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## Full STEAM Ahead: The Benefits of Integrating the Arts Into STEM

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### Abstract

There is growing interest amongst forward looking public officials, educators, and professionals in enhancing the education platform to better prepare students for both analytical and creative thinking. Traditional STEM (Science, Technology, Engineering, Mathematics) degrees focus on convergent skills whereas art degrees focus on divergent skills. Having the ability to execute both at scale can better position our nation for global competitiveness. A study by the Partnership for a New American Economy, called “Not Coming to America,” demonstrates the lacking interest of STEM in undergraduates throughout American born citizens. With a STEM job market increasing three times faster than the rest of the economy, and only 4.4% of American undergraduates enrolled in STEM programs, there is a huge shortage of qualified high-tech workers. Education must foster not only problem solving skills but also problem seeking skills all while maintaining the interest of the students. The author, an art educator with STEM interest, will summarize the major initiative in STEM, rationalize the value of arts integration, discuss objective driven assessment, evaluate literacy opportunities, provide examples of taking theory to practice, and challenge the audience to go full “STEAM” ahead.

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### 1. STEM education in the United States

The United States’ education system is comprised of both public and private sectors separate from the federal government. In public education, the state and local governments are primarily involved with establishing educational standards for their respective districts. Public school educators develop their curriculum based on these educational standards. Even though the states and local governments are responsible for developing the standards, the federal government still wields much influence within the education system through funding. A major initiative in place currently is the STEM (Science, Technology, Engineering, Mathematics) movement. Many professionals hold the belief that by focusing these keys areas, the students of tomorrow will propel our global competitiveness forward through the development of innovative ideas.

President Obama is a major advocate for STEM education. In 2008, Obama stated that, “Today, more than ever before, science holds the key to our survival as a planet and our security and prosperity as a nation. It’s time we

once again put science at the top of our agenda and work to restore America's place as the world leader in science and technology.” With his support and the support of many other public officials, organizations like the Math and Science Partnership, the National Science Foundation (NSF), and Project Lead the Way have both developed and funded a variety of STEM projects. In place currently is the America Competes Act of 2007, which is aimed at increasing the nation's investment in STEM education from kindergarten all the way through to postdoctoral education. The act authorizes significant funding increases for the NSF and the National Aeronautics and Space Administration (NASA).

## 2. STEAM and the need for innovation

As mentioned in the abstract, the “Not Coming to America” study done by the Partnership for a New American Economy demonstrates that jobs in the STEM fields are increasing three times faster than positions in the rest of the economy, but a huge gap of qualified American citizens exist (McDougall, 2012). The statistics are difficult to ignore. Only 4.4% of U.S.-born undergraduates are enrolled in STEM programs. This compares poorly with STEM students in Singapore, China, Germany, and the U.K (refer to Table 1). Moreover, the “Annual Industrial Capabilities Report to Congress,” from the Department of Defense in 2011, estimated that 70% of department employees would be eligible for retirement in the STEM fields by 2013. With a hasty youth focused on self-indulgence and leisure, we must make STEM education more appealing. Adding the arts into the STEM equation can re-invigorate the platform, providing not only an interesting approach, but also opportunities for the self-expression and personal connection new generations crave.

Table 1. Percentage of citizens enrolled in STEM degree programs in various countries

Country with STEM degree programs	Percent of undergraduate citizens enrolled in STEM
United States	4.4%
United Kingdom	6.1%
Germany	12.4%
China	31.2%
Singapore	33.9%

The push for the STEAM platform derives from the lack of creativity and innovation in recent college graduates in the United States. Currently, our education system teaches students how to execute given tasks fluidly, but rarely fosters curiosity and self-motivation. According to professionals like Michael Nance, a Chief Information Security Officer at Lockheed Martin, the U.S. is riding on the coat tails of technologies like personal electronics and personal computing creations instead of putting brain trust into new scientific and technological breakthroughs. “As the economic activity of our nation and the world continues to rapidly transform, the need to invest in education that promotes innovation and creativity has become primary to the central themes in this ongoing public dialogue” (Immerman, 2011). Historically, the United States was considered the leading country in innovation. There has been a dramatic decrease in innovative American ideas, and we are now finding the U.S. ranking 3rd to 8th in innovation, depending on the survey (White/Chairman, 2012).

