The Prospect of an "A" in STEM Education

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Introduction

Although the roots of the science, technology, engineering, and mathematics (STEM) movement date back to President Dwight D. Eisenhower, and the formation of NASA and NSF in 1958, the acronym STEM was coined by Dr. Judith Ramaley, assistant director of the Education and Human Resources Directorate, at NSF in 2001 (Chute, 2009). She defined STEM as an educational inquiry where learning was placed in context, where students solved real-world problems and created opportunities—the pursuit of innovation.

STEM education has since become perhaps the largest reform movement in PK-12 education over the last decade. It seems that everywhere you look there are stories about STEM education. Politicians are promoting STEM, federal and state agencies are promoting and funding STEM initiatives, for-profit and non-profit groups are discussing the importance of STEM education and corporations, and the media are promoting the idea, as well (Puffenberger, 2010). Within these education, media, corporate and policy circles, the acronym STEM has become commonplace. It is used frequently when referring to a broad area of scholarship and instruction that many deem particularly connected (i.e., those four subjects). Whether the acronym is understood and fashionable outside these education groups is not well known. What is known is that the acronym and associated term is not well-defined, even within groups that make heavy use of it (Storksdieck, 2011).

It is not clear whether, when referring to STEM, individuals are addressing any of the four subjects or those areas in which all four disciplines overlap (Storksdieck, 2011). Casual conversations with many professionals in science, technology, engineering and mathematics will quickly reveal a great deal of confusion and a sense that most individuals referring to STEM are really speaking of science or technology or engineering or mathematics individually. To be fair, there are some efforts under way, including a Promising Practices study at the National Academies, where researchers are attempting to explore whether education can benefit when the four disciplines are linked.

The rationale for increased emphasis in STEM education is driven largely by lackluster national assessments of PK-12 students over the last decade or two. These assessments continue to indicate that the United States is failing to compete with other countries when it comes to student performance and interest in STEM subject areas. The argument for STEM education is that if the U.S. is to compete with other nations, our children must be well-versed in 21st century workforce skills related to STEM education. We are also often reminded that a lack of investiture in STEM will have dire consequences for the economic and political power of the United States (Puffenberger, 2010).

White (n.d.) suggests that, in addition to STEM, the future of the U.S. economy rests on its ability to be a leader in the innovation that will be essential in creating the new industries and jobs that will be at the heart of our new economy. Where the U.S. has historically ranked first in innovation, it now ranks between third and eighth, depending on the survey (White, n.d.). Nationally, we have taken steps to reverse this slide by embracing and funding much needed improvements in STEM education (White, n.d.). When American education is in crisis, policy makers and educational leaders roll out the STEM argument, that the science, technology, engineering and math curriculum needs to be emphasized as the cornerstone of U.S. competitiveness in a world where Chinese students do lightening drills on the periodic table of elements at age 4 (White, n.d.). There is certainly no question that STEM education and STEM skills are a vital part of this country's perceived edge, but many educators would argue that STEM is missing a key set of creativity-related components that are equally critical to fostering a competitive and innovative workforce, and those skills are summarized under the letter "A" for Arts (White, 2011).

A Place for the Arts

Like technology education, arts education has always struggled with a tenuous position in PK-12 education. Often the arts have been considered a luxury in public schools-- an arena for self-expression, perhaps, but not a vital part of education. A sense of elitism clings to the teaching of the arts. Many schools regard the arts as special subjects to be pursued by a privileged or talented few. In very early times, the arts were either learned through group rituals that were an integral part of worship or taught to a selected few through arduous apprenticeship. While some societies regarded knowledge of the arts as the privilege of the social elite, others believed that the arts were subjects fit only for slaves and the children of artisans (Eisner, 2004). The conflicted history of art education in modern American schools is surprisingly similar to the history of technology education. Lewis (2004) noted that in the long march from manual training, the subject which today we call technology education has always had to contend with the question of its legitimacy as valid school knowledge. In this regard, it shares a similar history of struggle with other subjects (like art) whose initial entry into the curriculum was based on a utilitarian rather than an academic rationale.

