

*You can think all day and come up with a solution... Actually doing it, you see, this is where you run into mistakes. This is where the design flaws are...*

—Ellie, environmental engineering undergraduate and member of the “Shower Group”

**Our nation’s success depends on strengthening America’s role as the world’s engine of discovery and innovation... And that leadership tomorrow depends on how we educate our students today—especially in science, technology, engineering, and math [STEM].**

—President Obama in September 2010 at the launch of Change the Equation, a CEO-led effort to improve STEM education (as cited in Sabochik, 2010)

In the wake of the economic recession and increasing competition from developing economies, science, technology, engineering, and mathematics (STEM) education has emerged as a national priority. To art educators, however, the pervasiveness and apparent exclusivity of STEM can be viewed as another instance of art education being relegated to the margins of curriculum (Greene, 1995). Taking a different perspective, we find it helpful to look past STEM as a vehicle for promoting economic growth and international competitiveness and view it as a means toward overcoming the compartmentalized disciplinary approach to education (Holley, 2009). Considered in this way, STEM is about collaboration. In an educational setting, this means taking subjects that have previously been taught in isolation and weaving them into an integrated curriculum—a transdisciplinary endeavor that has the potential to lead to exciting and unexpected outcomes that can transcend the traditional goals of disciplinary education to address questions of social practice.

Recently there have been calls to expand STEM education to include the arts and design, transforming STEM into STEAM in the K-20 classroom (Maeda, 2013). Like STEM, STEAM education stresses making connections between disciplines that were previously perceived as disparate. This has been conceptualized in different ways, such as: focusing on the creative design process that is fundamental to engineering and art (Bequette & Bequette, 2012); emphasizing the role of creative and synthetic thinking to enhance student interest and learning in science and mathematics; and showing the value in exploring the science and mathematics that underpin different artistic techniques (Wynn & Harris, 2012). In this article, we describe how a collaboration between art education, engineering, and landscape architecture led us to conceptualize STEAM as a social practice that reflects concerns for community engagement and ecological sustainability.

Figure 1. An engineering student explains how art offers a different modality of ‘doing’ in a Transdisciplinary Design Studio.

# STEAM as Social Practice: Cultivating Creativity in Transdisciplinary Spaces

KELLY W. GUYOTTE, NICKI W. SOCHACKA, TRACIE E. COSTANTINO,  
JOACHIM WALTHER, and NADIA N. KELLAM

## Art and Engineering as Social Practices

There is a trend in contemporary art to conceive of artmaking as a social practice. While art as social practice may trace its aesthetic roots to John Dewey's *Art as Experience* (1934), recent scholars have also called for art to become a critical component of social life. For example, Suzi Gablik (1991) envisioned a reenchantment of art away from the modernist focus on the artist as an isolated creative genius to a practitioner engaged in the world with an ecological perspective. The relational aesthetics of Nicolas Bourriaud (2002) has had a significant influence on contemporary art education curriculum theory for its emphasis on art as a "social interstice" (p. 16), in which artists create a "hands-on civilization... which takes being-together as a central theme and focuses on the 'encounter' between beholder and picture, and the collective elaboration of meaning" (p. 15). In this project we have identified this social interstice as a collaborative doing.

The *Art and Social Practice Journal*, established in 2012, reflects the timeliness of the conceptualization of art as social practice and offers a useful definition for situating the many forms this practice may take, especially those with social reconstructionist intentions.

[T]he term Social Practice has been applied to an incredible diversity of artworks that traverse multiple disciplines, from community farming projects to activist organizing initiatives, and from antagonistic public interventions to alternative education models. The common threads... linking these practices include: engaging with or collaborating with a public, working across a variety of disciplines, and instigating works that have relevance to both an art and a variety of non-art audiences. ([www.psusocialpractice.org/aaspjournal](http://www.psusocialpractice.org/aaspjournal), para. 2)

Natalie Jeremijenko is an example of a contemporary, interdisciplinary artist working in this emerging area. Jeremijenko creates performance art and participative multimedia installations that explore nonviolent, sociotechnical change, with a particular focus on environmental issues.<sup>1</sup> Her work—which interweaves biochemistry, physics, neuroscience, precision engineering, and art—demonstrates the transformative power of conceiving STEAM as a social practice.

