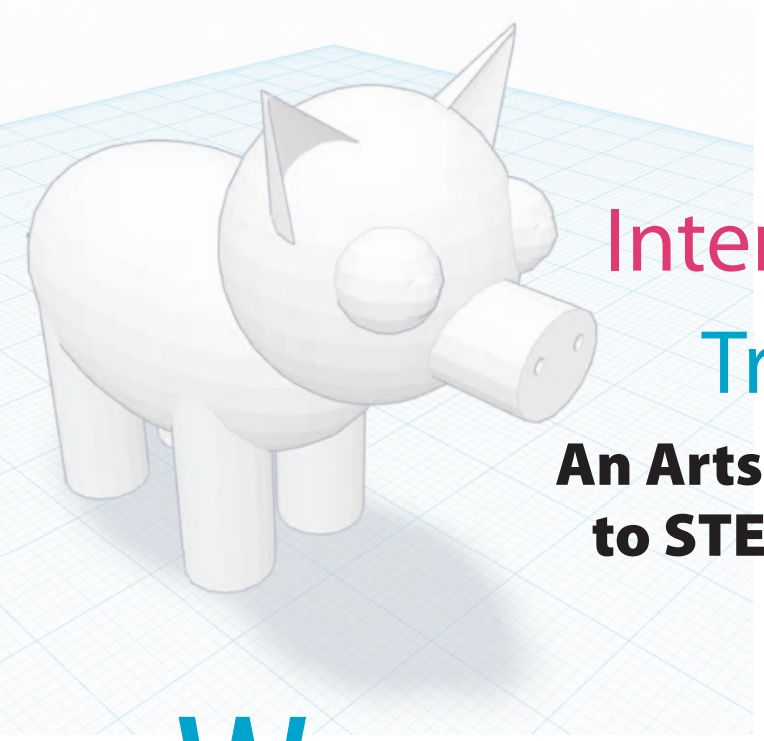

# From Interdisciplinary to Transdisciplinary: An Arts-Integrated Approach to STEAM Education

Christine Liao

## What should science, technology, engineering, art, and math (STEAM) education look like?

In the context of educational policy, the STEAM conversation has intensified and spread across the United States and some other counties (Eger, 2015; Yakman & Lee, 2012). Therefore, proposing answers to this question is a timely endeavor. I suggest an arts-integrated approach to STEAM education and discuss the potential of this approach for opening up a transdisciplinary space—a space "at once *between* the disciplines, *across* the different disciplines, and *beyond* all discipline" (Nicolescu, 1997, para. 4) and, therefore, capable of fostering an "innovated" society. However, for art educators to enter the STEM education dialogue and play a role in shifting the emphasis to STEAM, we must first establish what STEM education is and how it is practiced.

### Why STEM and STEAM?

The rhetoric of STEM education starts with the belief that future economic growth and innovation in the United States relies on STEM fields, yet the number of students pursuing studies in these areas is decreasing (U.S. Department of Education, n.d.). The promise that STEM holds for the future is based on the idea that STEM fields drive critical innovation and that innovation, in line with early- to mid-20th-century notions, is explicitly tied to economics (Godin, 2008). Similarly, the idea that innovation is connected to creativity is a product of mid-20th-century research on organizational productivity (Godin, 2008). This link between creativity and productivity supported the connection between creativity and innovation-based economics, and creativity—although explicitly not art-based creativity—gradually became associated with innovation.

One of the strongest arguments for STEAM derives from the view that creativity is the most important ability in the 21st century (Trilling & Fadel, 2009). Accordingly, the arts offer an important way to cultivate creativity. Among the proponents of this view is former president of the Rhode Island School of Design and champion of STEAM, John Maeda, who has argued that art and design education fosters creativity and innovation (2012, 2013).

Art educators have also advocated for STEAM. One view emphasizes STEAM's potential for advancing design education (Bequette & Bequette, 2012; Watson, 2015). Aligned with Maeda's (2013) viewpoint, this position highlights the potential of teaching design thinking skills and of encouraging students to become innovators. This position situates design education as essential to STEAM education. Another argument for STEAM aligns with the perspective of arts integration[1] described next.