As early as 1960, Snow (1960) wrote about the *Two Cultures* in education where the scientists and perhaps mathematicians were on one side and the other subject matter specialists on the other. Even though the individuals in the various fields were comparable in intelligence, comparable in ethnicity, not grossly different in social origin, and earned about the same salary, they had almost ceased to communicate at all (Snow, 1960). Between the two cultures existed a gulf of mutual incomprehension and sometimes, particularly among the young, hostility and dislike, but most of all there was a lack of understanding. Professionals in these disconnected fields have a curious distorted image of each other (Snow, 1960). In an effort to illustrate the gulf between the scientific disciplines and the non-scientific disciplines, Snow shared the following:

> "I have learned the story attributed to A. L. Smith- came over to Cambridge to dine. The date is perhaps the 1890's. I think it must have been at St John's, or possibly Trinity. Anyway, Smith was sitting at the right hand of the president – or Vice Master – and he was a man who liked to include all round him in the conversation, although he was not immediately encouraged by the expressions of his neighbours. He addressed some cheerful Oxonian chit-chat at the one opposite to him, and got grunt. He then tried the man on his own right hand and got another grunt. Then, rather to his surprise, one looked at the other and said, *'Do you know what he's talking about?' 'I haven't the least idea.'* At this, even Smith was getting out of his depth. But the President, acting as a social emollient, put him at ease by saying, *'Oh, those are mathematicians! We never talk to them"* (p. 2).

The gulf between academic and applied disciplines in PK-12 schools has grown unchecked for more than a century. In some cases, educators have seemed to take pleasure that their particular discipline held little in common with the other fields of study represented in the school curriculum. Ellis (2011) noted that educational silos developed early in American educational institutions as a method of control and a mechanism for wrestling the largest share of limited resources for those subject areas deemed to be most important to the various stakeholders. Linton (2009) noted that the "silo effect" in educational institutions and the academic isolation that results, goes against human nature. He further noted that student interaction with individuals and ideas from other fields can increase knowledge and insights, as well as lead to more productive and effective conclusions.

The divide between the disciplines has been exacerbated by the federal No Child Left Behind legislation that was passed in 2001 to improve school performance by setting standards of accountability. With mandated, standardized tests in mathematics, reading and language arts administered each year, the focus of PK-12 schools shifted to improving test scores in these areas, since negative consequences resulted for the school if scores did not achieve specified levels (Hetland et al, 2007). The result is even less support for the arts, as well as other non-assessed subject fields, in many of our schools than there had been in the past.

In reaction to the progressively weakened position of the arts in public schools, arts advocates have tried to make the case that the arts are important because they improve students' performance in traditional academic subjects, such as reading and mathematics. Believing that educational decision makers would not accept arguments based on the inherent value of arts learning, arts advocates have skirted the fundamental question of the core benefits of studying the arts and fallen back on the bonus effects of arts education as a justification (Hetland, et al, 2007). As with technology education, scant empirical, or even theoretical, evidence has been available to support such arguments.

Storksdieck (2011) noted two major arguments for increased arts in PK-12 education. The first argument refers to art as a way of knowing and learning that will expand the toolbox of STEM. For example, he suggested that art can provide a useful tool in engineering as researchers attempt to make products and systems more appealing, acceptable, and useful to people. Similarly, Storksdieck noted that in science, art can be seen as a different way of seeing the world, or a heuristic that leads to a different understanding of the world. The second claim is based on the limitations of scientific research and engineering design. Art, in this view, is a means to free the scientist's and engineer's mind and infuse a degree of creativity and innovation (Storksdieck). That same level of creativity and innovation is then seen as equally valuable to understanding science and applying engineering concepts outside the direct confines of those professional fields. Art-infused instruction may allow students, who have no particular interest in becoming a professional engineer or scientist, to understand and apply those concepts more readily to other endeavors.

White (n.d.) supported the second argument for increased arts participation in STEM education when he noted that STEM is based on skills generally using the left half of the brain and thus, is logic driven, while research suggests that the arts expand the right hemisphere of the brain where creativity and innovation are fostered. He went on to imply that the combination of STEM education with arts education (STEAM) would provide a curriculum that offered the best chance for regaining the innovation leadership essential to the new economy (White, n.d.). Arne Duncan, U.S. Secretary of Education, expanded upon this claim when he noted that:

> "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" (PCAH, 2011, p. 3).