Parallel to these developments in contemporary art, since the mid 1990s there has been growing interest in the value of considering engineering as a social practice. These efforts have been driven primarily by recognition of the need to reform engineering education to better prepare students for the realities of

an inherently socially situated and rapidly changing engineering workplace (ASEE, 1994; NAE, 2005). To this end, research has centered on how to shift prevailing perceptions of engineering as being "hard hat" and highly technical in nature to a profession characterized by complex social processes of negotiation occurring between different stakeholders in social contexts (Bucciarelli, 1994; Rojter, 2006).

Recently, there has also been a push to conceive of engineering as a social practice in the sense of how the profession might contribute to an increasingly just society (Baillie & Catalano, 2009). In a book on engineering ethics, Harris, Pritchard, and Rabins (2009) define a profession as a social practice if it has one or more morally justifiable "aims or goods that are especially associated with... or 'internal' to it" (p. 4). While many see the purpose of engineering as producing technology for the welfare of society, others view it as driven by capitalistic and militaristic goals that can be difficult to justify from a moral standpoint (Riley, Pawley, Tucker, & Catalano, 2009). Researchers holding this view are exploring what engineering might look like if conducted as a social practice, with social and ecological justice as central aims (Colledge, 2012). In what follows we describe how, in a STEAM educational setting, the Transdisciplinary Design Studio helped art and engineering achieve their respective social practice goals.

