Artistic Ways of Knowing: Thinking Like an Artist in the STEAM Classroom

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1 Introduction

The third graders are learning about the water cycle. Colorful posters display the different stages, from evaporation, transpiration, and condensation to precipitation and run-off. Tables are strewn with art projects depicting these stages and water-filled plastic bags are taped to the window showing signs of evaporation to measure each day.

Instead of sitting at tables, students begin today's class lying on the floor with their eyes closed, listening to *Clouds (Nuages)* by Debussy. After a reflective pause, questions arise. Which part of the water cycle does this music describe? How can we show this through movement? After students gently show the rise of evaporation to the music, they continue realizing the cycle through interpretive movement to *Beethoven's Pastoral Symphony (Storm)* and Smetana's *The Moldau.* The lesson closes as the rapids of the river widen to the ocean, with students swirling around the room personally expressing the water cycle through interpretive movement (Haroutounian 2017).

We can imagine what discussions may arise following this science/arts lesson. How did the music describe a cloud – a storm – a river? How did your movements change from one stage to the next in describing the water cycle? The students were actively engaged in the arts in this lesson while reinforcing their understanding of the water cycle. This STEAM lesson encouraged them to interpret creatively, through movement, how water evolves from gentle evaporation to exciting precipitation and fluid run-off. And it was fun!

The lesson also encouraged students to "think like artists" by listening with focused attention to the music (perceptual awareness and discrimination), internalizing how they would move (metaperception), and creatively moving to interpret

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what the music expresses (creative interpretation – dynamic of performance). As the students critique the activity, they realize how the movements they chose mirrored the concepts they were learning in science.

The educational community is excited about the possibilities that arise when we integrate the arts with STEM fields to create STEAM (Science, Technology, Engineering, Arts, Mathematics). The rationale for including the arts rests on the importance of creative innovation during the problem-solving process within the STEM fields (Quigley and Herro 2016; Wynn and Harris 2012; Guyotte et al. 2015). This fresh approach incorporates creative collaboration across disciplines that challenges students to broaden their perspectives to include somewhat novel answers arising from working through the arts.

Educators have the opportunity to examine *how* children learn through this transdisciplinary process. Students engrossed in the sciences can learn the value of thinking like an artist when working through complex problems. Students in the arts can realize how their unique way of "knowing" can contribute to scientific results.

> *What most of us lack in order to be artists is not the inceptive emotion, nor yet merely technical skill in execution. It is the capacity to work a vague idea and emotion over into terms of some definite medium.* (John Dewey 1934, p. 75)

2 The Arts: An Overview and Rationale for the "A" in STEAM

The role of the arts in education has always been influenced by political fluctuation and pragmatic challenges. During the 1980s to 1990s, most schools offered music and art classes at the elementary level with several classes a week. Secondary school options included orchestra, band, and chorus performance classes with some dance and drama options rounding out the arts presence in schools. Nonperformance options often included humanities classes, which offered an interdisciplinary approach merging history, culture, and the arts. For people educated in the arts during that era, those were decidedly "the good old days."

We now must face the stark reality of the role that arts education holds in the twenty-first century, where only 27 states consider the arts as a core academic subject to even include in the curriculum. Most of these states refer to the arts in general terms rather than delineating the specific artistic domains of music, visual arts, dance, and theater. *A Snapshot of State Policies for Arts Education* (Arts Education Partnership 2014) notes that most states include policies that relate to arts instruction: however, these policies vary widely by discipline and grade level, content, frequency, duration, and qualification for delivery of instruction.

Establishing the voluntary *National Standards for Arts Education* in 1994 provided some guidance for arts educators by creating content standards in the four art domains (music, visual arts, dance, and theater). As the educational climate steered toward "core standards," the arts developed the *National Core Arts Standards* in

2014 (National Coalition for Core Arts Standards 2014). This conceptual framework describes the process of creating, performing/presenting/producing, responding, and connecting. Figure 1 illustrates the National Core Arts Standards Matrix. It is significant that the arts chose to organize their standards by *process*, reflecting the artistic-creative process that is used in artistic ways of knowing, described later in this chapter (Haroutounian 2015, 2016, 2017).

