Dance and mixed-media performance for building scientific understanding and environmental respect

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1. Introduction

1.1. A framework for sustainable development

The advancement of humankind requires adoption of new technologies, solutions that are safe and appropriate, understanding of long-term impacts and commitment to protecting natural resources even as economies grow. All of these require a strong and effective scientific discipline. Science is connected to all of the Sustainable Development Goals in some form.

Here I consider that the aim of development is supporting healthy lives and thriving communities for as many generations as we can imagine. Lives should be long and fulfilling; communities, including families, institutions, and countries, should be peaceful and supportive. And why do I use the word *imagined*? It is impossible to fully know what future generations need. Some have used this observation to modify early definitions of development, and have suggested we leave future generations with the resources we ourselves received. But I contend that we can do better. Conducting thought experiments on what could be helpful to leave behind may be a more appropriate method than leaving exactly what we received, or trying to "preserve" the environment. Even nature doesn't naturally preserve itself. It is dynamic. Such thought experiments may also enable us to identify additional unintended consequences of current actions. It is this forward-thinking aspect of science, and the creative processes often found in art, that can enable us to approach this type of development.

1.2. Awareness and transformation

It is good to use art to raise awareness, but that is not enough. The arts are not a tool for other disciplines to contribute to development. The arts are part of sustainable development; thriving communities create art. Even struggling communities create art; it is a part of human existence as old as records exist. Art born of struggle is often part of bringing about change. In fact, many artists believe that art should always change the way an observer feels, thinks, or acts in the future. In this paper I will focus mostly on this aspect of art- its transformative potential. Though they are valid ventures, I do not dwell here on aesthetics, art that makes us question what qualifies as art, or "art for art's sake". Specifically, I consider art that can create change related to science and the environment, and contend that science is better suited for raising awareness than art is. Science informs, and increases the body of knowledge about the world. Art can both help turn that information into transformation, and can help advance the scientific field by helping scientists discover in new ways.

2. Art and Science

2.1. The art-science schism

Italian artist Lucio Fontana said, “We refuse to think of science and art as two distinct phenomena… artists anticipate scientific deeds, scientific deeds always provoke artistic deeds” (Hamilton 2001). The art-science split is theorized to have been deepened when, in 1837, the scientific Royal Academy moved out of the London Somerset House which it shared with the arts-focused Royal Society, and by the environs of the Industrial Revolution. Scientists were then first called as such, and what was lost at the art-science split was “the colour, depth and shape of the interrelationships between artists and natural philosophers” as they had been called before (Hamilton 2001).

Rather than merging, it’s possible that the two have continued diverging, and modern technology may play a role. For engineers, drawing used to be a more important skill than it is today. In the past, calculating trajectories, ideation and design, and creating plans were done by hand drawings. Compare that with my mechanical engineering education in the 21st century. I spent two weeks of one class practicing hand drawing objects with appropriate perspective, shading, and clarity, versus six entire courses focused computer languages and modeling programs. The type of “art” an engineer is required to learn has shifted.

With that historical perspective, increasing technology could further divide art from science. But there are other ways in which it technology is becoming a bridge between the two, some of which are discussed in this paper.

A seminal and oft-quoted work discussing the division between art and science focuses mainly on the cultural difference between those who practice both fields (Snow 1993). While the schism remains, many of the characteristics of the two groups has changed. Some distinctions may have even flipped from one group to the other, such as political affiliations and level of optimism for the future. This paper discusses some of the past and current differences of outlook and approach. Updated analyses have been done on the two cultures (Nair 2005) and further quantitative data from surveys could shed additional light on the change. Some have suggested a third culture that bridges both, and when that third culture failed to be truly mutual, even a more equitable fourth culture has been suggested (Lehrer 2007).

2.2. Art and feelings create change: science alone often does not

Humans generally retain information better through visual intake than auditory. Why then are important scientific concepts so often communicated through words? The use of art, specifically visual or performing arts, can help people remember concepts and the importance of the natural environment. Art has been successfully used for years to expose social science phenomenon, political motivations, and to build community. It’s time we use it more to expose physical science discoveries and as a discourse about the environment that unifies more than do other modes of communication.

