STEM ART EDUCATION MOVEMENT
A creative approach to education in innovation for the 21st Century

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Abstract

The science, technology, engineering and math (STEM) movement has its roots back to Dwight D. Eisenhower, and the formation of NASA and NSF in 1958. The STEM Arts movement is a response, collage, and remix, of previous art education theories and STEM education concepts derived since that time. The STEM arts movement seeks to inspire youth with the multi-modal skills to inspire the next generation of innovators and global citizens. In this paper, I seek to draw a model of evolution in innovative education promoted by governments, corporations and ultimately American pride. However, several concerns still face the nation in the new era of Innovate + Educate, in the wake of the Bush era, "No child left behind" act. A new kind of social ethics confronts educators in the classroom as they teach STEM subjects to technically savvy students who are asked to use antiquated methods of technology, while students are asked to power off the most profound technological/information revolution in history. With increased population, saturation (technology/media) overload, climate change and globalization facing student populations, an approach to teaching innovation to youth in the 21st Century needs to be done with an expanded approach to STEM education, including multi-cultural, civic building practices in cyber, electronic, digital and mobile arts.

STEM Art Education Movement: A creative approach to education in innovation for the 21st Century

History of STEM Education

The Science, Technology, Engineering and Math (STEM) education movement was initially promoted by NASA (National Aeronautics and Space Administration) education public outreach program in the early part of the 21st Century. The program was started with the goal to increase student achievement and education in STEM subjects, expanding opportunities for potential future generation of NASA and advanced laboratory employees. Even President Obama recently announced additional focus on STEM subjects in his recent address of the nation in January of 2011. During his speech he unveiled his new STEM education plan, Innovate + Educate which includes several corporate partners.

However this concept is not a *new* approach to education, in fact the STEM education movement has its roots in an education movement similarly linked to innovation in the late 1950's during the height of the space race. Dwight D. Eisenhower constructed and promoted the National Aeronautics and Space Act of 1958. In this act, there were provisions to encourage students to focus studies at government funded universities in science, math, engineering and technology development. The students who participated in these programs not only participated in these expanding government agencies at the height of the space race, but they also helped catalyze the late industrial, digital technology and mass media revolutions as they entered the global market.

Ideas from the Space Race education era impacted art education encouraging instructors to integrate art with inquiry of other subjects, expanding student understanding. According to (Lowenfeild, 1975) "For children, art is a way of learning and not something to be learned."

With this approach, the student is taught to see from different perspectives, encouraged to ask questions, discover and explore through art, the subject at hand. As (Lowenfeild, 1975) explains, "the development of creative thinking has tremendous importance for us, both as individuals and as a society."(Lowenfeild, 1975)

Inquiry and integrated subject based art education models arose from an increase national pride in the United States position as leader of scientific and technological innovations. Most importantly the approach has the opportunity to expand the potential for students to fully understand multi-modal concepts which link STEM education to innovation.

> The term STEM was coined by Dr. Judith Ramaley when she was assistant director of the education and human resources directorate at the National Science Foundation (NSF) from 2001 to 2004 (Chute [2], 2009). Ramaley's concept of STEM situates learning in the context of solving real world problems or creating new opportunities—pursuit of innovation. Spurred by a public and private sector push for global competitiveness, STEM has become a lightning rod for education in 2010.(Brazell, 2010)

In order to fully analyze the STEM arts education movement, we must first confront historical perspectives with current challenges and issues facing the students we wish to educate. I believe important cultural, social and ethical issues beyond sparking innovation, face our youth today. STEM education is significant to the future of our nation's economy; however it must be approached with critical awareness of rising global issues in the 21st Century. "Creativity must be supported, but at the same time guided into socially acceptable channels" (Lowenfeild, 1975)

Dr. Schiavelli suggests, "Engaging and rigorous undergraduate STEM education provides the foundation for the STEM workforce, for advanced study, for well-prepared K-12

teachers, and for an educated 21st century citizenry." However, encouraging our students to even consider STEM undergraduate degrees is proving to be a challenge, in the age of cheap and accessible media and technology, overloading our circuits, giving rise to a new set of factors influencing education.

