014	20% 2010
MATHEMATICS	40% 2015	33% 2015	25% 2015
READING	36% 2015	34% 2015	37% 2015
SCIENCE	34% 2009	32% 2011	21% 2009
TECHNOLOGY & ENGINEERING LITERACY	—	43% 2014	—
U.S. HISTORY	20% 2010	18% 2014	12% 2010
WRITING	—	27% 2011	27% 2011

For More Information

NAEP Technological and Engineering Literacy Assessment:

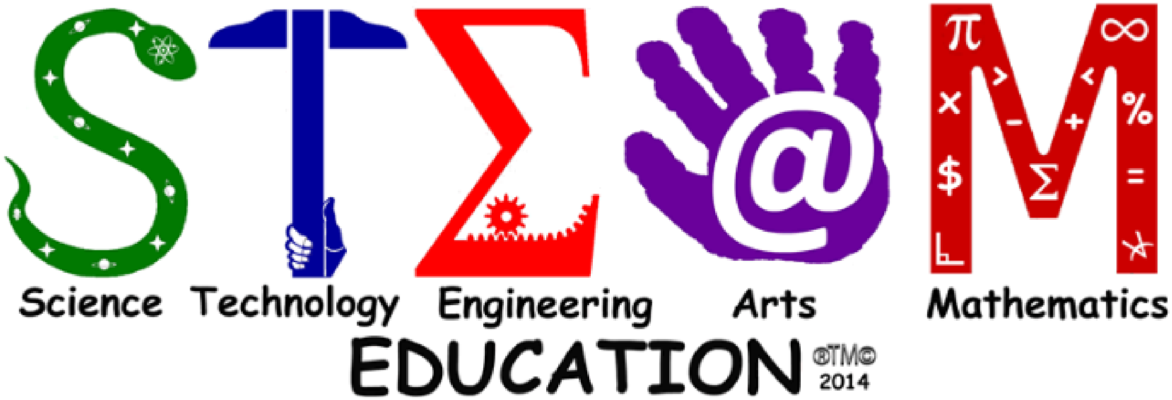
https://nces.ed.gov/nationsreportcard/tel/

NAEP
NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

STEAM

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

(Georgette Yakman, #STEAMeducation,2016)



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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

"learning by doing" research INTRODUCTION*

BY JOHNNY J MOYE, DTE, WILLIAM E. DUGGER, JR., DTE, and KENDALL N. STARKWEATHER, DTE

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

WHAT IS "DOING"?

The United States has been known as a nation of doers. Is this still true, or are we becoming a nation of passive viewers who stay glued to the computer screen, television, or other form of diversion—rather than being active tactile learners who should be learning by doing?

The word "doing" is used in many ways in the English language. "Do" could be used as a verb giving a meaning of action, performance, and execution as "doing." Some everyday phrases we recognize are: "this was more of my doing ...", "getting it finished by tomorrow will take some doing," "doing time," "any job worth doing is a job worth doing well," "let's do it, let's fall in love," "just do it," "what are you doing," and many others.

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 word doing as defined below:

> 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."

Elementary and secondary technology and engineering teachers use this type of doing in their courses. Many science and mathematics teachers could also perform the same type of doing in their courses.

Over the past several years, science and mathematics teachers have been directed to prepare their students for taking high-stakes tests. Both teachers and students experience the pressures of "teaching to the test." This scenario makes the test the focus of the curriculum, and the learning experience is primarily based on "cognitive education." As a result, John Dewey's "learning by doing" philosophy (Dewey, 1938) has been seriously undermined in today's education system.

WHY IS LEARNING BY DOING IMPORTANT?

In the early stages of humankind, the act of doing was essential for survival and drove the evolution of technology. For example, the earliest prehistoric technology used by humans was the use of chipped stones. These chipped stones were used to kill animals, to prepare pelts for clothing, and to carve meat for food, as well as for digging and other uses. Chipped-stone technologies were later used to develop tools such as axes, arrowheads, and spears. Development of these technologies required knowledge as well as the application of that knowledge. 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 (Dugger/Gerrish endowment) research project.*

Purpose of Study

LEARNING BY DOING – ANALYSIS

learning by doing study: ANALYSIS OF SECOND-YEAR RESULTS*

BY JOHNNY J MOYE, DTE, WILLIAM E. DUGGER, JR., DTE, and KENDALL N. STARKWEATHER, DTE

"This study identifies that science, technology, engineering, and mathematics teachers feel that students benefit from learning by doing.