A research study conducted by McGrath & Brown (2005) proposed that the visual arts had real potential to improve cognition in STEM education. Their research findings illustrated that visual learning is an important method for exploiting students' visual senses to enhance learning and engage the higher cognitive parts of the brain. By thinking and communicating visually, students in their study improved how they performed during experimental research tests. Other recent research also supports the connection between the arts, creativity and workplace readiness. In 2008, The Conference Board and Americans for the Arts, in association with the American Association of School Administrators, conducted a survey of 244 corporate executives and school superintendents in an attempt to define the role of creativity. The study, called "Ready to Innovate," demonstrated that companies are looking for employees that exhibit the creativity provided by the arts. The findings indicated that companies want employees who can identify problems, identify new patterns, integrate knowledge across disciplines, originate new ideas, and work with a fundamental curiosity (Lichtenberg, et al, 2008). Strikingly, the findings also noted that over 63 percent of the employers surveyed indicated that they prefer the creative employee to the employee with technical skills related to the job (Lichtenberg, et al, 2008). Similarly, both the superintendents who educate future workers and the employers who hire them agree that creativity is increasingly important in U.S. workplaces (83 percent and 61 percent, respectively), and that arts training are crucial to developing creativity (Lichtenberg, et al, 2008). Yet, there is a gap between understanding the need for creative employees and putting into place education and training systems that result in creative employees. The research findings also point out that most high schools and employers provided such education and training only on an elective or as-needed basis (Lichtenberg, et al, 2008). Given the results of this study, it seems that the arts have a case to make for a greater integration into all programs that advocate creativity as a goal.

The "Ready to Innovate" study, the Americans for the Arts 2007 National Policy Roundtable (where the "Ready to Innovate" study was first unveiled), and other similar studies have led many to suggest that STEM should be amended to STEAM. While there are plenty of detractors who suggest that if you add art to STEM you might as well add everything else (history, language arts, philosophy, etc), there is a specific learning theory that those who talk about STEAM have in mind when adding arts to STEM (Storksdieck, 2011). Root-Bernstein (2011) observed that while many people are at a loss to identify useful connections between the arts and STEM, it should be noted that the arts provide innovations through analogies, models, skills, structures, techniques, methods, and knowledge. Arts don't just make science pretty or technology more aesthetic, they often make both possible (Root-Bernstein, 2011). Root-Bernstein went on to provide common examples where art made science and technology a reality:

- Modern cell phones and PDA's use a form of encryption called frequency hopping to ensure your messages cannot easily be intercepted. Frequency hopping was invented by the composer George Antheil in collaboration with the actress Hedy Lamarr.
- Electronic display screens employ a combination of red, green and blue dots from which all the different colors can be generated. That innovation was the collaboration of a series of painter-scientists and post-impressionist artists like Seurat.
- The first programmable device was invented by J. M. Jacquard to control the looms that made his tapestries. The same technique was used to program the first computers.
- Computer chips are made using a combination of three classic artistic inventions: etching, silk screen printing and photolithography.
- Camouflage was invented by the American painter Abbot Thayer, who was unable to convince Teddy Roosevelt to use it in the Spanish American War. By World War I, however, painters like the Vorticists in England and the Cubists in France were co-opted by their governments to design prints to protect troops, equipment, and planes (Root-Bernstein, 2011).

There's a long tradition of artists-turned-inventors in the U.S. For example, Samuel Morse and Robert Fulton were among the most prominent American artists before they invented their ground-breaking devices, respectively the telegraph and the steam ship. Root-Bernstein (2011) recently published a study illustrating the connections between Nobel laureates in the sciences and engagement in the arts as adults. Nobel laureates in the sciences are 25 times as likely as the average scientist to sing, dance or act, 17 times as likely to be an artist, 12 times more likely to write poetry and literature, eight times more likely to do woodworking or some other craft, four times as likely to be a musician, and twice as likely to be a photographer. Many connect their art with their scientific creativity (Root-Bernstein, 2011).

White (n.d.) contends that art ability in the 21st century actually applies to a larger, broader segment of the workforce than skills commonly associated with STEM. America's competitiveness is distinguished by its productivity in creative industries and exports, from movies, television and games to architecture and the myriad of individuals who use their imagination to create new products and services. In his 2002 publication, *The Rise of the Creative Class*, sociologist Richard Florida noted that approximately 30 percent of the U.S. workforce or 40 million Americans, create for a living (Florida, 2002). In contrast, a quick look at NSF statistics indicates that science and engineering makes up approximately 10 to 12 percent of the U.S. workforce (White, n.d.).