The 21st Century challenge: STEM education vs. saturation overload and the consumptive western lifestyle

Today, the concept is *Innovate + Educate*, and the drive is to re-catalyze the emerging youth into a generation of innovators again. Since the 1990's, we have fallen behind in exporting technology; now America is the leading consumer, (not developer) of technology products. And recent reports show us losing the race for generating income through development of innovative technologies.

> In broader terms, the US share of global exports has fallen in the past 20 years from 30% to 17%, while the share for emerging countries in Asia grew from 7% to 27%. The United States now has a negative trade balance even for high-technology products. That deficit raises concern about our competitive ability in important areas of technology.(Sciences, 2005)

With expanding globalization, and international corporate agendas, innovative technologies and products are being invented and produced increasingly outside the United States. Have American students lost the ability to invent, in the wake of their consumptive lifestyles? Has media and technology saturation in our culture distracted us from our inventive skills?

> Innovation begins with the talent, knowledge and creative thinking of a workforce. High-quality STEM education and learning environments that prize innovation and imagination produce graduates who will germinate new inventions, develop new products, and create new solutions to many of our world's most pressing problems. (Schiavelli, 2008)

The *Innovate + Educate* program hopes to expand educational opportunities for United States youth in order to stimulate the next phase of innovation, further sparking the economy and creating a sustainable position for the U.S. in the global economy as a leader in design, development and manufacture of innovative products.

Dr. Schiavelli suggests in his essay, *Innovation stems from scientifically educated workforce,* that the United States future economy is directly correlated to STEM education.

> "STEM is now, and will increasingly be, the universal languages of the global marketplace. The nations that invest heavily in STEM education, research and the development of a skilled workforce will enjoy leadership positions. American students, however, are falling behind in the essential subjects of math and science, putting our position in the global economy at risk."(Schiavelli, 2008)

A decade ago, we could have said that the United States was the main consumer; however, with growing globalization from emergent industrialized nations, who are rapidly overtaking our consumptive lead as the new consumer middle class through urban manufacture centers in Asia, India, Latin America, the Middle East. Can we afford to continue to promote lifestyles of techno-consumerism?

American youth continue to be susceptible to dumbing down as a result of increased technology and media consumption, and less media and technology development in the U.S.,

thus fostering an education gap for students in STEM career paths. Is this problem going to be a global epidemic? What are the implications for innovation when compared to consumerism, factored by globalization?

A growing concern is that these youth are not learning how to manage their technology time wisely, many are overwhelmed, with thumbs rapid firing text messages on thier phone, while pale lights flicker on the screen, as users bounce between email, Netflix, Facebook, Twitter and a plethora of games, challenging the idea of multitasking.

In today's society, youth are struggling to keep up with technology, media, data, and its impacts on education are just starting to be realized by leading psychologist and researchers.

> Attention deficit trait is characterized by ADD's negative symptoms. Rather than being rooted in genetics, however, ADT is purely a response to the hyperkinetic environment in which we live. Indeed, modern culture all but requires many of us to develop ADT. Never in history has the human brain been asked to track so many data points. (Hallowell, 2005.)

As researchers begin to understand the impacts of technology, media and the information age on society, it is important that educators aiming to teach technology also implement techniques which promote healthy attitudes, habits and engagement in context with the digital generation.

The 21st Century Challenge: Population, Environment and Globalization

Another aspect to consider is the expanding human population including the growing youth population. Social, cultural, environmental issues and concerns must be considered when developing STEM education programs, so we can better prepare our students to "21st Century Citizenry" as Dr. Schiavelli suggests.

> What does it mean to be connected, connected electronically; to consume, consume indiscriminately, to multitask, multitask neurotically; to exist and find purpose solely within the parameters of technologically mediated culture? What is the saturation point, the point at which the body is overwhelmed and anesthetized by technological efficiency; the point of unrelenting pleasure at the expense of criticality; at what point should the sublime ideology of technology be held in check?(Sweeny, 2010b)

As the digital generation becomes increasingly connected researchers also wonder how this will impact global society, culture and environment. In fact, with Facebook reaching millions of users globally, the globalization of social media has transformed the younger generation into media savvy global communicators.