Always on the defensive in proving the value of the arts in American education, multiple studies have linked arts education with achievement in academic areas. Such studies include traditional arts-specific curriculum, as well as arts integration. The Arts Education Partnership (http://www.aep-arts.com) lists 40 studies on their website linking the arts with academic achievement and thinking skills in various areas. A sampling of these studies:

- Music students do better in math, with arts-integrated math instruction facilitating mastery of computation and estimation skills (Courey et al. 2012; Harris 2007; Kinney and Forsythe 2005; Smithrim and Upitis 2005).
- Arts education develops students' critical thinking skills – comparing, hypothesizing, critiquing, and exploring alternative viewpoints (Heath et al. 1998; Montgomerie and Ferguson 1999).
- Students studying the arts score higher than their peers on tests measuring the ability to analyze information and solve complex problems (Costa-Giomi 1999; Korn 2010).

Winner and Hetland's meta-analysis (2000) showed minimal causal relationships between studying the arts and non-arts cognition. However, they explained that "we do not justify the presence of mathematics education by whether such

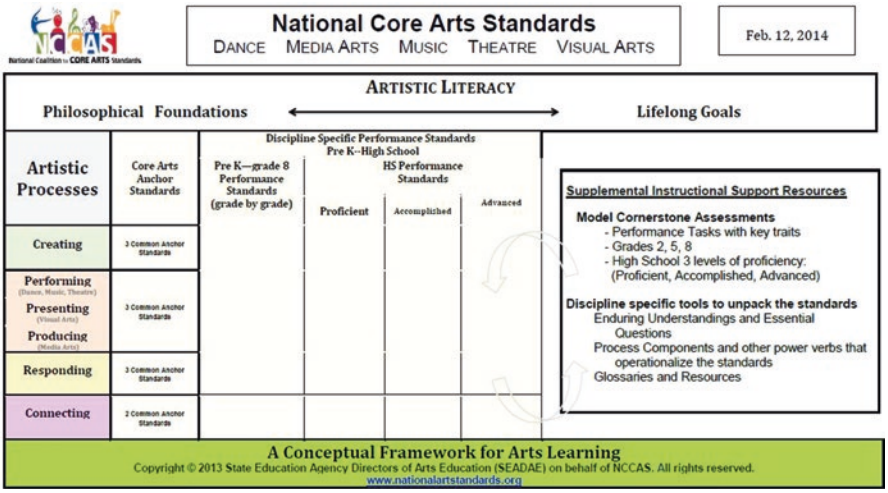

Fig. 1 National Core Arts Standards Matrix. Source: National Coalition for Core Arts Standards, http://www.nationalartsstandards.org/. Used with permission

study leads to stronger skills in English or Latin; nor should we justify the presence of arts education by whether such study leads to stronger skills in traditional academic areas" (Winner and Hetland 2000, p. 7). They conclude that there is a glaring oversight because "there are no studies to document the kinds of thinking that are developed through study of the arts" (Hetland et al. 2007, p. 4). This oversight may be addressed as STEAM research develops, recognizing how artistic ways of knowing play a part in the creative process for artist/student interdisciplinary experiences.

> *Whether work in the arts has consequences that extend to all aspects of the world cannot now be determined with any degree of confidence. What can be determined with a high degree of confidence is that work in the arts evokes, refines, and develops thinking in the arts. We might cautiously reason that meaningful experience in the arts might have some carryover to domains related to the sensory qualities in which the arts participate.* (Elliot Eisner 2002, p. xii)

Influenced again by political/educational priorities, the era of STEM immediately impacted the presence of the arts in American schools. With curricular emphasis on STEM subjects, arts programs were greatly marginalized. Schools devoted more time to STEM subjects by decreasing or eliminating the arts (Wynn and Harris 2012). Music and art classes, the mainstay of elementary arts education, met once a week, if at all. Budgetary limits in low-income schools eased out the arts to include more STEM for this population of students (Sousa and Pilecki 2013).

Used to ongoing pragmatic challenges from those beyond the arts education arena, the arts community forged ahead, offering ideas that are the basics of learning through the arts ("A") to those working in the academic/sciences of STEM. How can the arts make a difference in STEM? How can these "opposites" attract to create a more dynamic education for students? The STEAM literature offers concrete ideas that make sense when developing a transformative project-based curriculum.