This is the third of a series of reports discussing the Doing-Based Learning study. The first report (Round 1) (Moye, Dugger, & Starkweather, 2014a) introduced the study, defined "doing" in the context of this study, described why students "doing" in the classroom is important, why there is a need for this study, and also provided some selected findings from the first round of surveys. The second report (Round 2) (Moye, Dugger, & Starkweather, 2014b) identified the methods used and results of the first-round data. This report identifies the purpose of the study, identifies where the survey methods may be found, provides the number and percentages of responses, selected findings, and the future of this longevity study.

The purpose of this study is to determine the extent to which U.S. public school students are doing activities in their classrooms. This five-year study asks elementary and secondary (middle and high school) science, technology, engineering, and mathematics (STEM) teachers to respond to 13 statements concerning students doing in their classrooms. The first two statements are general in nature and were used at all grade levels. The remaining 11 statements are grade-level-specific and based on *Next Generation Science Standards, Standards for Technological Literacy*, and *Common Core State Standards for Mathematics*. Study methodology details can be found in Moye, Dugger, and Starkweather, 2014a, and Moye, Dugger, and Starkweather, 2014b.

The researchers sent emails to 5,232 teachers across the United States. The emails contained a cover letter explaining the study and provided a URL encouraging teachers to participate.

FINDINGS

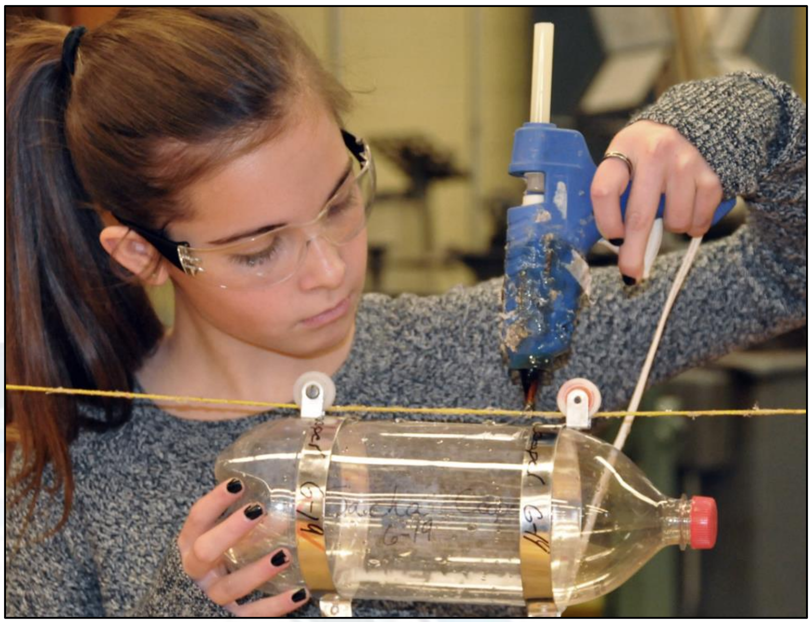
This round was open for teacher participation from March 1 until April 15, 2015. To be eligible to participate in this study, teachers needed to identify themselves as science, technology, engineering, and/or mathematics (STEM) teachers. Many responding teachers identified themselves as other than STEM teachers, and therefore were not included in this study. For example, some responding teachers were family and consumer science, automotive, health care, physical education, as well as other content area teachers. There were a total of 1,351 eligible teachers participating in this round. Of that number, 296 were elementary teachers, 254 secondary science, 606 secondary technology and engineering, and 195 secondary mathematics teachers. Teachers were asked to respond to two general statements. The statements were designed to determine how teachers felt about students learning by doing in the classroom. Table 1 identifies the first two statements, the number of teachers who responded "Yes," and the total number of responses to each statement. Data for both Rounds 1 (2014) and 2 (2015) are included.

*This research article is a result of an ITEEA/FTEE (Dugger/Gerrish endowment) research project.

18 technology and engineering teacher September 2015

- 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.