Not only do we want audiences to remember our discoveries, we want to create transformation. Environmental science has a goal: protect natural resources and enable people to live comfortably and long-term in their environments. Having a purpose means the communicator desires changed actions or thoughts. Change does not come easily, whether for an individual driving less or a politician prioritizing carbon emission policy over economic development opportunity. Personally, I act primarily on what I feel even if I also rationalize. For example, I recently started eating less meat. My “reason” was environmental. I had known for years that methane produced by cows affects the atmosphere, yet took no action. Then I calculated my

water footprint and related two bites of meat to a day of painstaking reduction in water use and experiences with water shortage. I felt those impacts deeply, related that to my environmental impact as I ate a burger, and changed.

2.3. Unique opportunities of dance and live performance

If people act on how they feel, how can we facilitate experiences of *feeling*? When an audience watches dance, their mirror neurons ignite, in a way as if they themselves are doing the movement. In a dance piece called Spill, choreographed by Emilie Plauché Flink about a bird in the Exxon Valdez oil spill. Witnessing struggled movement, stuck and viscous, embodied by a human but portraying a bird, I imagined what such a confined and condemned existence would feel like. I also imagined how I would react differently to the news if an oil spill affected humans the way it was affecting marine life. In short, I placed the human experience inside of the bird's; this is a very different type of empathy than can be evoked by images or words.

2.4. Unique application for today: environmental communication

Here I focus on physical sciences, rather than social sciences. The importance of art in the creation of societal fabrics has been well studied. Using art to increase understanding and advancement of the social sciences has also been successfully done many times. For example, art in the form of sound or visuals provokes emotions, which can be studied from a psychological perspective or measured with biometrics. Using a person's art-making such as dance or drawing can expose their psychological states or anomalies, and there are many more examples (Arends and Thakara 2003). The physical sciences are much less integrated with arts. I contend that they are especially fertile soil for dance and live performance collaborations, given the physical embodiment and movement in space.

One of the scientific disciplines most struggling today to communicate to broad audiences is the environmental sciences. Political climate skeptics are seen by many as experts, and scientists are considered self-interested liars. There are many reasons for this, one being the relatability of research results. Many questions addressed by environmental science are at scales unintelligible to people who are not environmental scientists. There are studies of tiny ants in Gabon and massive glaciers in Greenland. How can a human even relate? When I travel for research on water, I act diligently because I can relate to stories of people observing their land changed. I think of my rural homeland I visit every summer, and my sadness over even small anthropogenic changes. Stories, feelings, and experiences of nature motivate action. Yet global population is shifting to urban centers, where it's challenging to encourage reflection and feelings regarding the environment. For creatively communicating the physical world, I propose that dance is especially apt. In part, it brings a physical embodiment to physical realities; additionally, it invites an audience to posit their human experience into a story. To achieve the major cultural shift needed to save our warming planet, every human will need to relate to and deeply care about the changing environment.

3. Interactions between art and science

There are endless ways that art and science overlap, dialogue, and even oppose. The ones mentioned here are not suggested as an exhaustive classification or even a spectrum. Most individual projects or collaborations would defy categorization of any one approach. Between many of these types or approaches, there are connections and continuums. For the approaches below I give examples from my work and that of others, to instigate discussion. Rather than

tying the work to classifications, my hope is that this discussion highlights the complexity and wide range of opportunities for using art and science for creating positive development.

Ways the two fields interact includes: scientists hiring or using artists to effectively communicate their work to a wider audience; artists using advances in science and technology to facilitate their process and product; and the science of art-making, including studying methods, materials, and developing diagnostic and performance technology. In this section, I discuss: scientists creating artful presentations, art about scientific topics, science learning from art, and mutual art-science collaboration.

3.1. Scientists making art

Many scientists turn their research into art. Much effort goes into making their work "pretty"; being able to do good data visualizations is a valued skill. It's been argued that this is not art: "as unmediated science realism, this is abstract expressionism minus both the expressionism and the abstract, because not intentionally art, their function is the unambiguous communication of specific information" (Ede 2005). However, many decisions inform even what topic to study, how to study it, and what things are of interest and important for the world. There is human judgement in the process, all the way through how to present it. A scientist may be as proud of a final product and presentation as an artist is of their creation. Though none of my graphs about water quality I would call art, I hope that someday I master the presentation and complexity of analysis that will allow me to do so. I have been collecting references to other scientists' work that I hope to see hung in a gallery. Consider the additional curating process I'm undergoing, and the scientists' future decisions of size, printing methods, labeling, and a gallery owner's decisions of what to hang where… all additional steps that bridge from "science" to "abstract art" or more appropriately in much environmental art, "realism". Thus, if a fellow scientist wants to call their work art, even if seemingly "unmediated", I shall accept it as such.