### How Can Art Educators Participate in the STEM/STEAM Education Dialogue?

#### *Integrated Approach to STEM and STEAM*

Some educators argue that increasing the number of school hours dedicated to STEM subjects will not foster students' interest and ability in STEM fields. Therefore, they call for an integrated approach to STEM education as most applicable to the real world (Honey, Pearson, & Schweingruber, 2014). Numerous methods have been used to achieve an integrated approach of this nature,

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including project-based learning (Capraro, Capraro, & Morgan, 2013), problem-based learning (Lou, Shih, Diez, & Tseng, 2011), and integrative STEM education (Sanders, 2008). An integrated approach to STEM education emphasizes that at least two STEM subjects be used in concert to construct applications, especially those with real-world implications.

Arts-integration proponents have taken note of the continuing focus on STEM education. They see both integrated STEM education and arts integration as ways to support integrated learning (Riley, 2012; Sousa & Pilecki, 2013). Therefore, adding the arts to STEM and advocating for STEAM is the next step in pursuing an agenda designed to campaign for and elevate the importance of arts subjects. The goal of supporting STEAM from this viewpoint is integrated learning; however, it should be understood that arts-integration practices are diverse.

Integrated learning is also pushed by some art educators (Chappell, 2005) who see interdisciplinary collaboration as a best practice for arts-integrated education. In Bequette and Bequette's (2012) view, art and design educators should communicate with their peers in STEM fields to determine how to integrate art with STEM to create a STEAM curriculum. However, they caution that art should be emphasized as a discipline. Similarly, Wynn and Harris (2012) encourage art teachers and STEM teachers to learn from each other. Their view on STEAM education is expressed through creating a class environment where students learn through creative problem solving. This viewpoint also corresponds with problem-based integrated STEM education. Another view takes the communication between art and STEM educators to a transdisciplinary space (Guyotte, Sochacka, Costantino, Walther, & Kellam, 2014) where the focus is applications to social practices. Indeed, art educators have long promoted interdisciplinary art education and arts integration (Stokrocki, 2005). Integrated STEAM education, in this regard, is interdisciplinary education focused on transformative learning experiences whereby STEAM subjects are presented together.

The increasing importance of STEAM education is evident in that the National Art Education Association (NAEA) recently published a position statement on STEAM, defining it as "the infusion of art and design principles, concepts, and techniques into STEM instruction and learning" (2014, para. 1). This definition is closely associated with the arts-integration approach (i.e., an approach generally understood as referring to the use of the arts in teaching other subjects; Goldberg, 2011). Silverstein and Layne (2010) define arts integration as "an approach to teaching in which students construct and demonstrate understanding through an arts form. Students engage in a creative process which connects an art form and another subject area and meets evolving objectives in both" (para. 1). This definition recognizes the importance of creative production and promotes hands-on learning through artmaking.

Advocates of arts integration connect STEM and art with integrated teaching and learning in mind. However, there are drawbacks to STEAM from this viewpoint. Although integrated teaching takes multiple forms, discussions of STEAM education in this camp often focus on arts-integration instructional strategies and lesson ideas as constituting STEAM education. As arts integration before the advent of STEAM already included strategies and curricula that integrated the arts with other subjects, including STEM subjects, discussing the same content and ideas (arts integration) under a different term (STEAM) could cause confusion. Arts integration is also often misunderstood as referring to the use of the arts only to enhance teaching and learning. Unfortunately, when arts integration is misunderstood in this way, art is often watered down in classroom practices (LaJevic, 2013). Additionally, although in arts integration, art and other subjects should be equally important (Silverstein & Layne, 2010), art is usually a vehicle for learning STEM—not the other way around. Therefore, maintaining the integrity of art education is a concern for art educators (Roucher & LovanoKerr, 1995; Ulbricht, 1998).

## New Perspective on Arts Integration for STEAM

Despite the confusion that could arise as discussed in the previous section, I suggest that art teachers start by positioning STEAM education along the lines of arts integration. I advise that this approach be followed because arts integration has long-established strategies that are beneficial to classroom work. Bringing STEAM directly into the individual teacher's classroom is an easier starting point than executing a larger-scale project in the current general and curricula environments of many schools. By producing tangible results in the classroom, teachers can lay a

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foundation for creating their own more sophisticated initiatives. Further, newer perspectives on and practices in arts integration are bringing arts-integration practices to a new level. For example, Marshall (2010, 2014) proposed using contemporary art strategies to integrate art and key ideas in other subjects and to view visual arts integration as a transdisciplinary space. From this perspective, using an art-centered approach to integrate art into STEM does not fall within the established pedagogical conversation, but is instead a new transdisciplinary method capable of bringing fresh ideas to STEAM.

