

Integrative STEM Education As “Best Practice”



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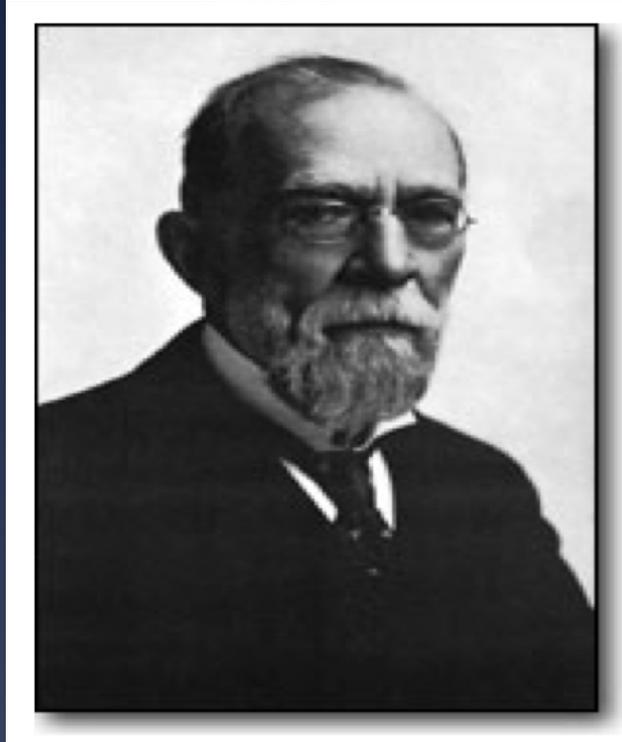
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December, 2012

Overview

- Historical Perspectives
- Integrative STEM Education Defined
- Rationale / Validation
- Investigating iSTEM Education
- Q & A

Historical Perspectives

Historical Perspective



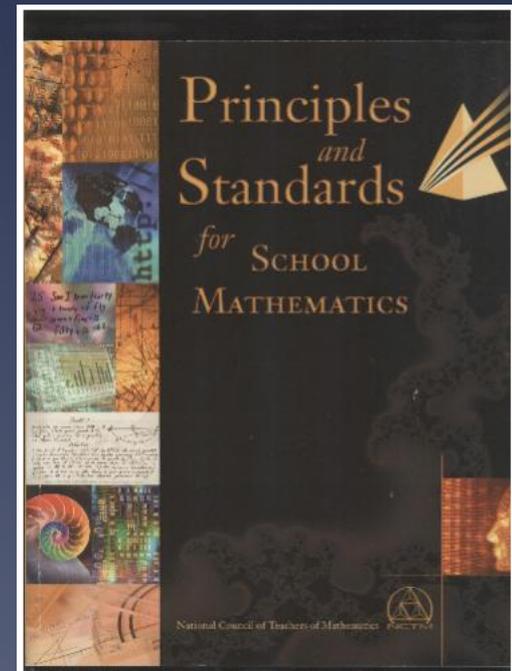
- Dr. Calvin M. Woodward
- 1870s: Professor of Mathematics, Washington U

Historical Perspective

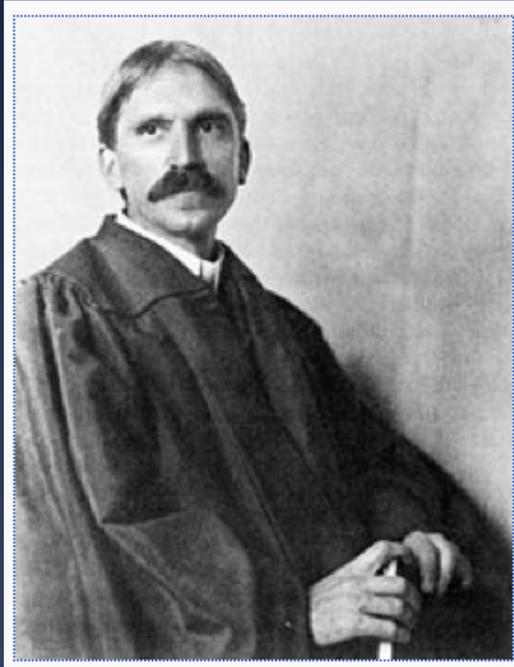
SCHOOL SCIENCE AND MATHEMATICS



- *School Science & Mathematics* (launched 1900)
- National Math Standards (*PSSM*) (NCTM, 1989/2000)
 - “Making connections builds mathematical understanding.”