Their rationale emphasizes how innovation and creativity are enhanced by meshing learning through the arts with the STEM subject areas (Duncan 2010; Saraniero 2016; Tarnoff 2011). Rather than being total opposites, scientific and artistic processes actually complement each other. Both explore ideas and possibilities and both seek a culminating product/performance.

> *Innovation happens when convergent thinkers, those who march straight ahead toward their goal, combine forces with divergent thinkers – those who professionally wander, who are comfortable being uncomfortable and who look for what is real.* (John Maeda 2012, p. 1)

The arts offer a way to reach outside the box with novel solutions and intriguing new ways of thinking. Imagine the possibilities when divergent thinkers work closely with convergent thinkers, learning from one another. The list below offers comparative descriptors gleaned from the arts and STEM literature that can open up a discussion about the rationale for including the "A" in STEAM (Maeda 2012; Sousa and Pilecki 2013; Thurley 2016; Haroutounian 2015, 2016):

STEAM – opposites attract

Arts	STEM
Subjective, intuitive, perceptive, novel	Objective, logical, analytical, useful
Divergent thinking	Convergent thinking
Creative interpretation and collaboration	Scientific process and research
Problem-finding, critical thinking/ making	Problem-solving, critical thinking

Reviewing the vocabulary of thinking skills and processes on the list above, I see a challenge in future discussions that would be exciting for students who wander, enjoy being uncomfortable, and invigorated by the creative process. It's time to hold hands with your science colleague and search together for what is *real* – shall we dance?

3 STEAM Is Rising

3.1 Early Childhood: A Natural!

What better way to present the idea of STEAM education than with *Elmo the Musical*, appearing in 11-min episodic segments throughout the 43rd season of Sesame Street! Elmo sings and dances while using his imagination to explain math skills such as enumeration, relational concepts, addition/subtraction, and geometric shapes to solve problems. Sesame Street reinforces at-home activities through STEAM-based games and learning tools offered through their website. Rosemarie Truglio, Senior Vice President of Education and Research at Sesame Workshop, explains that "incorporating the arts into our STEM curriculum was an exciting and natural addition, as Sesame Street has always used music, visual and performing arts as tools to education and entertain children" (stemtosteam.org).

Hedda Sharapan worked with Fred Rogers of Mister Rogers' Neighborhood for decades and explains that many early childhood educators feel uncomfortable working with science-related topics. However, the arts are naturally part of early childhood education. "This new term, STEAM, can help early childhood educators to build the foundation of science-related knowledge, using the arts to encourage children to express their ideas in a wide variety of creative ways" (Sharapan 2012, p. 36).

Sharapan shared a STEAM everyday experience between an early childhood teacher and her class of 3-year-olds. The class came into the school after an exceptionally hot playtime outside. She lined them up in the hallway and asked if they felt a difference between the air outside and the air inside. It was a simple question that required a hesitant pause and the answer "It's colder." The everyday experience lesson followed with a discussion of air conditioning, what makes things hot, cold, and how engineers devised a way to create air conditioning. Students created other ways to stay cool making their own fans, feeling the air created through their own "engineering and art." These youngsters experienced authentic learning by paying attention to detail in the world around them.

3.2 K-12 Schools and Programs

The Rhode Island School of Design championed the STEAM movement early on, aligning it with their interest in furthering art and design as an element merged with STEM. Their objectives were to transform research policy to place art and design at the center of STEM, to encourage integration of art and design in K-20 education, and to influence employers to hire artists and designers to drive innovation. The school has connections with many STEAM projects and hosts STEAM conferences to help train teachers. Their website includes a number of case studies of STEAM school programs worth investigating (stemtosteam.org).

Not surprisingly, fresh new STEAM program initiatives in schools are beginning to grow nationwide, sponsored by national and local funding. Here is a sampling of projects emerging in different parts of the country:

Fort Garrison Elementary School (MD) is enjoying a dance-integrated program called "Teaching Science with Dance in Mind" with a goal to show how "dynamically dance can bring deep and complex learning to children" (Robelen 2010, p. 1). The program is sponsored by the nonprofit organization, Hands on Science Outreach. Program Director Rima Faber explains, "The more we teach through dance integration, the more we realize how dynamically it brings deep and complex learning to children" (Robelen 2010, p. 14).