Arts-integration practices are diverse. It is, therefore, difficult to determine the limits of an arts-integrated approach to STEAM education and to pinpoint best practices. Borrowing from Silverstein and Layne's (2010) definition of arts integration, I suggest that creation/production is essential for art teachers focusing on STEAM. Creative problem solving through artmaking should be at the center of this approach. This view also accords with problem-based learning through which students learn by solving problems presented in a given project. This approach encourages students to see connections among their knowledge, skills, and abilities and to draw on these connections in advancing their own education and eventually in contributing to solutions to 21st-century problems.

## How Can Art Educators Integrate STEAM Into Pedagogical Practices?

### *The Arts-Integrated Approach to STEAM Education*

I provide an example of an arts-integrated STEAM education project to demonstrate the opportunities this approach offers for STEAM learning, creating transdisciplinary knowledge, and teaching 21st-century skills. This example is a learning activity in my undergraduate elementary teacher education class. It is centered on one characteristic of arts-integrated approach to STEAM education—the creation of art that is simultaneously applied work. Students were required to create an application (a physical 3-D storybook that could be used to teach a concept) by acquiring and utilizing STEAM knowledge and skills.

The project integrates language arts (children's literature), science, technology, engineering, art, and math. Over a 3-week period, the students worked in groups to create interactive 3-D storybooks to teach the concept of embracing difference. The students could either modify a children's story of their choice or create an original story. Using an online 3-D modeling program, TinkerCAD, the students created 3-D characters (Figure 1), which they 3-D-printed to illustrate their books. The 3-D storybooks included interactive object components (buttons) for users to touch so that the recorded story and/or sounds associated with it would play. For example, one group created *The Turtle and the Pig*, a story about a turtle who is different from other turtles and is bullied as a consequence. The story ends with the pig and the bullied turtle working together to save the other turtles in a crisis. The bullied turtle uses the ways in which he differs from the others to rescue them. The design relies on a scene at a pond with a night sky dominated by the moon (Figures 2 and 3). When the moon is touched, the recorded story plays, and when other features

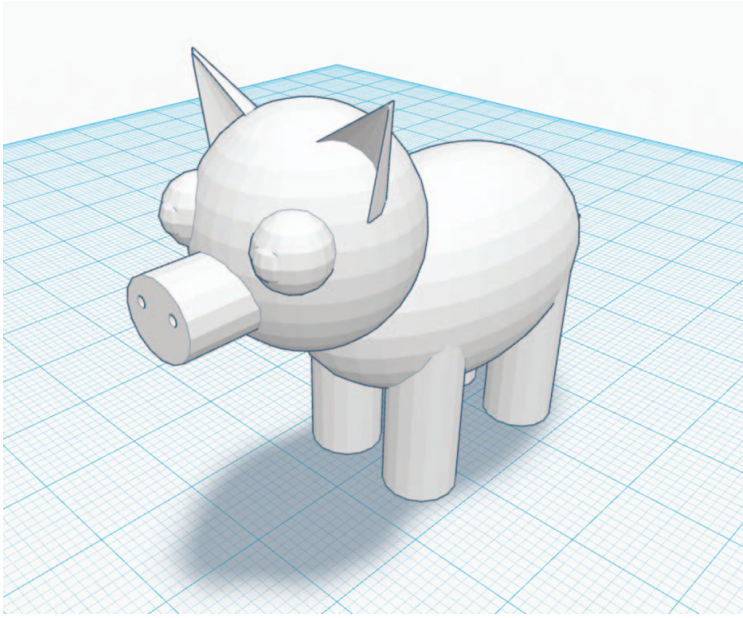

Figure 1. Student-created 3-D model of a pig in the online program TinkerCAD.

such as the pond or rock are touched, a corresponding sound plays. The students created the interactive aspects using Makey Makey (an electric circuit board) and Scratch (an online visual programming tool). They learned about the scientific concepts governing electronic circuits and electricity, acquired some coding skills, and gained art and technology skills. They also designed and engineered a 3-D display of a story by drawing on mathematical knowledge (i.e., by designing interactive components/buttons, engineering the wires connecting the buttons to Makey Makey, and calculating the proportion and scale of their models). Moreover, they created stories conveying the concept of embracing difference that they could use in their own teaching.