Historical Perspective



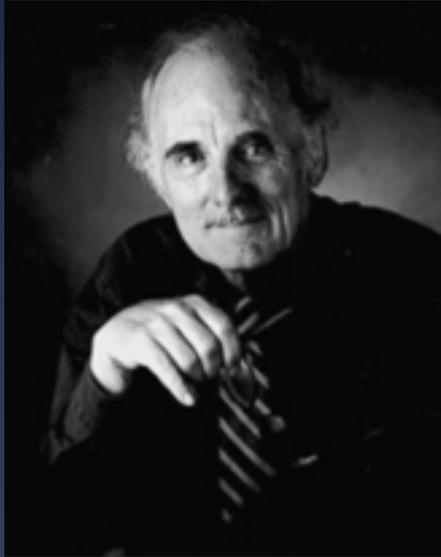
- John Dewey
- “There is no such thing as genuine knowledge and fruitful understanding except as the offspring of doing.” (1916)
- “As in the case of other tools, math and science can be learned only by use.” (1916)

Historical Perspective

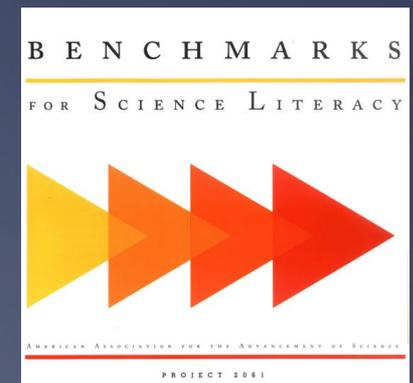


- Donald Maley (1959)
- “Where else in the school [other than the Industrial Arts Lab] is there the possibility for the application of math and science so closely resembling society outside of school”?
- R & E 9th grade course

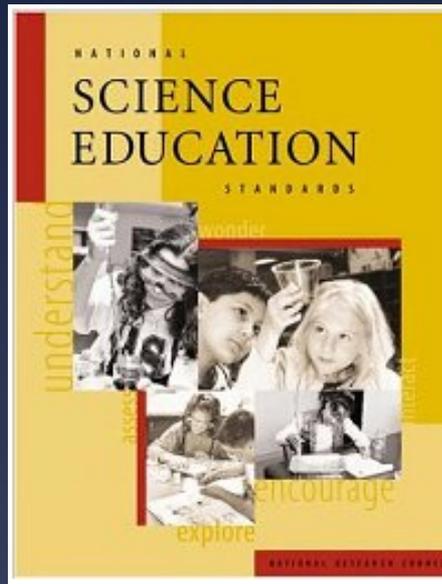
Historical Perspective



- James Rutherford
 - Science for All Americans (1989)
- “It is the union of science, mathematics, and technology that forms the scientific endeavor.”
- “The ideas and practice of science, mathematics, and technology are so closely intertwined that we do not see how education in any one of them can be undertaken well in isolation from the others.” (1993)



Historical Perspective



- *National Science Ed Standards,* (NRC, 1996)
- “Science & Technology” Standard”
- Thou shalt do Technological design in science class

(Design / Make / Communicate)

**What is
“Integrative
STEM
Education?”**

“Integrative STEM Education is...

- a much more explicit term than “STEM Education”
- refers to instructional approaches that situate Math & Science learning...
- in the context of engineering design problems

(Design / Make / Evaluate / Iterate)

What's an Engineering Design problem?



- Design Brief

Design a paper airplane that remains aloft for the maximum possible time.

- Design
- Make
- Evaluate
- Iterate
- FUN !

About Engineering Design challenges:

- Great for “kids” of all ages
- Great context for applying math and science
- Most design challenges are NOT iSTEM Ed



Integrative STEM Education: The Operational Definition

- technological/engineering design-based learning approaches...
- that *intentionally* integrate the concepts and practices of science and /or mathematics education with the concepts and practices of technology and engineering education.
- may be enhanced through further integration with other school subjects, such as language arts, social studies, art, etc.” (Sanders & Wells, 2006).