Jakus (2011) affirmed that he believed a well-developed STEM/Arts partnership is essential for optimal innovation in U.S. education and economics. He maintained that a strong STEM/Arts partnership can provide educational and economic policymakers with a balanced approach that was not available to the relatively small, but intense, corps of theoreticians, experts and clever investors that led humankind to make the unbelievable technological advances we have witnessed in recent generations. A STEM/Arts partnership can lead to a more effective application of engineering and math skills and knowledge to promote the pursuit of life, liberty and happiness for the long-term (Jakus, 2011). Storksdieck (2011) supported this assertion when he noted that those in the STEM field should take a cue from those in the humanities field and have at least one thing that stimulates their creativity and imagination. Further support was added by White (n.d.), who noted that the mission is to make the country aware that arts are not just a *nice* thing to have in the educational systems, but rather they are an essential national priority to the future of the U.S. in this rapidly changing global economy.

Responding to concerns that the U.S. risks lagging behind other nations in both the scientific literacy and the innovative capacity of its workforce, the Art of Science Learning project (an NSF supported research project) convened scientists, artists, educators, business leaders, researchers and policymakers in three conferences in the spring of 2011 to explore how the arts can be engaged to strengthen STEM education and spark creativity in the 21st-century American workforce (Storksdieck, 2011).

Studio Thinking

Although the arts in U.S. schools are classified among the core subjects, and school districts generally identify them as such, there are unresolved issues about their position in the curriculum. No one wants to be regarded as a barbarian, yet at the same time privilege of a residence in the main school hallway is typically assigned to other subject areas. Despite the recent enthusiasm about their contributions to academic performance, the arts are generally regarded as nice, but not necessary (Eisner, 2004, p. xi).

The question of whether or not the arts do more than serve the needs of individuals, as important as such a contribution might be, is yet undeteremined. Eisner (2004) argues that the arts can serve as models of what educational aspiration and practice might be at its very best. The arts have an important role to play in refining our sensory system and cultivating our imaginative abilities. Indeed, the arts provide a kind of permission to pursue other experiences in a particularly focused way and to engage in the exploration of what the imagination might bring. Although many in the arts community seem inclined to promote the inclusion of art in STEM on the basis of its contribution to the core STEM disciplines, the evidence to support such claims is thin. Winner and Cooper (2000) noted that they could find no research-based evidence that studying the arts, either as separate disciplines or infused into the academic curriculum, raises grades in academic subjects or improves performance on standardized verbal and mathematics tests. Warning of the peril associated with basing the study of the arts on improved academic performance, Hetland et al (2007) stated that:

> "Justifying the arts only on instrumental grounds will in the end fail, because instrumental claims for the arts are a double-edged sword. If the arts are given a role in our schools because people believe that arts cause academic improvement, then arts will quickly lose ground if academic improvement does not result, or if the arts prove less effective in improving literacy and numeracy than high-quality, direct instruction in these subjects" (p. 3).

Hetland et al. (2007) additionally maintained that art education should not be justified wholly or primarily in terms of what the arts can do for mathematics or reading, but must stand on what it delivers directly. Also, it seems that art education has a learning heuristic that might have a great deal to offer education in general, and STEM education in particular. Similar to the *engineering design method* in engineering or the *design loop* used in technology education and the *scientific method* used in science classes, art utilizes *studio habits of mind* or *studio thinking* as an experience-based technique for problem solving, learning, investigatio, and discovery. Studio habits of mind refer to eight dispositions used in many academic arenas and in daily life. The dispositions include *Develop craft, Observation, Envisioning, Reflecting, Expressing, Exploring, Engaging and Persisting*, and *Understanding the Art World*.