3.2. Art about science

Further proposed by (Ede 2005) is that art cannot be directly about science. "Lectures, books or discussions are more successful at presenting explanations or stimulating debate. If art is 'about' anything, it is a reflection of human experience in complexity... conveyed through hints and ambiguity. Artist don't 'do' prettification, product or propaganda for the public understanding of science. But they can engage with it and create images which suggest alternative ways of seeing".

Artists can choose to take scientific information and make it more aesthetically pleasing if they are motivated to, and can also create propaganda- in fact this is a massive genre of art. A lot of social action art is created to motivate a specific set of responses and reactions. The artist has something they want to communicate and a social change they want to create. This may be considered propaganda, but rather than being for the benefit of some higher or other person or institution, it is for a higher purpose which the artist values.

However, art created very literally 'about' science is less artful than when it sheds new light. I have experimented with the level of literalness communicated to the audience. I choreographed a dance piece about gendered influences of water shortage, inspired by statistics from research I had done. Some people in the arts community gave feedback that their viewing experience was interrupted by the presence of the written statistics. The personal experience may be greater without the accompaniment of the literal scientific findings, but is that true for scientists

and for people not as steeped in the contemporary arts? I have since done other experiments to address this question. I gave different audience members different versions of the program notes; some knew the environmental phenomena, development statistics, and personal experiences that motivated the choreography in detail. Others received a one-line description, and others nothing. One such piece was inspired by infant mortality in areas with water shortage. When children are not expected to live, they are sometimes not given names until the age of two or three. Names help us remember and honor people; how can we honor those who never received a name? Reverent dance became my method, because it can be felt without words. The audience members that had no information enjoyed the aesthetics of the piece, and reported noticing the peaceful, reverent, innocent, and meditative qualities. Their possible interpretations and connections were far from the original inspiration. Those who had a one-line description noticed similar things and were also "moved" by the piece. The addition of a longer description did not seem to add much, at least in the interviews immediately following the performance. Whether such information motivates longer-term memory and action is yet to be determined, but is proposed in follow-up studies below. In the case of this performance, I felt that it was my role as the artist to portray my experience and interpretation of the reality through my art. Over-describing my experience in a literal way prescripted the audience's experience. Stating the reality, even a simple statistic, and being artful about its presentation seemed to be the "sweet spot" here. I hope that the next time those audience members hear a statistic about water scarcity or infant mortality, they react differently than they would have before, with a softer and more receptive heart. What I mean by that is that they listen closer, attentive, and therefore are ready to act or react. They may not remember that my performance played a role, if it did, but that is okay; my art lived its moment and served its purpose.

3.3. Science informed by art

This is rare, as I often notice a hierarchy in the relationship between science and art. Art can be inspired by science, but few recognize that art has something to offer science, and even fewer practice it. In one such exploration, a malaria researcher partnered and travelled with a photographer and poet. He reflected that "perhaps making connections between different realities causes us to question our assumptions, examine with fresh eyes what we take for granted and encourage us to see things more inventively… At the end of the project I have a deeper, more holistic view of this complex subject" (Holder 2003). As a result of detailed encounters with the artistic process, science "gains easier ways of understanding difficult ideas" (Arnolds 2003). They also achieve access to innovative thinking ahead of the curve, done by artists. Finally, art can also remind scientist of the importance of their work, the motivation. The malaria researcher who saw the issue through the eyes of the photographer is an example of this. Remembering the intention of the work helps direct it in the most meaningful direction, which is often the most direct. My short breaks when I'm researching, which often involve music or movement, are a chance to ask "where was I going"? If they are too long, I must ask "where was I?", which is not as helpful; the same thing happens on a longer scale if I leave a topic on the backburner for days or weeks. However, a daily dance class or a weekend working on an artistic project provide a shift in perspective and environment, enough to remember to start research again with the long-term goals in mind. Keeping an eye on the objective can help scientists not get lost in extraneous steps.

3.4. Science and art work together

Even rarer than science informed by art is a true collaboration in which an artist and scientist are mutual learners. This is not just cross-disciplinary or interdisciplinary. Transdisciplinary work is a "means of achieving new forms of knowledge" (Arends and Thakara 2003). An example of this is the dance company Black Label Movement. Director Carl Flink's choreography interacts with subjects such as gravity, cell collision, and evolution. He regularly partners with scientists, and offers a helpful explanation on the difference between collaboration and the other types of interactions mentioned previously. His work is "not so much about the science or subject as they are direct models to conduct research in the specific area of inquiry with the goal of obtaining useful information/data, subjective and objective, about the human condition and the subject itself" (personal communication, 2017).

