Science, Technology, Engineering, & Mathematics (STEM) Education is Here To Stay

STEM Science, Technology, Engineering, Mathematics

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Teaching, Research & Service in the “T” & “E” of Science, Technology, Engineering, & Mathematics

Prepare Technology & Engineering Education Teachers (Grades 6-12) & TVET Teachers
Presentation Outline

I. The Components of STEM
II. STEM Education
III. STEM Education: The Need!
IV. Delivering STEM Education
V. Conclusion: STEM Education is Here to Stay
Terminology

- **STEM**: Science, Technology, Engineering, and Mathematics

**Other Interpretations:**

![Image of plant parts]

- **The Stem Cell**
  - Red Blood Cells
  - Platelets
  - White Blood Cells
  - Liver Cells
  - Nerve Cells

- **Plant Structures**:
  - Nodes
  - Internode
  - Leaf
  - Petiole
Terminology

- **Technology & Engineering Education (T&E):** A U.S. general education program. *(Previously names: technology education; industrial arts)*

- **Design & Technology (D&T):** Popular in the U.K, Thailand, and other Countries. Similar to T&E.

- **Career & Technical Education (CTE):** In the U.S., it prepares youth & adults for a wide range of high-wage, high-skill, high-demand careers. Similar to **Technical and Vocational Education and Training (TVET).**
I. The Components of STEM
Science is the study of the natural world.
- Including the laws of nature associated with physics, chemistry, & biology.

Science is both a **body of knowledge** that has been accumulated over time and a **process (scientific inquiry)** that generates new knowledge.
How do Scientists Answer Questions in Science?

The Scientific Method

1. QUESTION
   Ask yourself, “What do I want to learn more about?”, or “I wonder what would happen if...?”

2. HYPOTHESE
   Research to help you make an educated guess, or hypothesis, and then answer your question.

3. EXPERIMENT
   Test your hypothesis by making a plan and conducting an experiment.

4. OBSERVE & RECORD
   Make careful observations and write down what happens.

5. ANALYZE
   Use your information to draw conclusions about your experiment. Was your hypothesis correct?

6. SHARE RESULTS
   Explain your results by presenting your experiment, observations, and conclusions.
What is Technology?
What is Technology

Modifying the natural world to meet the needs and wants of people.

It is human innovation that involves the generation of knowledge and processes to develop systems to solve problems and extend human potential.
Technology can be used to describe a:

- **System**
  - Fuel System; Braking System; Wireless

- **Specific Device**
  - Fuel Injector; Smartphone; Computer;
What Technologies Will Shape Our World in the Future?

Facebook reveals plans for drone-based Internet in the sky
What is Engineering

Engineering applies **math** and **science** to Create Technology
What is Engineering?

- Engineering is a Professional Occupation
- Engineering is about the **Design & Making of:**
  - Structures
  - Products
  - Processes
  - Models
  - Devices
  - Systems
How do Engineers Solve Problems in Engineering?

The Engineering Design Process

1. Identify the Problem, Need, or Preference.
2. Information Gathering to Develop Possible Solutions
3. Selection of the Best Possible Solution
4. Design and Making
5. Testing to See if it Works
6. Modifications & Improvement
7. Assessment

Many Models

Many Solutions

IPST’s 7-Step Technological Process

National Curriculum 2551
What is Math

- Mathematics is a language of numbers, operations, patterns, & relationships.
- Mathematics is used in science, engineering, & technology.
THE COMPONENTS OF STEM

- **SCIENCE** – Study of the Natural World
- **TECHNOLOGY** – Modifying the Natural World to Meet Human Needs and Wants
- **ENGINEERING** – Applying Math & Science to Create Technology
- **MATHEMATICS** – Numbers, Operations, Patterns, & Relationships
Many of the Concepts & Practices in STEM are Crosscutting

Science
- Experimentation & The Scientific Method
- Natural World
- Energy & Matter
- Force & Pressure
- Hydraulics & Pneumatics

Engineering
- Engineering Design
- Creating Technology
- Inventions & Innovations
- Applying Math & Science
- Systems & Systems Thinking
- Materials & Properties

Technology
- Computers
- Engineering Design
- Devices & Systems
- Positive & Negative Impacts
- Extending Human Potential
- Tools & Materials

Mathematics
- Numbers & Operations
- Formulas
- Patterns & Relations
- Measurement
- Geometry
- Drafting (2D & 3D)
STEM Is Involved in Almost Everything!

Scientists Announce New Methods to Combat Deadly Thai Shrimp Disease
STEM Impacts our Lives Daily!
II. STEM Education
What is STEM Education?

STEM
Science, Technology, Engineering, and Math

SCHOOL
Science, Technology, Engineering and Mathematics (STEM) and STEM Education are terms seen almost daily in the news.

NOTE: There is no one clear definition of STEM Education
STEM Education is a teaching and learning approach in which science, technology, engineering, and mathematics (STEM) are purposely integrated.
What is STEM Education?

STEM Education is Typically Not Taught as a Single Course. It can be Integrated into Most Subject Areas.
III. STEM Education – The Need!
Why STEM Education?