For example, youth in the Middle East choose to use social media and technologies in ways which catalyze change, they deem necessary as a result of generational population explosion exacerbated by a lack of social justice. Entire revolutions are being planned online, by the dominant cyber generation. Preparing students to respond to these kinds of social pressures, will likely require diverse approaches for learning, expanding educational opportunities for subjects and subject matter among multi-cultural communities.

Educators are starting to incorporate social justice inquiry into their STEM education curriculum, incorporating multi-modal uses of technology, as immersive educational techniques of inquiry in STEM arts. “One of Marya Spont’s favorite convention workshops was one which encouraged her to consider using the work of contemporary artists who deal with issues of torture and terror to engender empathy in her students”(Smith, 2009) Digital, media narratives allow students the opportunity to reflect and comment on social issues and develop empathy within a creative and constructive medium, expanding their voice, often encouraging additional

participation. A method well supported by the DBAE arts education movement which can also be seen as an influence in STEM arts.

June McFee explains, “mass media is a major factor to consider in social change.”(McFee, 1998) Because, “mass media, at present, is making shallow use of the arts to present a picture of the good life which centers around the use of its products.”(McFee, 1998) So how do educators engage in teaching their students to be creative, and innovative with respect to ethical, multi-cultural and social values within a defining modern middle class? And how do we teach our future innovators to create culturally and globally sensitive products and technologies accessible to diverse and local populations? I believe these goals can be reached through an integrated approach of STEM and Art education.

Evolution into STEM Arts Education

Many educators today are proposing interdisciplinary approaches to integrating subjects like STEM and the Arts. These concepts are being revitalized by our current STEM Arts Education advocates working with scientists and artists using digital arts, electronic, mobile and cyber-media to facilitate expanded educational opportunities. “Recent interdisciplinary studies linking the arts or relating art to science have their roots in earlier concepts of correlated and integrated arts.” (Chapman 1978)

Teaching students to be innovative in STEM subjects requires the ability to be creative, with process, technique and skill. It requires students to develop critical thinking, multi-modal, and scientific methodologies, applicable to tactile and tangible problem solving, in real-time, real world situations. For example, Dr. Sweeny explains how videogames have the ability to impact education, precisely fostering the skills needed for STEM concept building in innovation.

> A discussion of the multiple modalities of videogames-specifically how the visual relates to spatial, interpersonal, logical, linguistic, and kinesthetic modes-allows for connections with critical theory, film theory, gender studies, and art educational practices to be made, perhaps clarifying the potential for videogames in the art classroom. (Sweeny, 2010a)

Educators are finding that a unique approach to teaching STEM through immersion of arts is fostering desired skills for an innovative workforce. However, STEM education without the arts simply encourages an education gap in the students' ability to innovate, because they lack creative skills for innovation which are obtained through practice and inquiry through the arts process. "Indeed, when the Bauhaus philosophy is practiced seriously, children's experiments with art media are quite deliberate and in the spirit of scientific experimentation.(Chapman, 1978)

> Researchers have also found a strong relationship between instruction in the arts and learning mathematical skills and improving student observational skills in science. According to one study, students who studied music showed improved spatial temporal-reasoning skills, which helped them later learn math concepts. {Graziano, Critical Links) In another study researchers found that students who studied art were able to apply the observational skills that they had learned to view critically a painting to observing a science experiment. (Tishman, Critical Links).(Platz, 2008)

It is clear, that new approaches integrating arts and science are leading the way for the STEM arts movement, defining the future of innovation in the United States.

Benefits to STEM Arts Integration

This unique concept incorporates STEM subjects through immersion in an arts practice, and inquiry, fostering greater understanding of the STEM concepts explored. Incorporating STEM and the arts allows the instructor to include multi-cultural discussions about society, culture, environment and ethics within a critically engaged activity which gives students practical skills in STEM subjects and concepts.

There are several recent advocates for incorporating arts into STEM education, and many of these movements are utilizing Media Arts, and Electronic Arts as a means to exploring STEM arts education. The STEM arts movement focuses on theories of creative and inventive development through an inter-disciplinary approach to arts and STEM subjects.