Philadelphia Arts in Education Partnership is working with city schools to help elementary students better understand abstract concepts in science and mathematics (fractions, geometric shapes) through art-making projects, including a "fraction mural" displayed at one school. Education Director Raye Cohen notes that "visual arts just seems to be able to hone in on the concept, taking it from the abstract to the concrete so students are really able to understand it" (Robelen 2010, p. 8). The project has an intensive research component whose findings will be welcome in this new STEAM field.

The Wolf Trap Foundation for the Performing Arts, based in Vienna, VA, has developed early childhood initiatives that blend STEM with the arts. Funded by a 2010 federal Education Department grant and Northrop Grumman, it includes performing artists in theater, music, dance, and puppetry working alongside kindergarten and preschool teachers. Findings from the American Institute for Research study show that arts-integrated methods in early childhood education can increase students' math achievement by providing the equivalent of more than a month of additional learning. Wolf Trap participants outperformed their peers in the Early Math Diagnostic Assessment (EDMA) in 2 consecutive years (American Institute for Research, wolftrap.org, February 16, 2016).

The ArtScience Prize is built around the ideas of Harvard University Professor David Edwards, and the competition has expanded to Boston, Minneapolis, and Oklahoma City as well as international locations. The contest merges abstract concepts in the arts, design, and the sciences. Students work with abstract real-world concepts such as The Future of Water or Virtual Worlds bringing in the field of synthetic biology (Robelen 2011). Carrie Fitzsimmons, Executive Director of the ArtScience Labs in Cambridge, MA, states that "we are empowering young people to come up with their own ideas while exploring and playing in the arts and sciences. It's all fun, experiential learning, but we're teaching them to be critical thinkers and problem-solvers" (Robelen 2010, p. 8).

Hampton University Museum and School of Science, Engineering and Technology (VA) initiated "Jam Session: Jazz and Visual Art in Engineering" in 2010. The project applies jazz jams and improvisation principles to engineering students' design processes. Participants enjoyed John Sims' exhibit "Rhythm of Structure: Mathematics, Art and Poetic Reflections" (Wynn and Harris 2012).

Robious Middle School (VA) included "Keep Our Watershed Together…Be a Part of the Whole" project during the 2011–2012 school year which involved creating a mosaic depicting the natural processes within the ecosystem, the James River, and the food web. 380 sixth graders developed project sketchbooks creatively explaining what they learned from fieldwork at the river. Students sat with their sketchbooks on the riverbank painting botanicals with watercolors, using water from the river (Wynn and Harris 2012).

3.3 STEAM University Research

Texas A&M STEAM Camp The study focused on student perception about using creativity in STEM projects during a 2-week STEAM camp experience for 104 students from seventh to twelfth grades. The camp used problem-based learning activities that built bridges with popsicle sticks, made lip gloss from organic materials, prepared a video to explain created products, created an app for a cell phone, built robots with Legos, and designed an object with 3D modeling software. Student surveys indicated students believed that problem-solving requires artistic solutions.

Three implications for education emerged from this study:

- The arts should preserve or regain their prominence in the educational system.
- Opportunities should be provided in formal school settings for students to use both creativity and logical thought processes in solving problems.
- Engagement in the arts has benefits emotionally, giving the arts an importance on their own, outside of STEM (Oner et al. 2016).

Transdisciplinary Design Studio This college course incorporated collaborative creativity using a visual-verbal methodological approach. It included 11 undergraduate and graduate students from disciplines of environmental and civil engineering, landscape architecture, and art education. Design challenges included exploring waste reduction and a water ethic, with local and global implications. Students created sculptures while working together to develop individual visual-verbal narratives.

STEAM approaches engage students in interdisciplinary explorations of complex social issues and offer collaborative engagements through the arts that nurture holistic, authentic, and dialogic perspectives. A transdisciplinary STEAM curriculum fosters reflection of and understanding of an individual's creative process. "While many focus on what the arts bring to the STEM conversation, we are also interested in what STEM might bring to the arts." (Guyotte et al. 2015, p. 31).

