STEM to STEAM: Promoting divergent thinking

Christopher T. F. Hanson

215 North Johnson Ave

San Marcos, TX 78666

San Marcos High School Orchestra Director

PhD Student in School Improvement at Texas State University

Introduction

The STEM[1] to STEAM[2] initiative has become omnipresent in the ongoing conversation of modern school reform. Pedagogy and curriculum have come under serious scrutiny in the 21st century as the global economy continues to influence and dictate change in education to meet perceived needs in the work force and marketplace (Bertram, 2014). With an increased awareness and communication of such needs, policymakers are looking to the future through a lens of educational reform. The ultimate goal is to prepare students for what we believe are future needs. The challenge has become balancing those anticipated needs with the promise of intellectual freedom and creativity in education (Piro, 2010, Boy, 2012, Henrickson,2014). The STEAM initiative has been introduced in reaction to this apparent challenge as more classrooms seem to restrict instruction and place limits on student potential rather than benefit from encouraging and promoting divergent thinking through arts integration (Henrickson, 2014).

A Brief History

The STEM initiative was conceptualized by an amalgam of invested parties.[3] The acronym was coined by Dr. Judith Ramaley of the National Science Foundation (NSF) in 2001 (Watson & Watson, 2013). Ramaley envisioned STEM to be a system of learning that promotes problem solving skills with project based learning utilizing "real-world problems" (Ibid). This design also served a more political purpose to address America's growing concern for graduates that were underrepresented or deemed unprepared for careers in STEM fields (Jolly, 2014). According to research published by the Congressional Research Service (2012)[4] an estimated

[1] STEM stands for Science Technology Engineering and Mathematics
[2] STEAM stands for Science Technology Engineering Arts and Mathematics
[3] Watson and Watson (2013) attribute the need expressed to develop programs of STEM related disciplines to a series of studies by the National Science and Technology Council, National Science Foundation, the National Science Board, the National Academics of Science and Engineering, and the Institute of Medicine.
[4] This information was taken from an infographic entitled "STEM vs. STEAM" published by the University of Florida.

5.6% of college graduates in the United States earned degrees in STEM related fields. This is an incredibly low percentage, viewed from an international perspective, when 46.7% of Chinese graduates and 37.8% of South Korean graduates earn STEM degrees. Additionally, the Level Playing Field Institute published research that claims two out of every three engineers who receive PhD's from United States Universities are not from the United States.[5] This then adds to the United States' perceived disadvantage within what has been deemed the technological race of the 21st century's global society, culture and economy (Boy, 2012).

It has been argued that "STEM fields are at the core of everything we do (Bertram, 2014)." Such a statement purports the superiority of STEM fields over others, and this notion has been arguably validated by the eager promotions and astounding level of support that has been offered to STEM education reform. For example, in 2010 President Obama announced a $250 million initiative to recruit and train more STEM teachers on top of nearly $700 million the federal government already spends on science and math education programs within various agencies (Piro, 2010). Maeda (2013) asserts "with the global competition rising, America is at a crucial juncture in defining its economic future." Here, however, is where the conversation turns.

Maeda, the President of the Rhode Island School of Design and one of the leading supporters of the STEM to STEAM initiative, continues the above assertion by stating his belief that "art and design are poised to transform our economy in the 21st century like science and technology did in the last century, and the STEAM movement is an opportunity for America to sustain its role as innovator in the world (Ibid)." Piro (2010) clarifies by stating "if creativity, collaboration, communication, and critical thinking- all touted as hallmark skills for 21st century success- are to be cultivated, we need to ensure that STEM subjects are drawn closer to the arts."

[5] This information was taken from an infographic entitled "STEM vs. STEAM" published by the University of Florida.

Fowler (1996) believes, however, that the "unrelenting pressure on schools to serve corporate and commercial needs has established an elite core of subjects in American schools that are labeled *the basics*, the subjects that every student must master. But the arts are seldom admitted to this club, a shortcut that has angered those who recognize their enormous educational potential" (pg. 8). The subsequent debate, that suggests we must substantiate the arts in public education in submission to "the basics," has a mature and protestant history.

Fowler (1996) resists the claim that there is a shortage of STEM professionals, as mentioned before, arguing that in 1992 a congressional subcommittee "was informed that the country's impending shortage of scientists and engineers was based on a seriously flawed NSF study" (pg. 19). This alleged shortage was perpetuated between 1987 and 1990 by the former head of NSF, Erich Block. "Consequently," adds Fowler, "the shortage was blamed for [the United States'] declining competitiveness, and the NSF won higher federal appropriations" (pg. 19). Fowler passionately contests the inflated importance and damming effects that are suggested to come from STEM issues. Like most STEAM supporters, Fowler professes that…

> "If we are going to continue to compete advantageously in world markets, we must increase our investment in the development of creativity and the ability to solve problems… The arts complement the sciences. The development of human imagination is critical to both. Without imagination and the ability to create, we are struck with life as it is, and not as it might or could be" (pg. 19).