- *Developing craft* refers to learning to use tools and materials, learning artistic conventions, and studio practice (learning to care for tools, material, and space).
- *Engage and Persist* involves learning to embrace problems of relevance within the art world and/or of personal importance, to develop focus and other mental states conducive to working and persevering at art tasks.
- *Envision* involves learning to picture mentally what cannot be directly observed and imagining possible next steps in making a piece.
- *Express* includes learning to create works that convey an idea, a feeling, or a personal meaning.
- *Observe* addresses learning to attend to visual contexts more closely than ordinary "looking" requires, and thereby to see things that otherwise might not be seen.
- *Reflect* includes both questioning and explaining (thinking and talking with others) and evaluating (judging one's own work and working process, and the work of others in relation to standards of the field).
- *Explore* asks the learner to reach beyond one's capacities, to explore playfully without a pre-conceived plan, and to embrace the opportunity to learn from mistakes and accidents.
- *Understanding the Art World* includes learning about art history and current practice, as well as learning to interact as an artist with other artists and within the broader society (Hetland et. al, p. 6)

Studio thinking includes habits of mind that are important not only for the arts, but most other disciplines, as well. For example, PK-12 students must learn a great deal about tools and materials in a science or technology education lab, and this kind of learning is analogous to the art of studio habit called *Develop Craft*. The disposition to *Engage and Persist* is clearly important in any serious endeavor: Students need to learn to find problems of interest and work with them deeply over sustained periods of time. The disposition *Envi-*

sion is important in the sciences (e.g., generating hypothesis), in history (e.g. developing historical imagination, and in mathematics (e.g., imagining how to represent space and time algorithmically). *Express* is important in any kind of writing that one does. *Observe* is also required across all disciplines. The disposition to *reflect* is also important in any discipline. Similarly, *Explore* emphasizes the need to experiment and take risks, regardless of the discipline of study. *Understand the Art World* has its parallels in other disciplines, in which students are asked to identify links between what they do as students in a particular discipline and what professionals in that field do, have done, and are doing (Hetland et. al, p. 7).

Observe an art class where studio thinking is at the core and you will discover that learning is a great deal more complex than the practice of a craft. It seems probable that studio habits of mind differ from heuristics used in other disciplines only by emphasis. For example, there is likely more attention to express in visual arts than would be found in scienc, or history. Indeed, studio habits of mind should support constructivist or problem-based learning in any discipline in which instruction keeps discipline-centered work as the focus of the lesson and activity. It seems very likely that the STEM disciplines could utilize several components of studio thinking toward the improved delivery of truly integrative STEM education. The studio-thinking heuristic can provide a common language for intellectual growth and would almost certainly complement the tools used in each of the STEM disciplines and may actually extend those learning mechanisms. In *Smart School* (1992), David Perkins outlines two components of learning experiences that educators need to address. Teachers must decide *what* students should learn and *how* to teach them. Studio thinking may be informative in both arenas. Storksdieck (2011) suggested that U.S. schools tend to extract ingenuity from the education process after the first few years of school and replace it with the memorization of facts. This has proven to be a mistake, and many in the art community are now trying to envision STEM education built around and authenticating our native ingenuity through the inclusion of art.

Examples of STEAM

Numerous projects and curriculum initiatives have launched in recent years toward the end of expanding the role of the arts in STEM education. The specific goals of these efforts range widely, but at the core they all focus on the role of creativity, the benefits of interdisciplinary learning, the interconnectivity between disciplinary concepts, the role that knowledge from one discipline might have in learning in the other, and the benefits of a metadiscipline. The STEAM movement is the latest suggested addition to STEM education. By adding the "A" to create STEAM, educators are attempting to reinvigorate the role of creativity and innovation in STEM. Some examples of STEM efforts that include the arts are:

- The Learning Worlds Institute recently launched The Art of Science Learning to explore ways in which the arts can improve learning in the sciences. The project uses hands-on, imaginative approaches, and studio-thinking methods used in the creative arts to attract and retain young people in STEM fields.
- Time Warner Cable's Connect a Million Minds initiative is designed to increase students' awareness and skills in STEM-related fields specifically through the exploration of different media forms. Recently, Time Warner has launched the first of a series of programs they refer to as "Crack the Codes" as a part of their overall Connect a Million Minds initiative. Launched in late March of 2011, the first program was entitled "Cracking the Codes in the Digital World" and was designed to show K-12 students the science behind broadcast technology through on-site visits and meetings with Time Warner staff.
- The Institute for the Study of Knowledge Management in Education (ISKME) recently launched a learning program designed to incorporate the arts into STEM education. One of the lessons, called Sun Curve Design Challenge, is an example of incorporating design and creativity into science learning. The activity, created by San Francisco's INKA Biospheric Systems and inventor-sculptor Paul Giacomantonio, consists of a vertical hydroponic garden attached to a fishpond, along with a sculpture that serves as a scientific laboratory. Student teams, participating in the challenge, design a working model for an affordable and renewable way to grow food.
- Discovery Communications has developed a weekly *Science of the Movies* television show on the Science Channel in an effort to draw connections between STEM and the arts. The hour-long program examines the science of filmmaking through the exploration of a variety of topics including stop-motion animation, sound design and Foley techniques, and computer-generated imaging.
- The National Aeronautics and Space Administration (NASA) recently launched a design activity called *Space School Musical* that calls upon students to produce a musical based on the solar system. NASA provides the song lyrics and 36 activity guides and students produce a theatrical play.
- Science, Technology, Engineering, and Mathematics through Art (STEM-A), a center whose mission is to expand STEM education through arts immersion, recently launched a series of lessons and activities designed to immerse STEM with the arts. For example, Circuit Bending calls on students to modify or hack old toys and discarded electronics low-voltage battery powered musical instruments. Students acting as experimental electronic artists re-appropriate lo-fi, antique digital items for manipulation during live performances.
- CrayonPhysics is a website dedicated to combining technology, ar, and physics in creative ways. The site utilizes Newton's Laws of Motion in a web-based game that helps students design real-time contraptions? Students learn about the relationships of Newton's Laws while watching how their contraption knocks a star off different platforms. Kids solve puzzles while designing innovative, functional, artistic, two-dimensional physical objects. The goal is to help students solve puzzles with artistic and physics creativity.

Conclusions and Recommendations

In education and political circles STEM education has been gathering enormous support in the last decade. Not only has President Obama announced a $250 million public-private initiative to recruit and train more STEM teachers, but also the U.S. Department of Education's *Race to the Top* grants competition is giving bonus points for applications that stress STEM instruction (Piro, 2011). This funding is on top of the nearly $700 million the federal government already spends on science and math education programs within NASA, NSF, and other agencies (Piro, 2011). This financial support is largely being perpetuated on the belief that the U.S. is becoming less competitive and secure—that we are losing our national status in STEM fields. Yet, in the midst of all the interest in STEM education, educational and political leaders may want to invest in programs that promote innovation and creativity, as well as STEM.

In STEM education, learning goals are typically framed as cognitive outcomes—what we want the students to know. However, it may be in the best interest of the STEM movement to consider additional learning goals. Through this paper, numerous authors and studies have been identified that suggest the development of educational programs that engage both the right and left hemispheres of the brain. In his book, *A Whole New Mind,* Daniel Pink (2005) urged readers to foster and strengthen creativity and innovation. He noted that our society is transitioning from the "Information Age," powered by the logical, sequential and analytical left side of the brain, to a "Conceptual Age," powered by the inventive, innovative, and creative right side of the brain.

Generally, STEM education curricula focus on reasoned and clear solutions to the problems of society, while art education curricula typically express uncertainty, ambiguit, and vagueness—an essential foundation of educational experiences focused on the development of creativity and innovation. We need the products of both STEM and art education. There is nothing that prevents us from having both except a false divide that was manufactured more than a century ago—the belief that the arts and the sciences needed to be separated and delivered to different clients.

More than 50 years ago, Snow (1960) lamented the two cultures created by literary intellectuals and artists and the invisible and hostile divide between them. Many have begun to see that the divide is a myth and now work diligently to engage our youth in STEM and art education. While some might argue that adding art education to STEM might open the flood gates to all disciplines and that the arts community is simply attempting to attach itself to a popular STEM movement in PK-12 education, the results do not seem to support that assertion. In their book, *Meeting Standards through Integrated Curriculum* (2004), Drake and Burns offer numerous research reports that illustrate the cumulative positive impact of an integrated curricular approach and vastly improved test scores of students who complete such curricula. If one of the goals of STEM education is to increase innovation and creativity in the U.S., then it makes perfect sense to integrate artistic design, artistic expression, reflectio, and a multi-sensory appeal in the curriculum. It is not clear how such integration should be carried out, whether art should be fully integrated to create a STEAM acronym, or whether art should merely be used to inform STEM education, but it is clear that art education has a great deal to offer the movement.

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