4 Artistic Ways of Knowing and STEAM

Artistic Ways of Knowing describes the way students who are fully engaged in the arts perceive and create through these experiences. They describe the perceptual/cognitive processes inherent while learning and working through the arts (Haroutounian 1995, 2002, 2014, 2015, 2016). This artistic process includes perceptual awareness and discrimination, metaperception, creative interpretation, the dynamic of performance/product, and critiquing (summarized in Fig. 2).

There is a broad consensus that the arts are important to include in STEM because they bring creativity to the problem-solving process. However, creativity is a very generalized term, so we lose sight of exactly how students think as they create. If we examine each step of this creative-artistic process, we more fully understand how students "think as artists." Teachers and researchers can document and study what they witness in STEAM classes for future research of artistic thinking (Hetland et al. 2007).

The explanation of each element in the artistic process will include brief descriptions of how one can observe this element of artistic knowing in a STEAM classroom. Enjoy realizing these activities vicariously, and imagine how students can expand conceptual understanding as they work together to solve problems.

Fig. 2 Artistic Ways of Knowing. (Haroutounian 2015, p. xi)

4.1 Perceptual Awareness and Discrimination

Artistic knowing begins with fine-tuned sensory awareness and discrimination. Eisner (1986, p. 8) describes qualitative awareness as "critical abilities to differentiate, distinguish, to recognize and to make distinctions between many qualities that constitute our world."

Across each art domain, students are drawn to details through careful listening, moving, seeing, and connecting with others emotionally. Visual artists perceive the world with acuity, awareness of dimensions of space, color, and textures that go unnoticed by those who simply look (Clark and Zimmerman 1984; Hurwitz and Day 2007). Musicians can discriminate rhythm patterns, melodic shapes, and tonal colors that will translate into interpretive performance as the process continues (Gordon 1987; Sloboda 1985, 2005).

Perceptual Awareness and Discrimination and STEAM The 3-year-olds described earlier were drawn to the concept of temperature and discrimination of cold and hot and how this can be controlled. They had to truly focus their attention to "feel" these differences at the initial stages of this STEAM experience. This lesson not only included science, engineering, and art but allowed them to qualitatively connect to their environment.

4.2 Metaperception

Perceptual discrimination is the entry point of artistic awareness, but artistic knowing emanates from the molding of senses and emotions through a unique perceptual/cognitive process. This process is described differently dependent on perspectives.

Aesthetic education describes it as aesthetic knowing (Goodlad 1992) or thinking with an aesthetic sense (Costa 1991) or thinking within (Reimer and Smith 1992). The visual arts describe it as qualitative intelligence (Eisner 1972), visual thinking, or visualization (Arnheim 1969). In drama, it is called virtualization (Courtney 1990), and in dance this internal performance aesthetic is called body-thinking (McCutchen 2006). In music, Sloboda (1985) calls it thought representation of music, and Seashore (1938), the pioneer of music aptitude, describes it as the mind's ear.

The term, metaperception, can be used to describe this inner manipulation and monitoring of senses and emotion that occurs through the artistic interpretive process (Haroutounian 1995, 2002, 2014, 2015, 2016, 2017). Metaperception is the artistic parallel to metacognition, a term used to describe mental monitoring in cognitive thinking and problem-solving. Metacognition describes the process of "thinking about thinking" while metaperception describes the process of "perceiving/thinking about artistic intent." Artists filter and manipulate sensory perceptions combined with cognitive and expressive decision-making in order to create artistic solutions (Haroutounian 2002, p. xvi). The term is useful because it is understandable to both the artist and the scientist.

Metaperception and STEAM The students engaged in the Philadelphia Arts in Education group developed a Fraction Mural that was displayed at the school. The process began with students individually manipulating abstract concepts underlying fractions internally through metaperception. They shared their ideas collaboratively to transform these abstract concepts into a concrete artistic interpretation as a mural.