Chartrand (1992), who is frequently cited by Fowler, caries the debate further to question the misconceptions of science through the public's eye and reaffirm its interdependence with the arts.

> Once upon a time, our forebears spoke of 'the Arts and the Sciences' in a single breath… [Today] science is perceived by the public as a seamless web stretching from school to university to corporate lab to the 'high tech' home entertainment centre… The public is told repeatedly, by business and government, that more math and science education is required to preserve our jobs, competitiveness and freedoms. But, at the same time, public awareness is dawning that science is not, and has never been, *summum bonum* - all good: What science gives with one hand economic growth and material prosperity, it seems to take with the other - pollution, stress, technological displacement, weapons 'of mass destruction, etc." (pg. 10).

The point of the STEAM initiative then is to bring back our "forebears" ideals of integrated and interdependent fields of study that benefit each other together, more than they do apart. Boy (1993) insists "instead of dividing disciplines, we need to combine them. No longer can we be either poet or engineer. We must be both" (pg. 5).

Misconceptions

I believe Boy's statement addresses one of the biggest misconceptions of the STEM to STEAM initiative, that *we must have one or the other*. Advocates for the STEM initiative have been criticized for establishing and promoting schools and programs that restrict the coursework and opportunities of their students to focus solely on STEM fields (Henrickson, 2014; Watson & Watson, 2013). In contrast, advocates of the STEAM initiative are promoting the integration of the arts to STEM fields, rather than the isolation, addition, or promotion of one subject over another (Jolly, 2014; Madea, 2013; Watson & Watson, 2013) . The STEAM initiative is designed

to enhance and improve STEM instruction by promoting problem solving skills of real world issues in new and creative ways. Creativity is truly the key.

Consequently, much debate has been generated by the assumption that professionals of STEM fields have become less creative. Traditionally, STEM curriculum has proven to focus more on the completion of designed tasks with predetermined outcomes rather than offering students the opportunity to explore, discover, and create new solutions, and for that matter, new problems that may not yet have an answer. Henrickson (2014) states "the future of innovative thinking in STEM disciplines relies on breaking down the distinction between disciplines traditionally seen as "creative" like the arts or music, and STEM disciplines traditionally seen as more rigid or logical-mathematical" (pg. 1).STEAM, of course, is the proposed solution. It does not require rewriting the STEM curriculum, but implementing an approach that promotes alternative perspectives to the designed problems and allows for multiple creative solutions. Jolly (2014) suggests "the purpose of STEAM should not be so much to teach art but to apply art in real situations. Applied knowledge leads to deeper learning."

The focus must truly lie on the learner and expanding their learning opportunities. Anything else, particularly the initiatives that are disguised as a "focus" on specific content and curriculum, yields limitations to the students' potential. Maeda (2013) posits that "innovation happens when convergent thinkers, who march straight ahead towards their goal, combine forces with divergent thinkers- those who professionally wander, who are comfortable being uncomfortable, and who look for what is real" (pg.1). We must find ways to intellectually challenge the student while supporting multiple solutions and perspectives, "inspiring them to be more divergent, creative thinkers across disciplines (Henrickson, 2014)." Watson & Watson (2013) state:

> "The original Ramaley concept of STEM education purused innovation, but it fell short because artistic thinking was not included. STEAM does not merely add art to STEM, it changes STEM's focus from better test scores in the core STEM academic disciplines to better quality of inclusive thinking and from focus on the development of a larger, technically competent workforce, to one that is also more innovative" (pg. 4).

Another huge misconception that Fowler (1996) discusses in great detail, is the notion that the arts must justify their place in public education. Fowler states "in comparison with other subjects, arts educators have spent a disproportionate amount of time and effort over the years trying to justify the role and value of the arts in schooling" (pg. 35). Most of the resources sited in this paper, in fact, perpetuate this notion and attempt to seek justification for the arts through its benefits to STEM education (Henrickson, 2014; Jolly, 2014; Maeda, 2012; Piro, 2010). Although the benefits of art integration have been proven and correlated through a wide range of published research, the sheer fact that art is seeking justification for its existence in public schools speaks to a much larger issue of the perceived value of the arts in general. Such a conversation, of arts perceived value, is both worthy and needed, but lies beyond the scope of the current paper. Rather, a reference to a select number implementations of STEAM concepts seems appropriate in developing a better understanding of how and why debates of justification continue.

