

The Role of Art in STEM

A Component of STEM or a Supporting Role

by Michael Daugherty

STEM: Should an “A” be added?

Background

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The STEM movement has roots back to President Eisenhower, and the formation of NASA & NSF in 1958



Background

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Term STEM coined by Dr. Judith Ramaley (NSF, 2001)

- *Stipulated learning in context, solving real-world problems and creating opportunities—pursuit of innovation.*



Background

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U.S. has fallen behind in export technology

- Now leading consumer, *not* developer technology
 - ▣ US global exports fallen 30% to 17%
 - ▣ Asia grew 7% to 27%
 - ▣ U.S. has negative trade balance
 - Even for high-technology products
 - ▣ Concern about competitive ability (NAP, 2005)
 - ▣ Decreased student interest in STEM

STEM Education Movement

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- Perhaps largest reform movement in last decade
- STEM acronym not always understood
 - ▣ 4 subjects with something in common, or
 - ▣ 1 trans-disciplinary subject
- STEM interest largely driven by lackluster student test performance
 - ▣ And, dire consequences for US political and economic power

The Role of Creativity

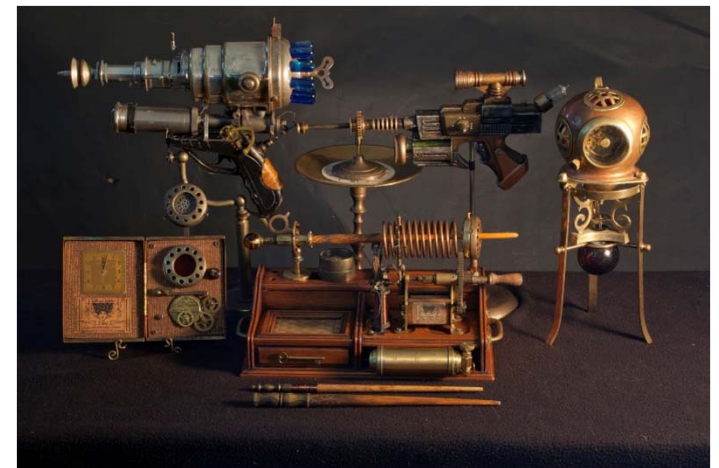
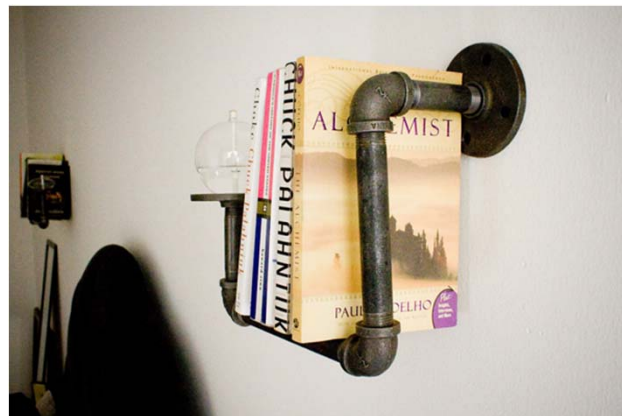
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- In addition to STEM, US economy is powered by creativity
 - ▣ US historically ranked #1 in innovation/creativity
 - Since beginning of Industrial Revolution
 - ▣ Now 3rd and 8th depending on the survey
- Funding for STEM is an effort to reverse trend
- Many STEM initiatives fail to address creativity
- Many suggest that including the “arts” may best foster the creative and innovative workforce needed

Art and Innovation have a Connection

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- Industrial art, to industrial chic, to Steampunk



Arts' Tenuous Position

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- Considered a luxury in many schools
- An arena for self-expression, not education
- Exacerbated by federal legislation (NCLB, 2001)
- Reaction of Arts Community
 - ▣ Arts' role in improving student performance in “important subjects”
 - ▣ Sometimes ignoring “core benefits” of arts while stressing the “bonus effects” without empirical or even theoretical evidence (Hetland, et al, 2007)
 - No evidence that arts raise grades in academic subjects (Winner & Cooper, 2000)

A Risky Plan

- Justifying the arts only on bonus effects will in the end fail (double-edged sword).
 - If arts are only included to cause core academic improvement, then:
 - Arts will quickly lose ground if academic improvement does not result, or if the art is less effective than high-quality, direct instruction in STEM subjects (Hetland, et al, 2007).
 - Many in the arts community believe that arts must stand on what they add through core benefits

Two Major Arguments

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- Art as a way of knowing (core benefits)
 - ▣ Expanding the STEM toolbox
 - ▣ A heuristic that leads to a different understanding
- Art as a tool for expanding creativity/innovation (bonus effects)
 - ▣ STEM generally based on left-brain & logic
 - ▣ Art expands upon creativity and innovation (right-brain)

Creative Innovators

□ *For today's students to be the innovators and economic leaders of the future, they will need to have experiences as musicians and dancers, painters and sculptors, poets and playwrights — in short, they will need to be creative innovators who will build our nation's economy for the future.*

□ Arne Duncan, U.S. Secretary of Education

The Life of a Hunter: A Tight Fix by Arthur Fitzwilliam Tait (1856)



Research Support the Inclusion of “A”

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- Arts learning engages higher cognitive parts of brain (McGrath & Brown, 2005)
- Corporate executives and school superintendents prefer creative employees/students to those with advanced technical skills (Lichtenberg, 2008)
- Arts provide innovation through analogies, models, structures (Root-Bernstein, 2011)

Artist Inventors in U.S.