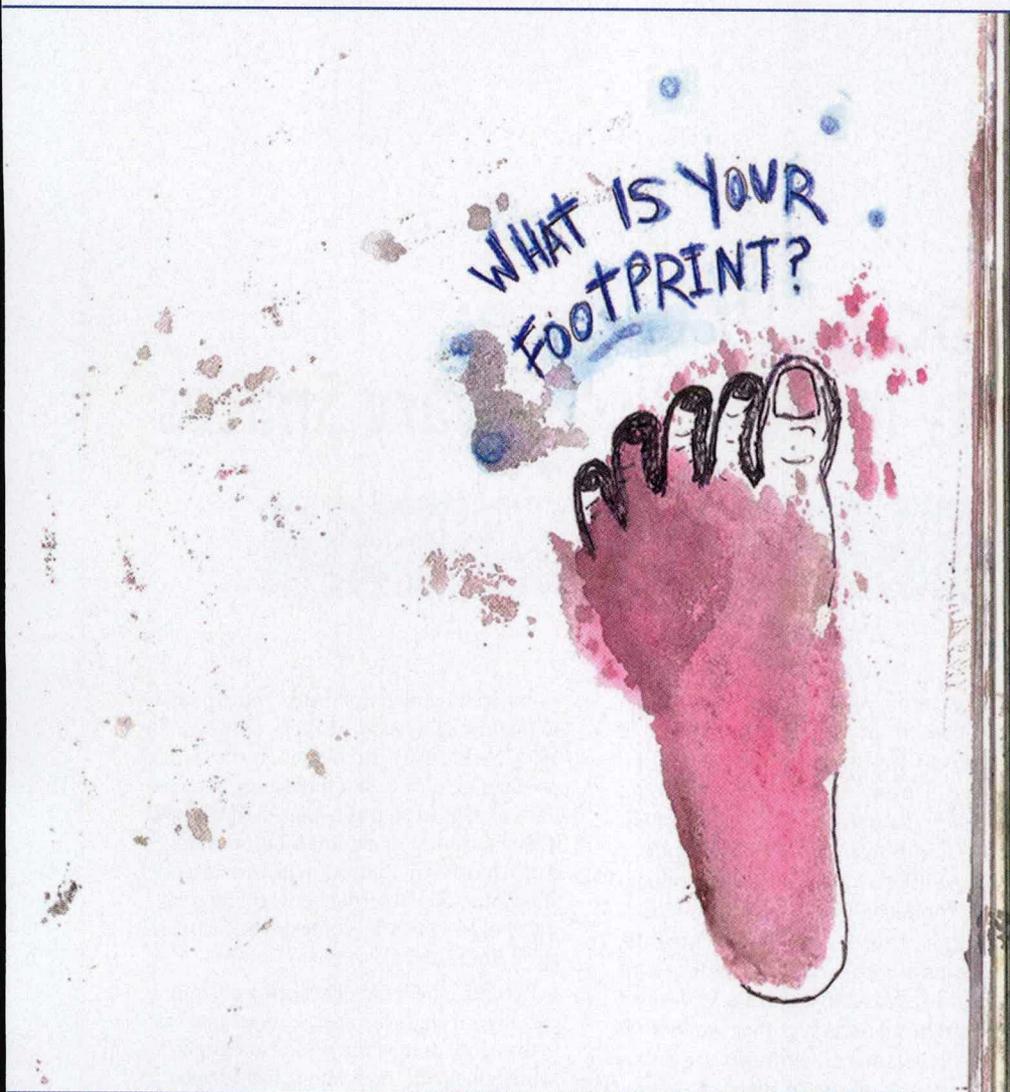


Figure 2. Image from an engineering student's visual journal considering the concept of a water footprint.

Visually, we conceived of transdisciplinarity like a watercolor painting... where vibrant new colors reflect the importance of these emergent spaces.

## The Transdisciplinary Design Studio

The Transdisciplinary Design Studio originally emerged through a collaboration between faculty from engineering and art education as part of the Synthesis and Design Studio Environmental Engineering curriculum, and has been supported by two grants from the National Science Foundation (Costantino, Kellam, Cramond, & Crowder, 2010; Kellam, Costantino, & Cramond, 2009; Kellam, Walther, Costantino, & Cramond, 2013).<sup>2</sup> In the present iteration of the Studio, we expanded the model and invited students from landscape architecture to participate, recognizing the complementarity of this discipline with engineering and art. The course brought together 11 undergraduate and graduate students from art education, landscape architecture, and civil and environmental engineering. Further emphasizing the interdisciplinary context, the two instructors (the first two authors) represented different disciplinary homes: the College of Engineering and the School of Art.

In designing the curriculum, we were mindful to place the three disciplines on equal ground through a transdisciplinary approach. We strove for what Boix Mansilla, Miller, and Gardner (2000) called a *purposeful intertwining* where “concepts and modes of thinking in one discipline enrich students’ understanding in another discipline” (p. 29). Inherent to this idea is a reciprocity, or dialogue, among the disciplines. Under the umbrella of interdisciplinarity, Lattuca (2001) explained transdisciplinarity as “the application of theories, concepts, or methods across disciplines with the intent of developing an overarching synthesis” (p. 83). Visually, we conceived of transdisciplinarity like a watercolor painting in which colors bleed together and blur the boundaries between disciplines, and where vibrant new colors reflect the importance of these emergent spaces.

Inspired by *Sparks of Genius*—a text written by Robert and Michèle Root-Bernstein and required for the course—the curriculum focused on 13 creative thinking tools, such as observing, recognizing patterns, empathizing, playing, and synthesizing. The Root-Bernsteins (1999) present these thinking tools as universal to creativity across disciplines and propose creativity as a transdisciplinary process of thinking and doing. A second required text, *Are Your Lights On?* (Gause & Weinberg, 1990), fostered

thoughtful consideration of the social challenges embedded in the problem-finding, -framing, and -solving process. The exploration of transdisciplinary creative thinking tools and a process-oriented approach to problem solving provided students with a shared language for venturing into a collaborative space of STEAM learning.

The instructors constructed two design challenges addressing the sociotechnical complexities of waste and water sustainability. Through both design challenges, the goal was for students to apply, stretch, and reconstruct their understandings of these topics—moving from a disciplinary way of knowing into a transdisciplinary way of doing. The engineering students, for example, were encouraged to refrain from jumping to a technical solution, while the art education students tackled the challenge of working collaboratively. The first design challenge asked students to consider what a local initiative on solid waste reduction might look like if landfill diversion goals were extended to zero waste by the year 2030. Students were tasked with conceptualizing, but not undertaking, a community initiative to engage a broader population on some aspect of this goal, as well as to visually inquire into the challenges and implications of zero waste. Both the community initiative and the visual exploration were displayed in a gallery exhibition that served as a studio structure for learning (Hetland, Winner, Veenema, & Sheridan, 2013) through which students presented their concepts and process to the class, instructors, and other faculty.