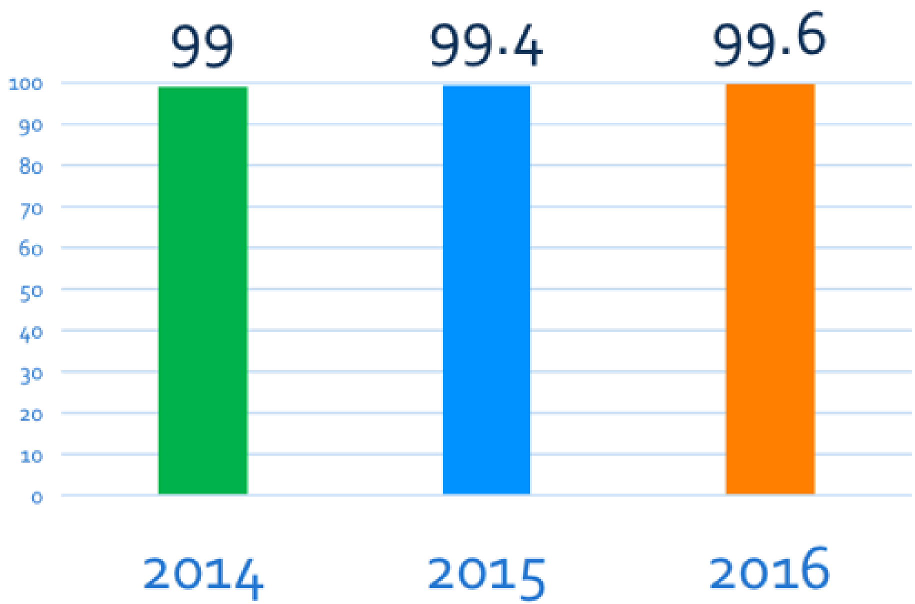
Importance of Study

- *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)

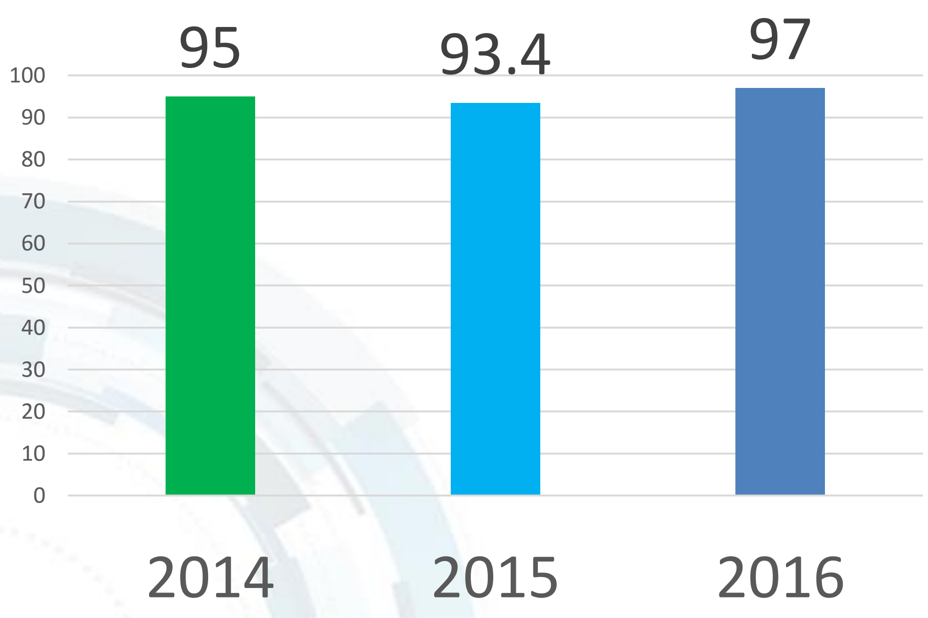


Overwhelmingly teachers feel that students benefit from doing activities to support learning.

General Statement 2

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

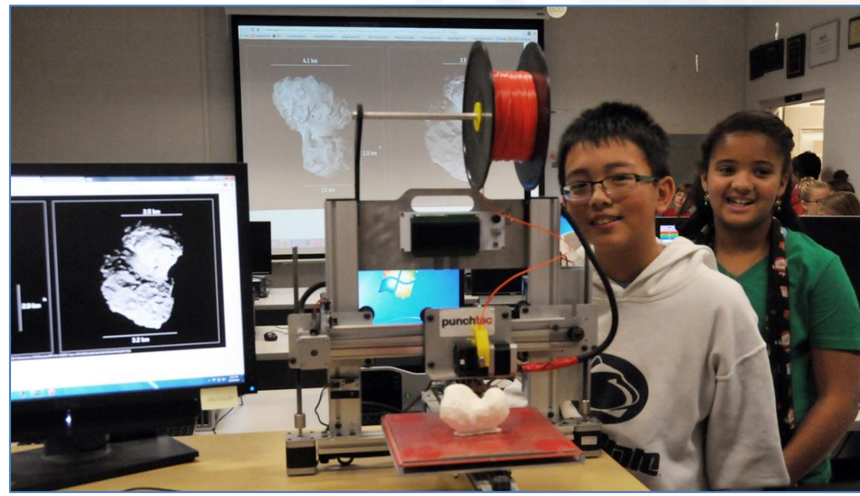
(Percent Yes)



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)

SUMMARY

Thank You!

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