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- Camouflage invented by the American painter Abbot Thayer
- First programmable device invented by J. M. Jacquard – to make tapestries
- Electronic display screen invented by series of painter-scientists such as Seurat
- Cell phones use encryption called *frequency hopping* invented by the composer George Antheil and actress Hedy Lamarr
- Long tradition of artist-turned-inventors in US
 - ▣ Samuel Morse and Robert Fulton were noted American artists before creating the inventions for which they are famous

Art Engagement & Nobel Prize

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- Nobel laureates in science are:
 - 25 times more likely to sing, dance, or act
 - Than average scientist
 - 17 times more likely to be an artist
 - 12 times more likely to write poetry and literature
 - 8 times more likely to practice woodworking or craft
 - 4 time more likely to be a musician
 - Twice as likely to be a photographer
 - Many connect their art with their scientific creativity (Root-Bernstein, 2011)

Rosie the Riveter

- Norman Rockwell, 1943





Rise of the Creative Class

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- Currently, art abilities apply to a larger segment of workforce than skills commonly associated with STEM (White, 2011)
- 30% of the U.S. workforce (40 million) create for a living (Florida, 2002)
 - ▣ Meanwhile, science and engineering account for 10-12% (NSF)
- US competitiveness distinguished by creative industries (movies, television, games, design, etc.)

STEM/Arts Partnership Essential

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- Art may not be just nice, but essential for expanding creativity and innovation in the US
- Art may be the spark to creativity in STEM education
- The key may be the art heuristic: Similar to the *engineering design method* in engineering or the *design loop* used in technology and the *scientific method* used in science classes, art utilizes *studio habits of mind* or *studio thinking*

What does Art Add?

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- How do the best art teachers teach and what do students learn as a result?
 - ▣ Variations on time, space, and interactions
 - ▣ Best teachers strive to instill “studio habits of mind” (or dispositions)
 - Eight Studio Habits of Mind: Develop craft, engage and persist, envision, express, observe, reflect, stretch and explore, understand the art world.

Studio Habits of Mind

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- Develop Craft: Using/caring for tools, materials
- Engage and Persist: Embracing problems of relevance
- Envision: Picturing mentally what can't be directly observed or imagining next steps.
- Express: Creating works that convey ideas or feelings.
- Observe: Seeing things that otherwise might not be seen.
- Reflect: Judging one's own work in relation to a standard
- Stretch/Explore: Learning from mistakes, stretching abilities
- Understanding the Art World: Understanding art history and current practice, interacting with other artists

Integration of Studio Thinking

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- Similar mental habits are deployed in fields like dance, music, theater, science, mathematics, history, literature, writing, and technology/engineering education.
 - For example:
 - The disposition “Envision” is important in the sciences (e.g., generating hypothesis), in history (e.g., developing historical imagination), in mathematics (e.g., imaging how to represent space and time algorithmically), and in technology/engineering education (e.g., developing thumbnail sketches)

Characteristics of Studio Thinking

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- Studio Thinking differs from heuristics required in other disciplines only by emphasis:
 - ▣ There is likely more concern with “express” in visual arts
 - ▣ Studio Thinking can expand any discipline where the discipline is central in learning activities.
- Studio Thinking benefits to non-arts disciplines
 - ▣ Other disciplines can benefit by adding more visuals and demonstrations, making lectures briefer, and focusing on immediately useful information

“War News
from Mexico”
•Richard
Woodville
(1848)



Benefits of STEM Arts Integration

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- ❑ Creative behavior emphasized
- ❑ Inventive/innovative skills developed
- ❑ Critical thinking practiced
- ❑ Constructivist learning practiced
- ❑ Envisioning skills expanded
- ❑ Aesthetics emphasized
- ❑ Reflection utilized
- ❑ Ethics explored



STEM Art Education Programs

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- **STEAM** (Science, Technology, Engineering, Arts, and Math): Goal to provide a curriculum that focuses on creativity and innovation.
- **TEAMS** (Technology, Engineering, Arts, Math and Science): A story based curriculum focused on creativity.
- **STEM+Arts**: Goal to create hybrid curriculum between art/science/technology/engineering/math.
- **STEM-A** (Science, Technology, Engineering & Math thru Art): Goal to expand STEM education through arts immersion. Spark life-long passions in STEM subjects.
- **Art STEM**: Teaching and learning at the intersection of the arts and STEM disciplines.

More Examples of STEAM

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- **The Art of Science Learning:** Uses imaginative approaches to science learning
- **Connect a Million Minds:** Time Warner® Cable's TV series
- **The Institute for the Study of Management in Education:** Developed lessons that incorporate art into STEM
- **Science of the Movies:** Discovery Channel® weekly TV show
- **Space School Musical:** NASA design activity focused on STEM and the arts
- **Visual Culture Art Education:** Interdisciplinary pop culture-based visual arts curriculum approach
- **Discipline Based Art Education:** Focuses on production, criticism, history, & aesthetics
- **CrayonPhysics:** Web site based lessons combining art and STEM

Conclusions and Recommendations

- ❑ STEM support largely perpetuated on fear that US is becoming less competitive and secure
- ❑ Art added to STEM could add emphasis to innovation and creativity
- ❑ Art could assist in engaging both hemispheres of the brain in STEM education
- ❑ A false divide currently separates arts and sciences
- ❑ If innovation and creativity are one of the goals of STEM education, then integrating the arts makes sense
- ❑ Must decide if the arts would be used to inform STEM education or become an equal partner

The Island by Walton Ford