There are instances when art and science discovered similar things, with parallel but separate processes. Examples of when art's understanding came before that of science is provide by (Lehrer 2007). I see these as fascinating but tragic examples of forgone opportunity. If there had been mutual learning and discovery, perhaps the arts could have understood more deeply and the science advanced more efficiently.

4. Addressing challenges

4.1. Questions of usefulness

As a researcher, I understand the struggle of wanting to focus only on my project and not get distracted. My workplace hosts many workshops that would help a researcher, but it's hard to justify going to one even as relevant as data visualization, effective communication, or statistical reporting, when I'm struggling to even import my data correctly and need to do so by the end of the week.

Yet on a long-term scale, those seemingly "unnecessary" ventures are valuable. On a national scale, it is a good sign for the economy of a country when they invest in R&D. It indicates a shift from survival mindset to long-term growth. In science, we need to move from a mindset of poverty to one of plenty, and trust that creating room for innovation will propel both the field and individual careers.

4.2. Being serious

Art, to scientists, can seem not serious. That is a good thing. Modern studies of neuroplasticity reversed the previous view- that we are born with all our neurons, determined mostly by studying animals in cages. However, once monkeys were put in a simulated natural environment with a rotating selection of toys and hidden food, they grew new neurons (Coe et al. 2003). Well before the term *neuroplasticity* was accepted in the scientific lexicon, this dynamic nature of the brain was understood by author George Elliot. Her novels exposed that "the most essential element of human nature was its malleability" (Lehrer 2007). Engaging scientists in transdisciplinary play and new types of challenges may increase neurogenesis and aid in scientific discovery.

Open-mindedness and creativity have a lot to do with innovation, which is essential in the advancement of science. "Indeed, pioneering scientists have always challenged the status quo, operating through guesswork and intuition sometimes more than through deductive logic… think of evolution which has advanced at random and without any vision or goal" (Ede 2005). Perhaps random playful moments are like mutations (Flink and Odde 2012)- many resulting in nothing or failure, but every once in a while, resulting in (r)evolutionary breakthrough.

4.3. Differing viewpoints

There are real differences between the approaches in art and science. One difference often addressed is that scientists try to be impartial, whereas for artists, “meaning depends on countless variables” (Ede 2005). However, absolute truth *does* depend on infinite variables, but to varying levels of importance. Both disciplines search for essential components, hidden. Can science learn from art’s intuition of complexity, and can science’s quest for distilled truth challenge artists to allow a momentary landing on something true, even if they must recognize its momentary nature and subjective process of discovery or presentation?

A beautiful text about a photojournalistic exhibition of glacial change stated that “the Anthropocene may not mark the end of the world, but it marks a point of no return” (Horn 2017). What *may* mark the end of the world, however, is building walls around disciplinary fields. The field of art and the field of science must be in humble dialogue and playful co-experimentation. “For if we’re not prepared always to wonder what it’s like to see things from an entirely different point of view, to imagine impossible scenarios and adapt to unknown circumstances, it may spell the end of the human race. It is good to see the world from the point of view of many ‘others’” (Ede 2005).

I recognize that this analysis has been ethnocentric, with few examples outside of Europe and the United States. Even the discussion of the original division between art and science was located in London (the separation of the Royal Academy and Royal Society) and broadly in the western world (the Industrial Revolution). Perhaps other cultures that have not so strongly adopted culture exported from London, whether directly or indirectly via other European countries or the U.S., have maintained an integration between fields that the world can learn from. These countries and cultures can be instrumental in restoring/leading a much-needed perspective and practice. Today, most of easily discoverable books published on the combination of art and science have still been published in London, as evidenced by the references in this paper. Future study must actively seek insight from those who may be able to more naturally lead this discussion.

5. Best practices in the interaction

In the examples of types of art-science interactions, I have already introduced some collaborations that work well. I now share additional themes that emerged from my research and interviews on the topic.