iSTEM Ed– Scope

- For ALL students, K-PhD
- Does NOT replace all (or even most) “silo” instruction
- Occurs during and /or after school

iSTEM Ed– Pedagogy

- Technological Design-based pedagogy
 - Design / Make / Evaluate / Iterate
- Students usually work in teams
- Teachers sometimes work in teams
- Engages & assesses grade-appropriate S, T, E, & M concepts and practices
- “Purposeful Design & Inquiry”

**Why iSTEM Ed
as “Best
Practice”
Candidate?**

Because It's an exemplar of many “Learning Principles”

- Learning is an active process
- Motivation is integral to cognition
- Learning occurs through social interaction
- Knowledge is contextual
- Embodied cognition
- **iSTEM Ed *nails* these Learning Principles!**

(Bransford, Brown, & Cocking, 1999; Bruning, Schraw, Norby, & Ronning, 2004)

iSTEM Ed as Best Practice, because...

- It's been shown to increase student:
 - Interest;
 - motivation;
 - Engagement;
 - learning (achievement); and
 - retention
- See, for example...

LRDC Study— Mehalik, Doppelt, & Schunn (*JEE*, 2008)

- Design-based science vs. Scripted Inquiry Science
- Investigated 1053 students in 46 science classes (Pittsburgh / LRDC)
- **CONCLUSION:** An engineering design approach employed by science teachers...
- significantly improved core science content knowledge (achievement), engagement, and retention compared to the traditional scripted inquiry science comparison group.
- “The systems design approach was most helpful to low-achieving African American students.”

Engineering Is Elementary Research

- EiE reports 3.8 million students & 41 thousand teachers using the EiE curriculum
- Their studies over past 6 years conclude:
- “EiE students perform significantly better than control groups on engineering, technology, and science questions; and
- EiE participation enhances interest, engagement, and performance among under-represented populations”

OK... So maybe it's a good idea...

but... **Why should TE**

consider iSTEM

Ed as a “Best

Practice”

Candidate?

Why should TE consider iSTEM Ed as “Best Practice”?

- Technology Ed has been **investigating / validating** iSTEM Ed since Woodward (1870s) and Maley (late 1950s) developed iSTEM Ed courses
- TE iSTEM Ed curriculum projects since the early 1990s
- For example...

Elementary (K-5) iSTEM Ed Curricula

- Mission 21 (1992)
- Project UpDate (1990s)
- Children's Engineering Convention (1996)
- City Technology (2001)
- Children Designing & Engineering (2002)
- Engineering by Design - I³ (ITEA 2004)
- Engineering by Design – TEEMS)ITEEA
- Engineering is Elementary (2004)

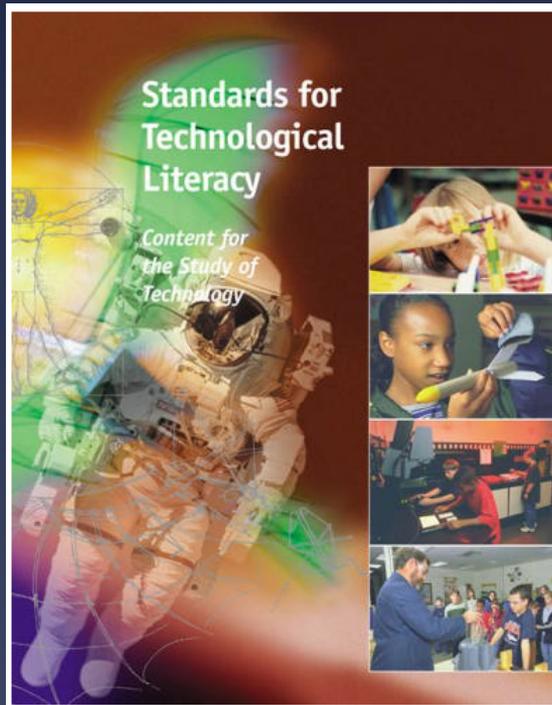
Middle School iSTEM Ed Curricula

- TSM Connection Activities (1996)
- IMaST (1998)
- Gateway to Technology (PLTW)
- Engineering By Design (ITEA, 2005)
- Building Math
- Design & Discovery
- Infinity Project
- Learning By Design
- Lego Engineering
- A World in Motion

High School iSTEM Ed Curricula

- Phys-Ma-Tech (1993)
- Principles of Engineering (NY, 1995)
- Project Lead the Way (1997)
- Tech-Know (Peterson, et al., 2000)
- Engineering by Design
- Designing for Tomorrow
- Engineering the Future
- Material World Modules
- A World in Motion

STL (ITEEA, 2000) Validates iSTEM Ed



- Engineering Design
- Connections with Science, Math & other subjects
- It's now the ITEEA...
 - Can't do "E" without M & S!
- iSTEM Ed = design-based Engineering Ed?