The students' reflections show that the perspectives, knowledge, and skills they acquired in this project transcended what they learned about the respective subject areas covered. One student wrote:

> I find it hard to describe exactly what I have learned from this project because I feel like it all has to do with the new thought process I was introduced to.… [This project] had my brain working on many levels at once. (Personal communication, December 7, 2015)

The students reported gaining an understanding of how integrating subjects can produce a greater learning experience. Additionally, many students indicated growth in their collaborative skills.

> The creative process is as, if not more, important than the final project. Learning to develop these processing skills was crucial to this assignment. As a group, we came up with many different ideas and had to problem-solve in some situations. I also learned a lot of team work skills. Together, we had to combine ideas and distribute job positions to complete the book. (Personal communication, December 4, 2015)

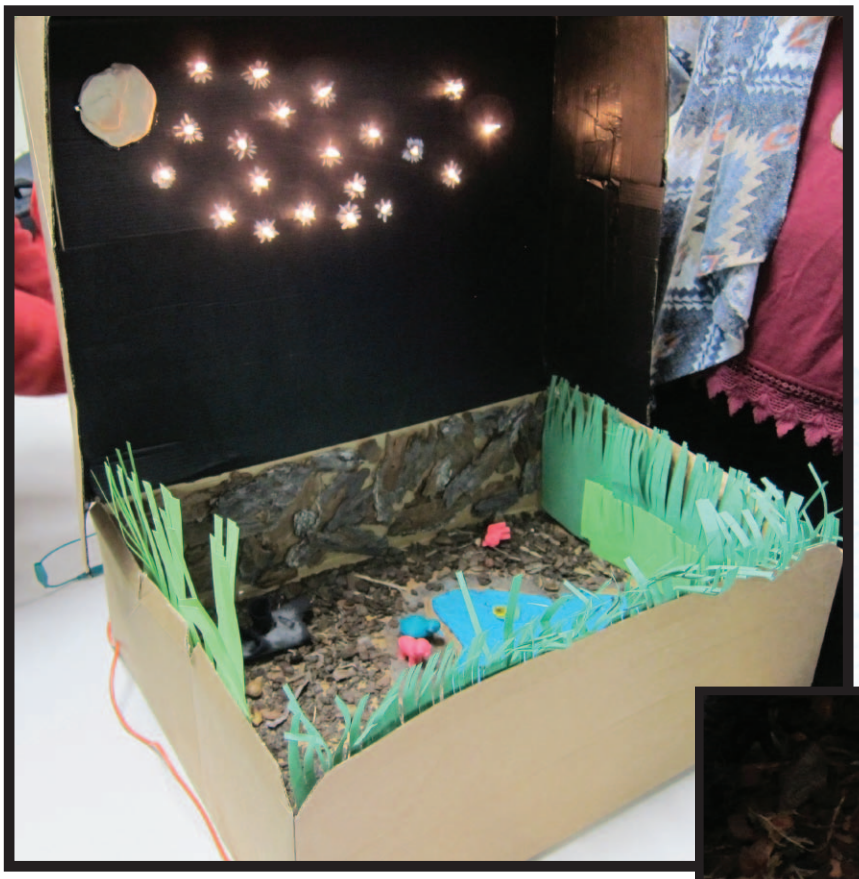

Figure 2. A 3-D storybook for *The Turtle and the Pig*.

Figure 3. Close-up of a turtle and a pig standing next to the pond in the 3-D storybook.