1. Globalization
   • A STEM-Education Workforce is needed to stay competitive in today’s global society.

2. Innovation
   • Most inventions & innovations involve STEM in their development.
STEM Education

Why STEM Education?

3. World Problems

- STEM professional will be needed to solve many of the world’s problems (e.g., Clean drinking water, food security, global warming, etc.)
How will knowledge in STEM be needed to solve this problem?

A section of road in Saraburi's Nong Khae district collapsed after a canal running alongside it dried up.
STEM Education

Why STEM Education?

4. Promotes Interest in STEM Careers

- Can help young people get interested in pursuing a career in a STEM field.
- Engineer
- Automotive Technician
- Computer Programmer
- Inventor
- Electronics Technician
- STEM Instructor
Why STEM Education?


The 4Cs

- Critical Thinking
- Collaboration
- Communication
- Creativity
Why STEM Education?

6. **May Improve Learning**

Helps to better show how the concepts and practices of STEM are connected.
Today, maintaining a citizenry that is well versed in the STEM fields is a key portion of the public education agenda of the USA.

(Obama, 2011)
STEM Education in Utah

TV Commercial
STEM Education

Important to The World

ASEAN

Europe
Science and Technology Minister Pichet Durongkaveroj said STEM Education “was crucial for Thailand's workforce to achieve the government's target of a 4% annual growth rate for industrial and labour productivity.”

7 July 2015
IV. Delivering STEM Education
Delivering STEM Education

Technology & Engineering Education Helps Brings STEM to Life through its “Best Practices” that promote Integrated STEM Learning.

Delivering STEM Education

1. Student STEM Competitions
2. Using Project–Based Learning
3. Emphasizing The Engineering Design Process
4. A STEM Education Classroom
1. Student STEM Competitions

Student Competitions that promote STEM help engage students in learning how it is connected.

- Robotics
1. Student STEM Competitions

- Underwater Robotics

Competitions that promote STEM help engage students in learning how it is connected.
1. Student STEM Competitions

- Alternative Fuel
- Concentrating Solar Power
- Energy and the Environment
- Hydropower
- Nuclear Power – Plant Safety
- Nuclear Power Spent Fuel
- Smart Homes
- Wind Energy
2. Project-Based Learning

Problem Solving

- One of the “Top 21st Century Skills” employers say they want in new employees.

- STEM Education Promotes Problem-Solving and encourages Project-Based Learning (PBL)
2. Project-Based Learning

- Project-based Learning (PBL): Is an approach to teaching in which students explore real-world problems & challenges. Problems/Challenges are “open-ended” Many Possible Solutions
5 Keys to Making Project-Based Learning (PBL) Work:

1. Establish Real-World Connections in the Project.
2. Use it to Teach the Core Content Being Learned in the Class.
3. Make it a Structured Collaboration – Students work together with assigned responsibilities!
5 Keys to Making Project-Based Learning (PBL) Work:

4. **Student Driven** – *Students are involved in choosing & directing the project – the teacher becomes the facilitator!*

5. **Multifaceted Assessment** – Integrated throughout the activity – lots of *formative assessment!*
2. Project-Based Learning

Project-Based Learning Requires Lots of Problem Solving
There are many methods used to solve problems in STEM.

Two Common Practices:

1. **Science Education** uses the “Scientific Method” to investigate scientific questions.

2. **Technology & Engineering Education** uses the “Engineering Design Process” to solve problems.
Scientific Method

One Solution
Scientific Method

1. **Question:** Are colors of candy equally distributed in a bag of M&Ms?
2. **Hypothesis:** The colors are not equally distributed.
3. **Experiment:** Count the Colors
4. **Observe & Record:**
5. **Analyze:**
6. **Share Results**
3. The Engineering Design Process

Used To Solve Problems

Many Solutions

1. Identify the Problem, Need, or Preference.
2. Information Gathering to Develop Possible Solutions
3. Selection of the Best Possible Solution
4. Design and Making
5. Testing to See if it Works
6. Modifications and Improvement
7. Assessment

IPST’s 7-Step Technological Process

Many Models

National Curriculum 2551
3. The Engineering Design Process

Used To Solve Problems

Many Solutions
In the U.S., the recently released Next Generation Science Standards (NGSS) represent a commitment to integrate Engineering Design into the structure of Science Education by raising engineering design to the same level as scientific inquiry when teaching science disciplines at all levels, K-12.
3. The Engineering Design Process

It is Important!

Included in the National Standards: *Standards for Technological Literacy: Content for the Study of Technology*
3. The Engineering Design Process

It is Important!

Emphasized in Most Technology & Engineering Education Curricula Today

PLTW Engineering - Curriculum

In PLTW Engineering, students engage in open-ended problem solving, learn and apply the engineering design process, and use the same industry-leading technology and software as are used in the world’s top companies. Students are immersed in design as they investigate topics such as sustainability, mechatronics, forces, structures, aerodynamics, digital electronics and circuit design, manufacturing, and the environment, which gives them an opportunity to learn about different engineering disciplines before beginning post-secondary education or careers.
3. The Engineering Design Process

It is Important!