### *(Re)Thinking the Second Design Challenge*

While the instructors were impressed with the planning of the community initiatives as well as the visual manifestations of each group's explorations, they felt that the first design challenge could have given students an even deeper conceptual and experiential understanding of the topic of waste reduction, had they actually undertaken their community initiatives. This realization led to a restructuring of the second design challenge inspired by Cynthia Barnett's (2011) book *Blue Revolution: Unmaking America's Water Crisis*. Barnett calls upon Americans to see their interconnected relationship to our environment and to take responsibility for threatened water resources by embracing a *water ethic*. For this challenge, each group was asked to organize and implement a



community initiative, beginning to explore social practice as doing. The final gallery exhibits included a documentation of the community event and a focused visual exploration of the idea of a water ethic. This exhibit drew upon the students' experiences with various studio techniques, creative thinking skills, and other arts-based inquiry methods in the course to insightfully explore their conceptions of a water ethic.

Figure 3. One group's visual explorations of Project Zero Waste. The wire sculptures depict a native bird, the blue heron, and a figure constructed from trash collected from the banks of a local stream.

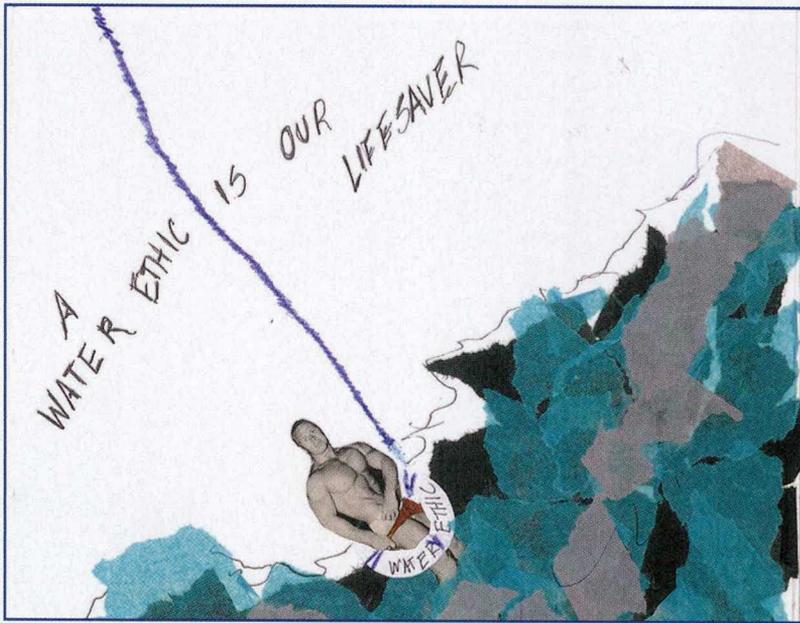


Figure 4. A visual journal exploration of water ethic as a metaphor.