Progress does not come from technology alone but from the melding of technology and creative thinking through art and design. If the United States wants to remain a global competitor, it will be crucial to foster creative thinking and practice. As long as an individual is pushing personal boundaries and developing his or her own conceptual methodologies in an innovative way, a person can have a creative practice in any field. Moreover, the

arts can help develop STEM skills because of the more divergent approach. For example, Robert Root-Burnstein's study of scientific Nobel laureates demonstrated that most all of the scientific "geniuses" between 1902 and 2005 were proficient in not just science but also the arts (Root-Burnstein, 2012).

Have you ever heard anyone refer to him or herself as a strictly auditory learner? According to fMRI (functional) brain research on the different modalities of learning, this is a common misconception. Everyone is a visual, auditory, and kinesthetic learner. If an individual is taught the concept of seed germination through a series of images, this person may be able to describe how the different stages of seed germination look. When accompanied with an auditory description of how seed germination occurs, a person is more likely to recall the stages of germination. Finally, if that person illustrates the stages of germination or climate necessary for the process, this individual has more access points for that information. When an individual is taught a single concept, the brain creates neural pathways connecting that concept to his or her experience. The more access points or neural pathways established, the greater the chance of retention and recall. Integrating the arts into core content areas not only enables students to explore a single concept from different vantage points, but it also utilizes all the different modalities of learning previously mentioned, both leading to the formation of more neural pathways.

### **3. The need for objective driven assessment**

In 2001, teachers were made accountable through rigorous testing of their students due to the passing of the No Child Left Behind Act (NCLB) (Aldridge). School curriculum changed to meet the content and performance standards. Before the NCLB was passed, students were taught to be problem seekers and solvers. With the standardized tests, students are measured on memorization rather than comprehension. In preparation for the exams, a student is taught that only right and wrong answers exist. The real world is not in black and white. We must encourage the youth of tomorrow to seek out multiple solutions to complex problems, and the addition of the arts within the STEM fields can combat this issue. Well-rounded art problems never have one answer. Within the art classroom, opportunities arise for student to construct their own learning through the decision making process. Artistic license forces students to articulate their own interpretation of the material in a unit through the exploration of possibilities. Integrated art education prompts can function as vehicles of understanding, or a synthesis of core content knowledge. Students should not be assessed on how well they can remember the parts of a cell by name but instead on the inner workings, attributes, or how they relate to the individual.

### **4. The arts and literacy**

The overarching goal of education is to prepare the individual for the responsibilities and encounters that take place in adulthood. Literacy creates the opportunity for individuals to become a functioning member of society and supports the progression of humankind. Without some form of language, whether it be spoken, gestural, or written, communication and the implementation of innovative ideas is impossible. Literacy encompasses education and critical thinking. To be literate is to be a comprehensive student, informed citizen, and successful employee (Anderson-Inman, 2009).

With the rise of 21st century technologies, the skills, or literacies, have drastically changed prior to the age of the Internet. Today's youth need to know how to work collaboratively within a collected intelligence, participate in social networks, negotiate across cultural differences, and navigate contradictory data available to them (Anderson-Inman, 2009). According to Harry Jenkins, the director of the Comparative Media Studies Program at MIT, his new media literacies can prepare students for up and coming jobs. These 21<sup>st</sup> century skills extend beyond textual literacy. The new media literacies Jenkins posed are play, performance, simulation, appropriation,

multitasking, distributed cognition, collective intelligence, judgment, transmedia navigation, networking, negotiation, and visualization (Sutherland, 2012). The new media literacies are easily explored in the art classroom. Visualization, for example, is a critical part of most art education classrooms today. Many educators create prompts inspiring students to translate their research, beliefs, memories, etc., to visual modes. Appropriation is the remix of content, and this relates to juxtaposition in art. Performance, simulations, and collective intelligence can be incorporated into the art curriculum through collaborative projects where students are assigned roles that relate to real world occupations to reach a common goal. An educator can incorporate play by posing questions to direct experimentation with new art media such as clay. Another way to incorporate new media literacies is through the physical technologies that are driving the new media literacies. Teachers can foster multitasking through the incorporation of music and documentaries relating to the content during studio time, or by scaffolding responsibility and giving multiple assignments to encourage time management. Projects utilizing online research, computer programs, and physical art objects can promote distributed cognition, judgment, negotiation, and transmedia navigation. Experimentation with networking, simulation, collective intelligence, and negotiation are accessible through facilitated community arts. Arts integrated learning units can work as a vehicle for not only understanding content the STEM fields but also literacy in general. If educators across disciplines collaborate to focus on arts integrated project-based learning, the youth of tomorrow will be capable and invested citizens.