Students learn to apply the Engineering Design Process through Engineering Design Challenges
Engineering Design Challenges

Helps Students Apply the Problem Solving Approach of Known as ENGINEERING DESIGN
1. **Conditions**: The setting, situation or context of the problem.

What’s the Situation Here?
2. Challenge: A clearly written challenge or problem statement that clarifies what students are required to do.
3. Criteria and Constraints:

- **Criteria** relate to the challenge presented and are those **things that must be followed** or satisfied when completing the challenge.

1. Must be able to hold 10 kilograms.
2. Must be able to float on its own without tipping.
3. Must stay afloat at least 5 min.
Engineering Design Challenge Components

3. Criteria and Constraints:

• **Constraints** are typically limits related to the challenge or problem that must be followed.

1. Time - Activity must be completed in 15 minutes.
2. Must use only tools & materials supplied.
3. Must be no larger than 50cm square.
Engineering Design Challenge Components

4. **Resources:** The materials, tools, or equipment that is provided or can be used to help solve the problem or complete the challenge.
5. **Evaluation**: How the solution to the problem will be assessed & evaluated.
Engineering Design Challenges

1. Context/Situation
2. Challenge
3. Criteria & Constraints
4. Resources
5. Evaluation

**Situation:** The Street Has Flooded

**Challenge:** Develop a safe way to “float” across it
1. Situation: Street Flooded
2. Challenge: Develop a Method to Transport an Item and Keep it Dry
1. **Situation:** A store owner wants a “free” M&M Dispenser
2. **Challenge:** Develop a M&M Candy Dispenser
3. **Criteria & Constraints:**
4. **Resources:**
5. **Evaluation:**

**Learning How To Apply the Engineering Design Process**
3. The Engineering Design Process

1. Identify a Challenge
2. Explore Ideas
3. Plan and Develop
4. Test and Evaluate
5. Present the Solution
Resources

Learning How to Apply the Engineering Design Process
Learning How to Apply the Engineering Design Process

Criteria: Use Only Tools & Materials Supplied
Constraints: 30 Minutes to Build
Applying the Engineering Design Process:
(2) Exploring Ideas
Applying the Engineering Design Process:
(3) Plan and Develop
Applying the Engineering Design Process:
(4) Test and Evaluate
(5) Present the Solution
Situation: Bike For Mom

Challenge: Design and Build a “new bike” model.
What does STEM Education Look Like in the Classroom?
The Instructor is Purposefully Teaching Students that the STEM Subjects and their associated Concepts are Not Independent, But Connected.

- **Math (Magnification)**
- **Science (Studying Plant Cells)**
- **Technology (The Microscope)**
- **Engineers (Built the Microscope)**
4. A STEM Education Classroom

- The Instructor is Purposely Teaching Students about **Practices** used in STEM.

Students Using the *Scientific Method* to Study Cell Growth

The Instructor Provides Opportunities for Students to **USE Both Science** (e.g., the scientific method) and **Engineering** (e.g., engineering design process) **Practices**

Which Practice Do You Use?
Which Practice Do You Use?
Depends on the Activity?

For Example
Scientific Method: Test Temperatures Inside & Outside of a Greenhouse

Engineering Design: Build a Greenhouse
The Instructor is Purposely Teaching Students about **STEM Careers**.

**Engineers** and **Scientists** use electron microscopes to study the structure of materials, and how they react to physical and chemical changes.

**Doctors** use microscopes to study changes in tissues that can cause illness.
A STEM Education Classroom

Instructors as a Facilitators

STEM Concepts & Practices are Purposely Being Integrated

21st Century Skills & STEM Careers Being Promoted

Project-Based Learning

Student-Centered Learning
Examples of Popular Hand-on STEM Activities That Students Design and Build to Learn about the Concepts and Practices of STEM
Popular STEM Activities

Robotics

Programming Systems
Popular STEM Activities

Quadcopters

Project-Based Learning

Engineering Design

Bernoulli’s principle
Popular STEM Activities

3-D Printing

Creativity

Engineering Design
Popular STEM Activities

Laser Engraving

Design

Measuring & Scale
Popular STEM Activities

Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware & software.

Raspberry Pi

The Raspberry Pi is a low cost, credit-card sized computer.
The Maker Movement

We All Like To Make!

Turning Consumers Into Makers!
V. Conclusion: STEM Education is Here to Stay
VI. Conclusion

- STEM is Important in all of our lives!
- It’s connected to almost everything
VI. Conclusion

- STEM Education promotes the **Integration of STEM Concepts and Practices** which may help students:
  - Better **learn & understand** the materials being studied.
  - Develop **interest in a STEM Career**
VI. Conclusion

- A STEM-Educated workforce can help a Country grow & prosper
VI. Conclusion

- STEM Education promotes real-world Problem Solving & 21st Century Skills that students need to live and work in today's society.
VI. Conclusion

STEM Education is Here to Stay!
Thank You!
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Questions
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