The project illustrates characteristics of the arts-integrated approach to STEAM education. First, it focused on learning through artmaking, which is one of the most important aspects of arts integration. Further, although it relied on artmaking as a method for learning, art did not disappear among the STEM subjects, as the students were also asked to focus on the aesthetics and design of their storybooks and required to learn art skills such as creating a 3-D model. Second, the assignment involved learning and applying knowledge and skills deriving from multiple STEAM subjects. Third, it provided opportunities for the students to collaborate and develop communication skills through teamwork. For all these reasons, the experience transcended subject boundaries such that transdisciplinary spaces opened up, as the students worked across, between, and beyond individual subjects. Although this work was undertaken by undergraduate elementary education students, K-12 art teachers can learn from it as an applied arts-integrated project that they can modify for their own classrooms. For example, K-12 art teachers could have their students create a 3-D storybook integrating art with language arts, technology, and other subjects. The developmental process would be similar in a K-12 classroom except the content would be based on grade level. Another option is a 3-D application, such as a model, as a learning tool to teach a concept.

This example constitutes a starting point for art educators planning to integrate STEAM into their pedagogical practices, because this project can be executed by a teacher either independently or in collaboration with partnering teachers and it requires minimum outside resources. Therefore, assignments of this nature offer a gateway to more sophisticated STEAM education opportunities, such as endeavors on the part of students to solve a real-world problem with STEAM skills acquired in the classroom.

## Transdisciplinarity in Arts-Integrated Approaches to STEAM Education

An arts-integrated approach to STEAM education affirms the process of creative production, utilizes the creative process to acquire knowledge, and teaches 21st-century skills, such as communication and collaboration (Framework for 21st Century Learning, 2007). Moreover, STEAM should create a

*STEAM should create a transdisciplinary space that cannot be defined in reference to any traditional sense of discrete disciplines… such a space is opened up when students do not categorize what they are learning as science, technology, or art.*

transdisciplinary space that cannot be defined in reference to any traditional sense of discrete disciplines. For instance, such a space is opened up when students do not categorize what they are learning as science, technology, or art. Instead, students view their work as created through engaging with all these subjects and beyond these subjects such that they can apply their work to and even solve problems in other settings. In my example, the students' reflections on the blended nature of their learning indicate that a transdisciplinary space was achieved. Further, they view their learning included the development of collaborative and critical thinking ability through applying STEAM skills.

Teachers can create a transdisciplinary space in their own STEAM lessons by designing assignments that engage with multiple disciplines and thereby nourish students' ability in transferring learning in multiple disciplines. Student's engagement, reflection, and ability to explain the implication of the project and apply their knowledge and skills to new areas are ways to determine transdisciplinarity in the lesson. Overall, the experience of learning in a transdisciplinary space enables students to connect their work to real world settings thereby demonstrating that their learning is useful in ways that transcend achievements within the classroom.



## Concluding Thoughts

Art educators can begin to implement STEAM education through an arts-integrated approach, such as the focal example described in this article. Ulbricht's (1998) guidelines for interdisciplinary art education "emphasize art's unique perspective and [that it should] not become a handmaiden for other disciplines." Further, Ulbricht specifies that "*new* understandings [should be] developed as a result of connections" and that interdisciplinary art education should be "concerned with important social and personal issues" and "organized around important themes." And, finally, that "art study should be collaborative" (pp. 16–17). These guidelines also hold for STEAM education. But what is new in the context of STEAM education is that a transdisciplinary space should be created in the STEAM experience. Defining the goal of transdisciplinary (research) as "the understanding of the present world, which cannot be accomplished in the framework of disciplinary research" (Nicolescu, 1997, para. 8), Nicolescu argues that transdisciplinarity is necessary for solving complicated problems in the modern global landscape (2002) such that STEAM should provide innovated solutions to contemporary problems.

To achieve the goal of creating a transdisciplinary space through STEAM, innovation can be directed toward the creation of a more just society (Turner, 2015). The transdisciplinarity of STEAM has the potentiality to address contemporary social issues, perhaps even on a global scale (e.g., Ahn, 2015; Guyotte et al., 2014). An arts-integrated approach to STEAM education is political in nature: while it might ensure future prosperity, it also offers educational opportunities, thereby equipping students with transdisciplinary experiences that contribute to a more just and "innovated" society. ■


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## Endnote

[1] The term *arts integration* includes all the arts areas (visual art, music, dance, theater). However, I use it here with an emphasis on visual art.