5.1. Exchange of perspectives

The theoretical physicist Dirac summarized his philosophy with “physical laws should have methodical beauty” (Farmelo 2002), perhaps a surprising statement from such a methodical and unemotional person. Can the practice of art help scientists and mathematicians develop their intuition for what is beautiful? On the other hand, perhaps it is the artists who have in the past century maintained the centrality of chaos and complexity. “The artist’s experience of life is uncoordinated, dislocated, contingent, incomplete” (Ede 2005). In fact, modern physics and other scientific disciplines are discovering the importance of chaos. While they previously sought governing equations, now it’s believed most of those have been found. What is left unknown is what governs the chaotic motion, and complexity. The slow viscous flow is simple, laminar, predictable, but the turbulent waters remain troubled. Can artists help us discover those

regions? Of the two fields, art has been the one digging in the dirt to expose the unknown, while science has been trying to order it.

5.2. Partnership across disciplines

This one is perhaps obvious, but I offer two particularly effective ways of partnering across disciplines. The first is defining discipline very specifically, as in a sub-discipline, and being willing to branch to seemingly unrelated sub-disciplines. An example of this is found at the Gowanus Canal, an infamously contaminated waterway in New York City. A community organizer there, Owen Foote, often partners his canoeing organization with artists. How can art affect change? He engages new groups by connecting with what they already care about. For example: creatively exploring the connection between dog-loving neighborhood walkers and city-dwelling nature lovers. If Owen's canoeing organization pursued only canoers, it would never become the neighborhood-wide advocacy force for environmental cleanup for which he aims. For art to be effective, people need to be both challenged by it and connected to it. Specificity in partnership provides the connection, and seemingly disparate partners can bring a newness or challenging perspective. I observe that this is more effective as a practice than as a one-time experiment. People who easily jump between and partner with varying disciplines seem to have a strong interdisciplinary background. As this kind of work becomes normal, the innovator focuses less on the "originality" that others perceive, and more on what comes of it.

The second effective way of partnering across disciplines is a deep, mutual exploration. A true partnership, where none can achieve the goal without the other. Where each discipline or innovator is involved throughout the process. Carl Flink, a choreographer mentioned above, has worked with a biomedical professor Dr. David Odde to create a process called *bodystorming,* a kinesthetic version of brainstorming (Flink and Odde 2012). "Its purpose is to create a modeling tool using bodies in space and choreographic tools to conduct substantive research in areas where it can be an effective tool for the discovery of new knowledge" (personal communication, 2017). These collaborations have resulted in published scientific work, and new forms and approaches to choreography.

5.3. Quantitative analysis and impact assessment

A study funded by NASA found that a program called *Beautiful Earth* increased the value that audience members ascribed to understanding the environment. The number of participants who thought it was "very important" to learn more about Earth's condition doubled after seeing the presentation. The most highly rated parts of the program incorporated live music, projected visualizations, and interactive experiences: sections that had a "wow" factor (Juffer 2003). Interestingly, discussion groups were the most poorly rated, which is a common way to address the question, "how can we get people to *engage* with this topic?". Conferences and events purporting to advance a particular field (read: change and develop) should more often include arts than endless discussion. Arts and interaction are effective, and more studies like the one on *Beautiful Earth* can guide the refinement of effective approaches.

6. Proposed study about art about science

I have personally experienced dance as an effective way to communicate, but I recognize that all people are different. How can we better understand how well dance engages with environmental science? I propose a study about a performance, with the following methodology.

In it, audience members' reactions will be filmed and the audience will complete a survey right after the performance and one month later. The performance will include dance, visual art, theater, poetry, live music, video, and mixed media (projected image behind dancers with live music also playing). Each medium will be based on at least one fact related to environmental change, will draw inspiration from an aspect of the natural world that is wonderful or admirable, and each artist will identify possible actions that an audience member could take as a result of seeing their performance. These, however, will not be communicated explicitly to the audience. The research questions being addressed by the surveys, and analysis of the video, include:

Q1. Which artistic medium produced greatest physical or emotional feeling?

Q2. Which inspired the most personal reflection and thought?

Q3. For which medium was the knowledge or experience gained also retained over time?

Q4. Which media motivated action or lifestyle change?

Q5. Which inspired conversation related to the environment in the days following the performance?

I recognize that the quality, style, and topic of individual pieces will affect the outcome. Thus we will look for themes that emerge, so that in the future those themes can be incorporated across disciplines and add more control to follow-up experiments. The results of the study will enlighten how dance and other art mediums can not only raise awareness but also help achieve the SDGs.

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