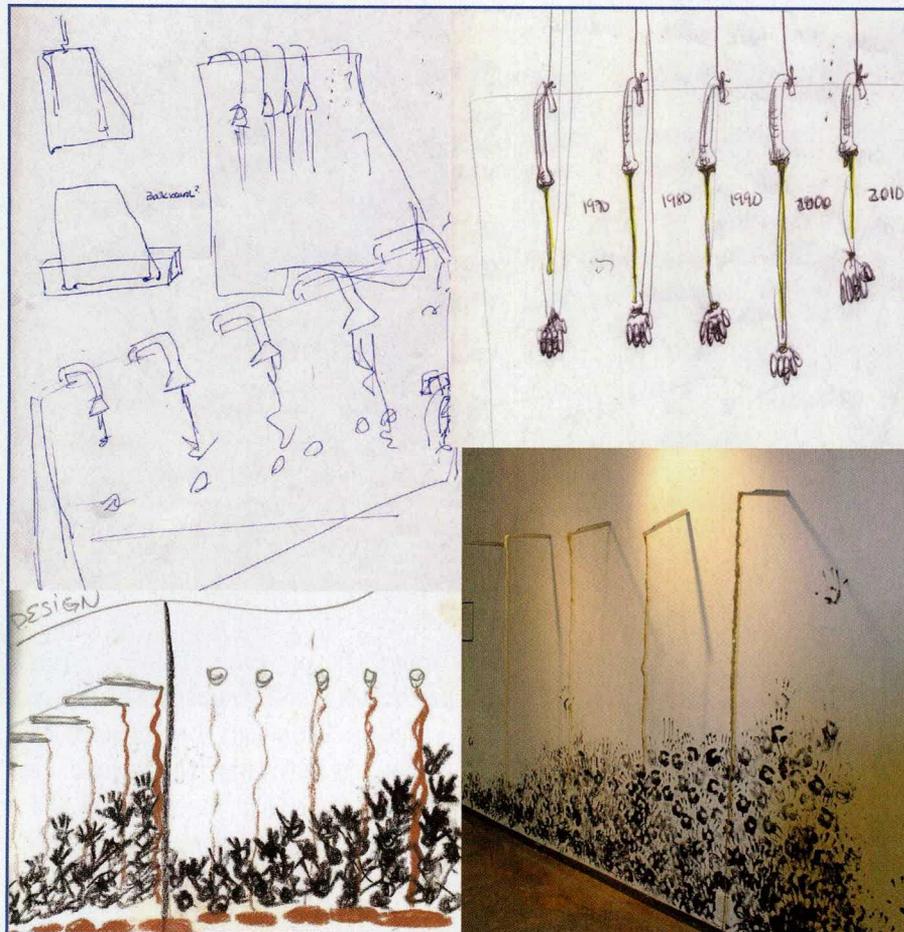


Figure 5. The Shower Group's idea progression. The first two images are from an art education undergraduate's visual journal and the third was sketched by an Environmental Engineering undergraduate. The final image represents the artwork as it appeared at the gallery exhibit.

### The Story of the Shower Group

As the groups engaged in their explorations of a water ethic, it became clear to the instructors, Kelly and Nicki, that the implementation of a community initiative added a level of complexity to the second design challenge. One group, the Shower Group, caught their attention as they dialogued during a class meeting. Their story provided compelling insight into the complexities in the (re)envisioned design challenge where social practice involved a thoughtful engagement in creating a visual artwork and an engagement with the community:

Kelly and Nicki stood in the corner of the classroom and listened attentively as the group discussed the second design challenge. At the table sat four students—two undergraduates from environmental engineering, an undergraduate from art education, and a Master of Landscape Architecture student. The students spoke about their concerns regarding water usage and rainfall, suggesting that the recent statewide drought was alarming and rainfall deficits were to blame. Turning a visual journal toward the instructors, Amy,<sup>3</sup> the art education student, presented her rough sketches of the artwork the group was planning (Figure 5). The gallery exhibit would visually depict the declining rainfall averages since 1980 through gilded water dripping from showerheads affixed to the gallery wall. Sculptural hands would also adorn the wall, desperately grasping for the gold-flecked water—thus symbolizing both the increasing demand for water by the growing populace as well as dwindling supplies and rainfall.

Grant, the sole graduate student in the group, outlined their plan for the community initiative. It was a risky albeit impressive plan to set up an installation on the north part of campus corresponding with football game tailgating. Grant described the empty gallon water jugs that would be arranged sculpturally on the campus lawn representing the amount of water used in a normal 10-minute shower and then the far fewer full water jugs demonstrating the water used with an energy efficient showerhead. The group nodded in agreement as he spoke and appeared confident in the direction their design challenge was heading.

We were silent as they spoke, absorbing the groups' emerging ideas. Nicki was first to speak up and politely asked the group where they had found the rainfall statistics. The



Figure 6. Thinking Through Materials.

group members shot glances back and forth, finally admitting that they had not, in fact, researched the rainfall but surely it must have decreased dramatically since 1980 as there was a drought coupled with increasing calls for water conservation. Nicki posed a few more clarifying questions and the group's discomfort heightened as they realized the assumptions they were making might not be accurate. Kelly then gently pointed out that the amount of water needed to fill the water jugs at the football game might contradict their purpose in cultivating a more water-conscious mindset. Once again silence overcame the group as they hit their first roadblocks in the second design challenge.

Developing ideas for a gallery exhibit and community initiative had proved easy for this group, but they held a responsibility to themselves, the audience, and the community to construct and exhibit their explorations in an accurate and thoughtful manner. It was through this interaction with the Shower Group that we began to realize that social practice as doing might push these students to more meaningfully consider and engage with the issues and materials at hand, as well as the audiences they intended to reach.