## 5. Building STEAM

All over the nation, the forward thinking movers and shakers are developing their own STEAM curricula. In September 2010, the Wolf Trap Foundation for the Performing Arts was awarded a \$1.15 million grant to be split over four years. This grant helped launch the “first-of-its-kind” early childhood STEM learning through the arts initiative (Wolf, 2012). In Upstate New York, Dr. Maggie Madsen, Potsdam University Provost, is working with a team to establish a STEAM degree program for submission to the SUNY system in partnership with Lockheed Martin. Developers for this multidisciplinary degree include: Art, Music, Theater, Biology, Psychology, Chemistry, Computer Science, Mathematics, Physics, and Business. Higher education will likely see a trend of more dual degree programs from both the arts and STEM disciplines. Future careers such as astronautic geologists, biomimicry analysts, quantum linguists, roboticists, medical mathematicians, and crypto-privacy engineers will most likely benefit from these STEAM degree programs. The President of Rhode Island School of Design (RISD), John Maeda, has facilitated a partnership with CreativeMornings, a monthly lecture series, to highlight professionals exploring the thin line between art and technology. Additionally, Maeda recently participated in a Capital Hill briefing to the newly founded Congressional STEAM Caucus. At the briefing, the Congressional STEAM Caucus reintroduced House Resolution 51, a resolution stating that art and design promote creativity and economic growth within the country.

## 6. Theory to practice

Supporters of the STEAM initiative may theorize how STEAM looks in the classroom, but it is the educators’ job to develop and/or implement the curriculum. When it *boils down* to it, STEAM is cross-curricular collaboration. With every newly formed teaching method, the teachers involved in designing STEAM units must be team players willing to co-plan and maybe even co-teach. Ideally, each content area has an equal amount of learning. If a mathematics teacher and art teacher implement a STEAM unit, both new mathematics skills and new art skills would be introduced through an overarching concept. This overarching concept, or big idea, is the branching off point that relates the two content areas. For example, if the big idea was data, the mathematics teacher could introduce skills related to data collection and frequency charts. Simultaneously, the art educator could introduce the skills related to visual literacy through a use of color and icons. In the end, the synthesis of learning may be a data visualization representing personally collected data through the use of colors and icons. Other applications of STEAM may take the form of circuit bending, musical compositions, kinetic art, product design, prototype development, and performance art.

Fig. 1. is an output example of STEAM through the integration of design and technology. Fig. 1. is a scaled version of a visual representation for the research in this paper. The author created a large format poster with an augmented reality through the Apple based program called Aurasma. The user is able to view videos in real time by hovering over portions of the poster. Using a Quick Response (QR) code reader, the user is also linked to various websites delving deeper into the theory and application of the STEAM initiative. This is an example of how the arts can help facilitate a better understanding of a topic for both the creator and the viewer.