4.3 Creative Interpretation

As students work metaperceptively through an arts medium, the expressive reworking of ideas becomes an artistic-interpretive process that results in a creative interpretation. This interpretation grows through experimenting and adjusting ideas that will eventually become a performance, a product, or a critique. The arts are a perfect way to blend the invention of thought with perceptive/expression manipulation of ideas. Here is where the arts working with STEM content can produce products that uniquely extend outside the box.

Creative Interpretation and STEAM The Hampton University Museum and School of Science, Engineering and Technology merged the engineering design process with improvisation principles in jazz. Hearing jazz improvisation with all of its creative combinations working together can ignite ideas in engineering design through experimenting with ideas across both disciplines. Viewing John Sims' art exhibit adds visual inspiration to the mix. The collaborative result of all this creative interpretation can be innovative.

4.4 Dynamic of Behavior and Performance/Product

The musician, dancer, or actor communicates an interpretation to an audience through a performance. The audience experiences the performance sharing in the interpretive process. This mutual aesthetic experience of audience and performer creates the dynamic of performance. When experiencing an artwork, we find details that personally draw us to the work, creating this same dynamic between the artwork and viewer. The more aware the perception by the audience/viewer, the more dynamic the aesthetic connection.

Dynamic of Behavior and Performance/Product and STEAM The Transdisciplinary Design Studio went through the artistic-creative process using visual-verbal narratives to create interpretive ideas as they collaborated to design sculptures related to exploring waste and water real-world problems. One group placed empty water jugs on the campus lawn to represent the amount of water used in a normal 10-min shower, and fewer jugs demonstrating water used in an energy-efficient showerhead. This design challenge involved creating a visual artwork that engaged the community and established social significance in the dynamic between the artwork and the viewer.

4.5 Critiquing

The cyclical artistic process requires self-assessment of one's developing work in an arts medium as well as the astute critique of the artwork of others. This critique involves examination beyond performance through perception and reflection to add depth to the artistic process. Affording opportunities for students to reflect and critique their own work fosters artistic reasoning (Haroutounian 1995, 2002, 2013; Winner et al. 1992).

Critiquing and STEAM In the Robious Middle School watershed project, students prepared ongoing self-assessment of their individual project sketchbooks, as well as comments and ideas for fellow student sketchbooks. These sketchbook/journals functioned as works-in-progress and reference books. During their expedition to the river, and while testing the river water, the students used its water as a medium for watercolor interpretive drawings, thus expanding on this reflective self-assessment. This STEAM experience provided ongoing critique opportunities reflecting artistic critique methods.

Incorporating artistic ways of knowing in STEAM classrooms will ensure that arts experiences are adding depth and breadth to the STEM curriculum while developing the specific thinking skills that define the artistic process. STEM educators will observe artists at work in their classrooms and arts educators will realize the opportunities afforded to their students through creative collaboration with the math and sciences.

STEAM – What are we learning? Even though concepts for broadening STEM to STEAM are still emerging, we can already see the impact of bringing the arts into STEM classrooms.

- When the arts are integrated with STEM concepts, creative collaboration between different ways of thinking works positively in solving problems (Sousa and Pilecki 2013).
- The arts draw attention to the idea of broadening approaches to learning and seeking novel solutions that provide room for students to explore and question as well as solve problems (Robelen 2011).
- Students are engaged in solving real-world problems, realizing how the arts play a role in effectively communicating their ideas, utilizing an appropriate arts field that works for that project (Piro 2010).
- When the arts are added to STEM disciplines, students are less intimidated and become more engaged in learning. STEAM classes are stimulating and inspiring, with creativity allowing students to express themselves as they solve complex problems (Wynn and Harris 2012).
- The STEAM approach to education should not be the only arts experience available to students. Each domain of the arts – music, visual arts, theater, dance – must be recognized as an essential component of the basic curriculum (Oner et al. 2016).

It is exciting to see how quickly the concept of STEAM has taken hold across the country – basically starting less than 5 years ago, it is already accepted as a valuable transdisciplinary approach to education. As someone dedicated to the arts in education, I was initially hesitant to embrace STEAM, worried about the possibility of lessons that may use the arts peripherally rather than as an integral part of the collaborative learning process. The examination of a handful of STEAM projects showed exciting possibilities of student exploration across disciplines that can also provide opportunities for teachers to see artistic ways of knowing in action in their classrooms.

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