### Social Practice as Doing

The role of art as social practice became especially manifest to Tracie in the second design challenge as she observed students presenting their installations during the exhibition opening. As the project team discussed this realization, a framework for STEAM as a social practice of doing began to take shape, consisting of: Thinking Through Materials, Considering Audience, and Engaging with Community. This framework interfaces with articulations of thinking through the Arts described especially by Eisner (2002), Gude (2013), and Hetland et al. (2013); and reflects holistic views of engineering practice as put forward by authors such as Baillee and Catalano (2009) and Robbins (2007).

#### Thinking Through Materials

AshLeigh's insight (Figure 6) was taken from her final reflective paper, where she describes how thinking through materials or "media" allowed her to make connections between art, landscape architecture, and environmental engineering. This example of synthetic thinking recasts engineering problems as creative challenges, like artmaking, and solutions as creative

*I consider all problems to be a piece of art now because the ideas you come up with to solve the problem require similar patterns and methods of thinking. The media used to create the art (i.e. solve the problem) ranges for different people. For artists it can be clay, paint, [printmaking] or more. For engineers it may be textbook resources or experiences in the field. In other words, knowledge about a given problem like air pollution can be solved using background knowledge in the field which I consider to be a form of media.*

—AshLeigh, environmental engineering undergraduate and member of the "Shower Group"

manipulations of different forms of knowledge, which AshLeigh now understands as various types of media. This understanding of engineering echoes research that highlights the difference between classroom problems, which "possess knowable, correct solutions... achieved by applying preferred solution methods... [that emphasize] getting answers over making meaning" (Jonassen, Strobel, & Lee, 2006, p. 139), and workplace problems, which are ill-structured and complex, possessing multiple stakeholder perspectives and solution methods. AshLeigh's words powerfully demonstrate how a STEAM setting, in which she experienced thinking through materials, helped her develop a deeper understanding—not only of other disciplines, but also of her own.

#### Considering Audience

In *Sparks of Genius*, the Root-Bernsteins (1999) describe the creative-thinking tool of empathizing as "learning to perceive the world through someone else's mind and body" (p. 186). Amy's reflection (Figure 7) demonstrates empathizing as essential to making the Shower Group's installation successful by allowing them to thoughtfully consider the audience for their initiative.

*When it came time to select an actual form... I felt that everyone tried to stand back from what they aesthetically liked, and stepped into the skins of the people viewing the piece on game day in north campus... each one of us had to step into each other's skins to try and work together cohesively. I strongly believe that the ability to empathize is an important one to have. Being able to empathize with someone or something is to have the capability to understand them in a very basic, but deep way. If future designers are not able to empathize with their target audience, they will not be able to successfully design the object they plan to sell.*

—Amy, art education undergraduate and member of the “Shower Group”

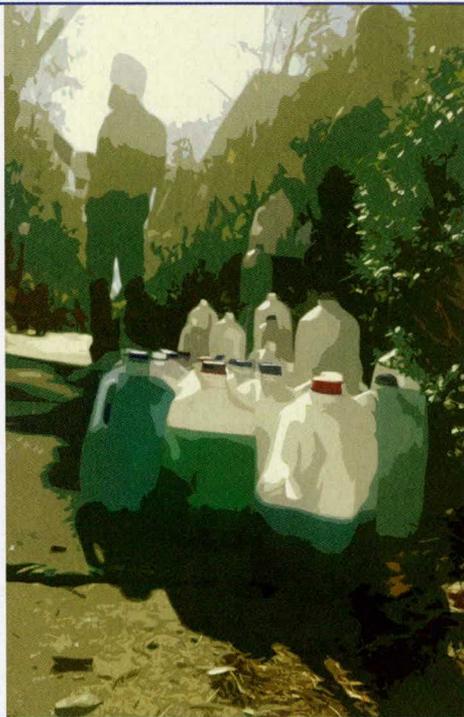


Figure 7. Considering Audience.

As Amy explains, it was through stepping into the skin of the potential audience that the group was able to deeply explore the relationship between form and function in order to effectively communicate their intended message. She connects empathizing to the design world, providing important implications for a STEAM-as-social-practice framework. It is through the lens of socio-technical complexities that contemporary designers must perceive the design process, where their responsibility extends beyond the confines of the studio/laboratory and into the hands of others. Amy reminds us that empathizing with the “other”—considering one’s audience—is an integral aspect of the design process.