Implementation and study

Working from higher education down, the Rhode Island School of Design (RISD) has "consistently upheld its mission to educate the public about the vital role of art and design in

society" since its founding in 1877. [6] Today, "the RISD community remains committed to the belief that the arts and design, in concert with fields like science and technology, will bring about the global innovation needed in the 21st century." As a vital part of their identity as an educational institution RISD communicates their goal "to foster the true innovation that comes with combining the mind of a scientist or technologist with that of an artist or designer."

The University of Florida has also done a great deal in recent years to promote the STEM to STEAM initiative and has developed degree plans and curriculum that encourages learning and teaching within STEM fields through the arts. They have published several popular infographics to support ongoing conversations on STEM to STEAM programs, adding to what continues to be a lively debate of perceived and expressed value, impact, and importance of integrated curriculum in public education. Most recently, in 2014, the University of Florida (UF) assisted with the development of curriculum and implementation of a STEAM program at the St. Thomas Episcopal Parish School in Coral Gables, Florida. "The concept of teaching STEM subjects through integrated, hands-on, community-based, service-learning projects rather than as stand-alone disciplines has been at the educational forefront for many middle and high school programs in recent years. Developing a comprehensive STEM/STEAM program for the elementary grades, however, is a pioneering adventure that St. Thomas and UF are ambitiously pursuing–full STEAM ahead." [7]

As mentioned above, a number of secondary schools have developed their own programs and curriculum that promote arts integration into STEM subjects. An invaluable resource to such developments is David Sousa and Tom Pilecki's pivotal book *"From STEM to STEAM: Using*

[6] This description is taken from the about section of the RISD webpage at www.risd.edu/about/stem_to_steam
[7] Additional information on the elementary STEAM programs developed at St. Thomas with the University of Florida's College of Education is available at https://education.ufl.edu/news/2014/06/17/uf-pioneering-steam-education-outreach-for-elementary-grades-at-coral-gables-school/

brain-compatible strategies to integrate the arts" (2013). The book moves beyond the literature published that perpetuates the conversations seeking justification for arts integration, and presents STEAM education through the practical perspectives of researchers, educational leaders, teachers, parents, and students. The introductory chapters grapple the controversies, assumptions and science behind art integration and encourage implementation through a series of progressive lesson plans and instructional strategies that have been used in Kindergarten through 12th grade. Truly unique to other material published in the field, the book offers research-based teaching strategies that promote integration and collaboration through the arts by maximizing existing resources within public schools. Although the book is designed for STEM teachers that are interested in arts integration, the content moves past conversation and promotes action through instructional practice.

Recommendations/connections to SI models

Harris (2002) describes the goal of school improvement as a method to "bring about positive cultural change by altering the processes that occur within the school (pg. 17). I believe the recognition and ultimate appreciation of the arts as an instructional tool to generate and promote divergent thinking amongst diverse learning communities is one such change. Furthermore, I believe it operates as a model for school improvement that supports both 21st century skills and needs. "The problem" clarified by Noblit et al (2009) "is not so much a lack of appreciation for the arts but priorities. Despite similar pronunciation, the arts quite simply are not a part of the three "Rs." They are not "core" subjects (although in the state of Texas they are legally designated as such). The instructors are not "regular" teachers. Most states include the arts in their mandated courses of study but not in their testing programs. No matter how valuable people perceive dance, drama, visual art, and music to be, they remain add-on programs" (pg.

35). This is not an invitation to justify the arts for their potential benefits to other disciplines, but it is a call to change the culture of schools which do not appreciate the potential of divergent thinking and cannot appreciate the limitations of segregated curriculum and assessments.

Fowler (1996) identifies the arts as a change agent in education and offers the following list of reform initiatives that have realized the arts as an inducement for change: The Drew School in Arlington, VA which introduced an integrated art and language program for at-risk first grade children in 1992 (pg. 1610); the arts as a vehicle for promoting cultural diversity by providing "culturally vibrant models of teaching and learning that celebrate and reflect the diversity that has always been our nation's greatest strength"[8]; Ralph Burgard's A+ Project with the Kenon Institute in North Carolina[9] (pg. 163); The Chicago Arts Partnership in Education initiated by the Marshall Field's Department Store (pg. 166); The Gaelf Institute, designed by Linda Adleman as an interdisciplinary program for primary schools that joins history and social studies themes with the visual and performing arts, literature, writing, math and science (pg. 167); just to name a few. All of these arts based reforms have generated documented success.

The true question then, is not whether the arts can be realized as a model for school improvement, but rather, why have more schools and communities not capitalized on the apparent wealth of possibilities and benefits of complete art integration? The STEM to STEAM initiative should now appear to be the latest reform model to be added to the list started above that recognizes the arts as a powerful and accessible agent for educational reform.

[8] Fowler references this quote to Cortines, R. (1994). *The Arts: Partnerships as a Catalyst for Educational Reform*. Sacramento, California Department of Education.
[9] An extensive report of the A+ Program as a model for school reform is available in Noblit, G. et al (2009).

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