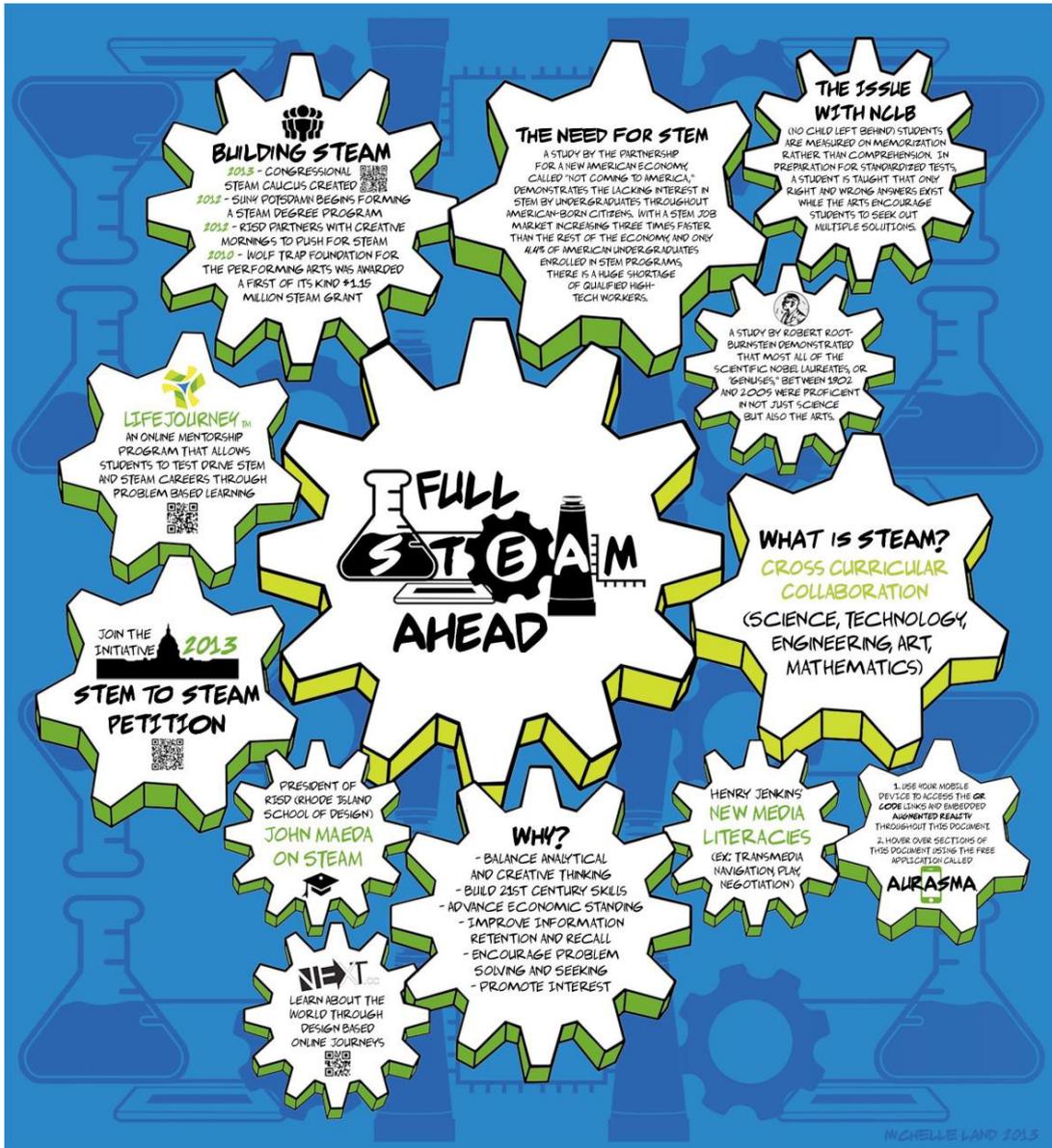


Fig. 1. Full STEAM Ahead poster, originally printed 44" x 48"

## 7. Conclusion

STEM education was created to educate a more realized youth with the high-tech skills necessary for the expanding STEM job market. Professionals across the board appreciate this effort, but even with a focus on STEM, recent graduates do not have the innovative spirit and drive to advance the United States forward. In the end, education should be about the students. The STEAM initiative offers students more than high-tech skills. Complex systems and solutions are conceptualized and designed with predominately analytical skills but ultimately desire to be transitioned into implemented and fielded capabilities providing business/mission value which require more creative skills. The integration of arts and sciences produces a unique skill set that can improve these transitional outcomes. Having the ability to simultaneously decompose a complex problem using convergent thinking and then apply the corresponding solution to the real world uses divergent thinking. Integrating the arts into the STEM curriculum provides pathways for personal-meaning making and self-motivation. Students are able to construct their own learning and go *full STEAM ahead*.

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