### **Engaging With Community**

Through conceptualizing art and engineering as social practices, it is likely that individuals in these disciplines will be increasingly called upon to engage with the community. Community engagement, however, is not part of either traditional engineering or art curricula. Ellie’s reflection (Figure 8) shows how exhibiting art in a public space gave her an opportunity to engage with the community about water conservation, a complex sociotechnical issue that is critical to contemporary urban water management. In doing so, Ellie was forced to let go of her preconceptions of the “right” way to interact with the public and, instead, adapt to the public’s preferred modes of communication. This process of observation, reflection, and adaptation demonstrates how it was through doing in a STEAM-inspired setting that Ellie developed a sensibility for public engagement.

### **Looking Forward: STEAM Education as Experience**

Our ongoing reflections on STEAM as social practice led us to consider a final reflection written by Marissa, an environmental engineering undergraduate: “This class was more like an experience than a class, and that’s how I feel college should be.



*The difficulty came most with the community initiative. People actually seemed more interested in speaking with us when we were not approaching them, which allowed them to wander up on their own and ask questions. That was really interesting to me because I assumed that they would all be extremely busy with the game, but the opportunity to approach the group willingly made them more excited to check out what we were doing.*

—Ellie, environmental engineering undergraduate

Figure 8. Engaging With Community.

**“This class was more like an experience than a class, and that’s how I feel college should be. I should be able to say, ‘I did this... and I did that... I know this... because I did that.’”**

—Marissa, undergraduate engineering student

I should be able to say, 'I did this... and I did that... I know this... because I did that,' (Final Reflective Paper). Marissa's words reflect the essential goal of an experiential education as proposed by Dewey (1934) and Greene (1995). It is through the Arts and through doing that we may come to know, understand, and engage. We hope that future students will view STEAM education as Marissa did: an experience rich in doing.

In this spirit, it was through doing—our planning of, participation in, and reflection on the Studio—that we discovered the potential of STEAM education for cultivating social practitioners. The focus on complex local and global sustainability design challenges served as a vehicle through which

thinking through materials, considering audience, and engaging with the community brought forth a framework of social practice as doing. We offer this framework as a structure for the implementation of a transdisciplinary and collaborative approach to STEAM education in diverse contexts, promoting the potential of STEAM for the purposes of attaining social and ecological justice.

---

Kelly W. Guyotte is an Assistant Professor of Educational Research (Qualitative) at the University of Alabama, Tuscaloosa, Alabama. E-mail: kguyotte@bamaed.ua.edu

Nicki W. Sochacka is a Senior Researcher/Instructor of Engineering at the University of Georgia, Athens, Georgia. E-mail: sochacka@uga.edu

Tracie E. Costantino is an Assistant Dean of Faculty at Rhode Island School of Design, Providence, Rhode Island. E-mail: tcostant@risd.edu

Joachim Walther is an Assistant Professor of Engineering at the University of Georgia, Athens, Georgia. E-mail: jwalther@engr.uga.edu

Nadia N. Kellam is an Associate Professor of Engineering at Arizona State University, Tempe, Arizona. E-mail: nadia.kellam@asu.edu