TE University Programs providing iSTEM Ed Options

- Virginia Tech: Integrative STEM Ed Grad Program
 - Founded 2005
 - Graduate Certificate, MAED, EdS, EdD, PhD
- College of New Jersey: MST Teacher Ed Program
- Illinois State University: STEM Ed Master's Option

The Engineering community (NAE) promoting iSTEM Ed for a decade

- 2002: NAE's #1 recommendation was:
- “Integrate engineering content into non-technical K-12 classes”
- Their current Project:
 - *“Toward Integrated STEM Education: Developing A Research Agenda”*

So, here's THE critical question for TE...

- Given: “Technological literacy for All” (1985)
- In the 21st century, shouldn't a technologically literate person...
- be able to apply math, science, and engineering concepts & practices in solving authentic problems?
- Do we really want to argue “NO” to this Q?
- If “NO,” is TE viable in the 21st century curriculum?

Consider: Next Generation Science Standards



- “What is different in the NGSS
- is a commitment to fully integrating engineering and technology
- into the structure of science education
- by raising engineering design to the same level as scientific inquiry
- when teaching science disciplines at all levels,
- and by according core ideas of engineering and technology the same status as core ideas in the other major science disciplines.

In 2003, I said YES to THAT Question...

- And, thus envisioned and then co-developed our Integrative STEM Education Graduate Program...
- Which investigates & validates iSTEM Ed as Best Practice
- Moreover, I'm suggesting that others in TE...

Investigate iSTEM Ed as Best Practice

- Establish Design Experiments (Brown, 1992)
- In each... create the best possible iSTEM “learning ecology”
 - (Lab + Curriculum + Instructional Procedures)
- Investigate student learning (using mixed methods)
- Continuously employ data to revise the pedagogy
 - To improve / validate pedagogy as “Best Practice!”
- Pose / investigate “humble theories” (about learning)
 - To develop new theories of technological learning!

What might become of TE in the 21st century...

- if TE teachers and researchers could provide convincing evidence...
- that TE's version of iSTEM Ed significantly improves student **interest, engagement, learning & retention** of science and math concepts & practices?

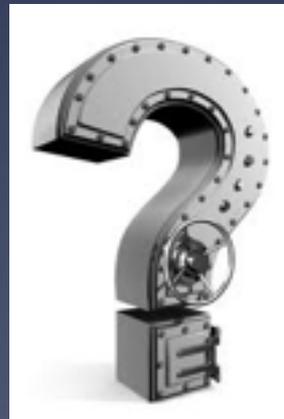
THANK YOU

THANK YOU

GRACIAS
ARIGATO
SHUKURIA
BOLZIN
MERCİ

BIYAN
SHUKRIA

TASHAKKUR ATU
SUKSAMA
MEHRBANI
GIAZIE
MAKSEK
KAZAMASHITA
EPCHAJISTO
JUSPAYAR
DANKSCHEEN
VAORHIFELAY
TINGKI



QA

Courses taught by iSTEM Ed faculty

- Core Courses
 - STEM Ed Foundations
 - STEM Ed Pedagogy
 - STEM Ed Trends & Issues
 - STEM Ed Research
- Other iSTEM Ed Courses
 - Biotechnology Literacy by Design
 - Readings in STEM Education
 - Field Study (Integrative STEM Ed)

iSTEM Ed State Frameworks

- New York
- Massachusetts
- Pennsylvania
- Maryland

Maker Movement



- Dale Dougherty
- Make Magazine
- Maker Faire
 - 90,000 (SF)
 - 50,000 (NYC)

Historical Perspective



- Donald Maley (1959)
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Future Directions

- National / State integrative Frameworks
- Articulated K-12 iSTEM Ed Curriculum
- iSTEM Ed Specialists
- Professional Development
- Investigate iSTEM Ed learning
- Rethink School Infrastructure

Makerspaces Project



- 1000 HS Makerspaces by 2015
- Anyone care to apply?

Why do iSTEM Ed?

- There's a growing body of research that supports the integrative approaches to STEM Education
- Because of it's potential to get kids interested in / excited about STEM learning.