It is believed that the exploration of STEM subjects through the arts allows for greater understanding by students of STEM subjects. Students also gain valuable skills in construction of art, critical thinking, ethics, aesthetics, technique and style within the practice of STEM arts, which can lend its self to innovation.

"Integration also benefits teachers. "Having students express their understanding of science in multiple ways gives the teachers insight into what students understand and don't understand about science," says Donna Sterling, professor of science education at George Mason University in Fairfax County, Virginia." (Shapiro, January 2010)

"To communicate with these students, educators must acquaint themselves with electronic products." (Sweeny, 2010b) How can educators be expected to teach children how to use, develop and invent technology, without knowing how to use, develop, invent or teach the technology themselves? Even more alarming, some teachers and schools minimize the use of readily accessible technology in schools to "protect" children.

Thankfully, research of technology in the classroom proves skeptics wrong. “Moreover, research has shown that the development of technology and advanced devices has strongly motivated the students to learn art.” (e.g., Boughton & Wang, 2002; Dorn, Madeja, & Sabol, 2004; Freedman, 2003; Wang 2004).(Sweeny, 2010b)

Platz advocates for the inclusion of Arts within a STEM education program, explaining how emerging companies require employees to be skilled in multiple artistic disciplines, with an increasing demand for media, technology and cyber arts.

“Music and the arts are essential educational components for all students to learn, including students who are pursuing careers in the STEM areas. Educational opportunities in music and the arts first and foremost prepare students for competitive careers in the $316 billion communication, entertainment, and technology industries as musicians, artists, dancers, actors, directors, choreographers, videographers, graphic designers, architects, photographers, designers, film makers, arts administrators, and other professions.”(Platz, 2008)

The STEM arts movement incorporates several different arts education and STEM education techniques creating a diverse approach to STEM education through the Arts fostering innovative society. The approach today includes at least two progressive approaches in learning, that of cyber and immersive education. The following area of my paper focuses on the current forms of STEM arts movement and their inclusion of cyber, and immersive STEM education.

STEM Arts Education: Cyber, Electronic, Digital and Mobile Arts Education for STEM learning

“Cyberspace creates a condition of hyperreality or simulations of reality that provide children with heightened aesthetic gratifications, a situation forcing educators to redefine the notion of literacy.” (Sweeny, 2010b) Cyber-education incorporates immersive education

techniques as a basic function of its implementation naturally. Media and technology literacy are raising the bar for students, driving cyber, electronic, digital and mobile literacy as essential for students entering and eventually competing in the global economy.

However districts, administrators and teachers encourage students to "power-off" their mobile and personal data devices, instead of utilizing this technology in the class room.

> By contrast, the cell phone is the quintessential technology of today's mobile generation. As reported in the CTIA 's 2008 survey, "cell phones are essential to students' lives." Unfortunately, schools are waging a battle—a battle they are losing and should lose—against cell phones. (C. Norris, Elliot Soloway., 2010)

Finding creative ways to utilize the popular technology, and incorporate youth interest promotes student achievement as a result of correlating personal ownership values as incentives for participation in learning.

"You can take this prediction to the bank: Within five years, each and every K12 student, in each and every grade, in each and every school in the United States will be using a mobile learning device, 24/7." (C. Norris, Elliot Soloway, 2010) So what is the real issue with mobile devices in the schools? Likely it is the lack of technology ethics and etiquette that disturbs the learning environment, therefore little tolerance for radical and practical exploration of the new technology is accepted. However researchers have pointed out, that these devices if used properly, can be effective learning tools, expanding access to an expanding diverse population.

> Turn off the voice and texting functions, and 95 percent of the school headaches go away. Students can then use the cell phones as powerful computing devices. Mobile devices will do for student-centric K12 what desktops and laptops have done for adult-centric industries. (C. Norris, Elliot Soloway., 2010)

STEM Arts Education: (iED) Immersive Education

The Merriam Webster dictionary's third definition of "immersion" relates directly to education and states,

> **im·mer·sion :** the act of immersing or the state of being immersed: as
>
> c : instruction based on extensive exposure to surroundings or conditions that are native or pertinent to the object of study; especially : foreign language instruction in which only the language being taught is used <learned French through immersion. (Immersion, 2011)