## REFERENCES

- American Society for Engineering Education [ASEE]. (1994). The green report: Engineering education for a changing world. Retrieved from www.asee.org/papers-and-publications/publications/The-Green-Report.pdf
- Baille, C., & Catalano, G. (2009). *Engineering and society: Working towards social justice* [Synthesis Lectures on Engineers, Technology and Society series]. San Rafael, CA: Morgan & Claypool.
- Barnett, C. (2011). *Blue revolution: Unmaking America's water crisis*. Boston, MA: Beacon Press.
- Bequette, J., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. *Art Education*, 65(2), 40-47.
- Boix Mansilla, V., Miller, W. C., & Gardner, H. (2000). On disciplinary lenses and interdisciplinary work. In S. Wineburg & P. Grossman (Eds.), *Interdisciplinary curriculum: Challenges to implementation* (pp. 17-38). New York, NY: Teachers College Press.
- Bourriaud, N. (2002). *Relational aesthetics (Esthétique relationnelle)*. (S. Pleasance, F. Woods & M. Copeland, Trans.). Paris, France: Les Presses du Réel.
- Bucciarelli, L. L. (1994). *Designing engineers*. Cambridge, MA: The MIT Press.
- Colledge, T. H. (2012). *Convergence: Philosophies and pedagogies for developing the next generation of humanitarian engineers and social entrepreneurs*. State College, PA: International Journal for Service Learning in Engineering.
- Costantino, T., Kellam, N. N., Cramond, B., & Crowder, I. (2010). An interdisciplinary design studio: How can art and engineering collaborate to increase students' creativity. *Art Education*, 63(2), 49-53.
- Dewey, J. (1934). *Art as experience*. New York, NY: Pedigree Books.
- Eisner, E. (2002). *The arts and the creation of mind*. New Haven, CT: Yale University Press.
- Gablik, S. (1991). *The reenchancement of art*. London, England: Thames & Hudson.
- Gause, D. C., & Weinberg, G. M. (1990). *Are your lights on?: How to figure out what the problem really is*. New York, NY: Dorset House.
- Gude, O. (2013). New school art styles: The project of art education. *Art Education*, 66(1), 6-15.
- Greene, M. (1995). *Releasing the imagination: Essays on education, the arts, and social change*. San Francisco, CA: Jossey-Bass.
- Harris, C. E., Jr., Pritchard, M. S., & Rabins, M. J. (2009). *Engineering ethics: Concepts & cases* (4th ed.). Belmont, CA: Wadsworth.
- Hetland, L., Winner, E., Veenema, S., & Sheridan, K. (2013). *Studio thinking 2: The real benefits of visual arts education* (2nd ed.). New York, NY: Teachers College Press; and Reston, VA: National Art Education Association.
- Holley, K. A. (2009). Understanding interdisciplinary challenges and opportunities in higher education. *ASHE Higher Education Report*, 35(2), 1-131.
- Jonassen, D., Strobel, J., & Lee, C. B. (2006). Everyday problem solving in engineering: Lessons for engineering educators. *Journal of Engineering Education*, 95(2), 139-150.
- Kellam, N. N., Costantino, T., & Cramond, B. (2009). *The impacts of an interdisciplinary design studio on creativity*. Paper presented at the Creativity and Innovation Symposium, Winston-Salem, NC.
- Kellam, N. N., Walther, J., Costantino, T., & Cramond, B. (2013). Integrating the engineering curriculum through the synthesis and design studio. *Advances in Engineering Education*, 3(3), 256-270.
- Lattuca, L. R. (2001). *Creating interdisciplinarity*. Nashville, TN: Vanderbilt University Press.
- Maeda, J. (2013). STEM + Art = STEAM. *The STEAM Journal*, 1(1), 1-3. DOI: 10.5642/steam.201301.34
- National Academy of Engineering [NAE]. (2005). *Educating the engineer of 2020: Adapting engineering education to the new century*. Washington, DC: National Academies Press.
- Riley, D., Pawley, A. L., Tucker, J., & Catalano, G. D. (2009). Feminisms in engineering education: Transformative possibilities. *NWSA Journal*, 21(2), 21-40.
- Robbins, P. T. (2007). Policy Area—The reflexive engineer: Perceptions of integrated development. *Journal of International Development*, 19(9), 99-110.
- Rojter, J. (2006). Engineering profession as a social practice: Impact on professional engineering education. *The International Journal of Technology, Knowledge and Society*, 2(7), 135-140.
- Root-Bernstein, R., & Root-Bernstein, M. (1999). *Sparks of genius: The 13 thinking tools of the world's most creative people*. New York, NY: Mariner Books.
- Sabochik, K. (2010, September 16). *Changing the equation in STEM education* [web log post]. Retrieved from www.whitehouse.gov/blog/2010/09/16/changing-equation-stem-education
- Wynn, T., & Harris, J. (2012). Toward a STEM + arts curriculum: Creating the teacher team. *Art Education*, 65(5), 42-47.

## ENDNOTES

- 1 See www.environmentalhealthclinic.net/natalie-jeremijenko
- 2 Support for this study was provided by the National Science Foundation's Course, Curriculum, and Laboratory Improvement (CCLI) program under Award No. 0837173, the Engineering Education and Centers' (EEC) program under Award No. 1160350, and the University of Georgia's Office of STEM Education. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or the University of Georgia.
- 3 All names appearing in this article are pseudonyms.

Copyright of Art Education is the property of National Art Education Association and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.