> Evidence supports the use of instructional practices that address the unique and varied ways that people learn. Young people thrive in environments that provide multiple means of accessing information and knowledge, supported by content that is presented in multiple formats. Advances in multimedia technology provide students with opportunities to use digital media to gain and share knowledge and work collaboratively on projects with their peers. (Marentette)

At Science Discovery of the University of Colorado at Boulder, children dress up in beekeeping protective gear and interact directly with a live bee hive, in the class Secrets of the Hive. Students also dissect captured bees (worker and drones) and dissect flowers to learn about pollination. Students also participate in a honey taste test, make candles and participate in various other beekeeping activities, immersing them in the art and science of beekeeping.

It appears that incorporating immersive educational opportunities with STEM arts, specifically, multi-modal techniques like cyber, digital, electronic and media arts expands learning opportunities and comprehension beyond basic STEM education. Programs incorporating video game development, multi-media, and digital fulldome education are just a few examples of cutting edge opportunities using immersive learning tools, today.

Conclusion: Current STEM Arts Programs and Philosophies in the United States

There are several small programs leading the STEM Arts education movement across a few scattered states in the U.S. None of the programs are national programs, however a few like STEAM are gaining national attention. John Maeda, President of the Rhode Island School of Design (RISD) is the founder of the STEAM program, which was recently funded by the National Science Foundation (NSF) to host a "forum to imagine, explore and invent ways to enhance Science, Technology, Engineering and Mathematics learning through the infusion of Art and Design thinking:" according to the STEMtoSTEM.org website.

ArtSTEM is an organization with the mission of teaching and learning at the intersection of the arts and STEM discipline. Mike Wakeford is the director of the program, encouraging collaborations between University of North Carolina School of the Arts (UNSCA) and RJ Reynolds High School, a local public school collaborating in the educational project. Several of the projects funded through the ArtSTEM program incorporate aspects of communication, entertainment and technology industries.

Another program, STEM Arts is located in Taos, New Mexico where the owner Agnes Chavez is focused on "Creating hybrids: dissolving boundaries between Art, Science and Technology." In Taos, Agnes invites artists to share their art with local schools, giving in-depth workshops to students in STEM Arts. This company is less than two years old, and is currently under development, with no clear future defined. With so many programs, it is exciting to see how all the movements are moving. This is the only model which is not a currently listed as a non-profit.

Technology, Engineering, Arts, Math and Science (TEAMS) is an acronym created by Dr. Judith Ramaley of NSF. TEAMS programs advocate for the inclusion of arts within STEM learning. Although many schools are listed at TEAMS schools across the United States, the

program was not scaled up to create a regional or national program. Rather the idea has instead catalyzed several other STEM arts programs, including my own.

In 2004 I worked at the Laboratory for Atmospheric and Space Physics (LASP) at CU Boulder on the Student Dust Counter for the New Horizons Mission to Pluto. I was an integral part of the project team, documenting the instrument build, and also creating educational media to share with schools and NASA online. It was at LASP that I stated to question STEM education philosophy without the arts. As I worked for this STEM education project, I realized that I was the translator, that without my artistic collaboration, the learning could not be disseminated to the public.

Science, Technology, Engineering and Math through Art (STEM-A) was started by myself in 2009. I first wrote about STEM education and the Arts in 2005 in a paper titled, "The inherent American design flaw in education youth in Science, Technology, Engineering and Math (STEM). Since that time I have been developing, researching and teaching the STEM-A concept and theory, exploring the immersion of STEM concepts through arts education.

Conclusion: Summary

In the 21st Century, students need to acquire skills to help make them competitive in the global market, while allowing them to be educated in multi-cultural, technology and ecology ethics, fostering a humanist approach to global citizenry. STEM education alone cannot support the future of American education in the digital age. The inclusion of arts within STEM education fosters greater opportunities for youth in STEM careers as innovators of new globally conscious markets. In the age of capitalization, climate change, and expanding population; regaining our lead as an "Innovation Nation" needs to done with vigilance to global moral virtue. STEM art

education creates opportunities for innovative youth to develop sedulous practices in innovation beyond economy.

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