9th International Conference on Public Communication of Science and Technology (PCST)
Seoul, South Korea, 17-19 May 2006

ART ABOUT SCIENCE: AN INNOVATIVE USE OF ART AND TECHNOLOGY FOR SCIENCE EDUCATION

Adrienne Klein[1], J. Douglass Klein[2]
[1] Science & the Arts, The Graduate Center of the City University of New York, New York, NY, USA [1]
[2] Center for Converging Technologies, Union College, Schenectady, NY, USA

Abstract

We describe a project in which we use art as a medium to teach science and technology to the general public. In July 2005, the Franklin Institute, the premier science museum in the U.S. city of Philadelphia, opened a new exhibition hall cleverly named *Sir Isaac's Loft* (referring to Sir Isaac Newton), featuring hands-on demonstrations of physics created in collaboration with artists. To inaugurate the space, the Institute commissioned artists to participate in a *Sci/Art Jam*. The event was a remarkably successful and innovative example of education on technology through the arts. This paper describes this particular example of science outreach through the arts, and places our example in the wider context, urging its more general use. We cite examples in university and K-12 education, and in informal science settings such as museums.

Keywords: Technology, Art, Science, Education, Connections, Converging, Public

1. Introduction: Why Connect Science, Technology and the Arts?

The desire to communicate science ideas contains the notion that science benefits from engagement with other disciplines. There seem to be two motives for the growing interest in interdisciplinary thinking. The first is the potential for novel insights when a problem is viewed from multiple perspectives. Frans Johansson, author of *The Medici Effect*, makes the point this way: "…we have the greatest chance of coming up with ground-breaking insights at the intersection of different disciplines or cultures." Both the U. S. National Science Foundation and the European Union have advocated an interdisciplinary approach to science and technology, although not necessarily involving the arts [2].

A second reason for looking at intersections between the arts and science and technology is to advance the interest and understanding of the latter. This is not to minimize the importance of the arts, but rather to acknowledge a certain feeling of urgency in creating a wider interest and understanding of science and technology.

The sense of necessity in promoting STEM (Science, Technology, Engineering and Mathematics) education is itself twofold. The point made by organizations like the Business Higher Education Forum and the U.S. National Science Foundation is that STEM education is the foundation of economic prosperity. In order for a nation to maintain a healthy and growing economy, it needs to attract and retain larger numbers of students in science and engineering fields [3].

The other quite different but equally pressing motivation for promoting STEM education has to do with creating an educated citizenry, capable of discussing science and technology policy at more than a superficial and emotional level.

Eric Drexler, who invented the term "nanotechnology" in his 1986 book *Engines of Creation: The Coming Age of Nanotechnology* expressed the need for substantive conversation about science and technology:

> As we approach a technological crisis of unprecedented complexity, it makes sense to try to improve our institutions for judging important technical facts. How else can we guide the leading force and minimize the threat of terminal [catastrophic] incompetence? [4]

Even the Dalai Lama has expressed the urgent need for scientific and technical literacy in his recent book, *The Universe in a Single Atom: The Convergence of Science and Spirituality*, when he observes:

> Although my own interest in science began with curiosity about a world, foreign to me at that time, governed by technology, it was not very long before the colossal significance of science for humanity as a whole dawned on me. … Seeing the tremendous importance of science and recognizing its inevitable dominance in the modern world fundamentally changed my attitude to it from curiosity to a kind of urgent engagement. …
>
> Given that the stakes for the world are so high, the decisions about the course of research, what to do with our knowledge, and what technological possibilities should be developed cannot be left in the hands of scientists, business interest, or government officials [5]

With the benefits of science engagement so compelling and the concern about its absence so strong, we are driven to seek innovative ways to make science accessible to all.

2. Examples: Teaching Science and Technology through the Arts

Studying science and technology is often perceived as "hard." It requires a lot of math, and in high school and college, long hours in the laboratory. If the engagement of scientists and technologists with people from other areas of study, including artists, leads to new, creative breakthroughs, and if the study of science and technology is important both for the economic health of the country *and* for rational civic discourse over scientific and technical matters, what is to be done? One answer being explored is to offer multiple entry points to science and technology, including through the arts.

An early adopter of the notion that art could be an entry point to science education is the San Francisco Exploratorium, which was founded in 1969 by Dr. Frank Oppenheimer. The Exploratorium bills itself as "a collage of hundreds of science, art, and human perception exhibits" [6].

From 2002-2005 one of the authors (Adrienne Klein) participated in a pilot program organized by the Arts Center of the [Albany, NY, USA] Capital Region (ACCR) and funded by the General Electric Foundation to teach science through the arts. The target audience was middle school students in three upstate New York school districts. Teams of teachers, artists, and GE scientists developed lesson plans to teach such concepts as wave theory and how buildings are designed to withstand earthquakes (earth science); convection currents (physics) and cell reproduction (biology). In some cases, students engaged in an art project, the result of which demonstrated a scientific concept (as in the creation of a collage following rules similar to cell reproduction). In other cases, students were given a technical challenge (design a structure that will not fall down when shaken), but encouraged to consider the aesthetics of the structure as well as the functionality [7].

Adrienne Klein also programs events for the adult audience through Science & the Arts at The Graduate Center of the City University of New York. The program, co-directed by physicist Brian Schwartz, brings science ideas to the public through the visual, literary and performing arts. Science & the Arts' first goal is to provide the public with information about science and technology through the vehicle of cultural events. In music, for example, the series has included a rock opera about the Galileo spacecraft, a musical based on Alan Lightman's novel *Einstein's Dreams*, and a forthcoming electronic music work about the Big Bang. This is a form of public outreach, conveying information about science research and the lives of scientists [8].

A second goal is to provide opportunities for the arts community to create work about science. The series produces science-content performances and now, with the aid of grants from the National Science Foundation and the Lounsbery Foundation, Science & the Arts is seeking to encourage other US college campuses to do the same. This provides opportunities for increased artistic interest in science.

A third goal is to encourage dialogue between scientists and artists. Such dialogue might introduce innovative methods into science instruction and, perhaps, spur creativity in the lab.

J. Douglass Klein's work focuses on the education of college students. Union College (Schenectady, NY, USA) established the Center for Converging Technologies in 2002 to promote intersections between engineering and the liberal arts (including humanities, the social sciences, and the natural sciences including mathematics). The Center, of which Klein is the Director, supports the development of curriculum and research that bridges those areas, including strictly technical areas such as nanotechnology and bioengineering, and more interdisciplinary endeavors such as digital arts, ethics, history, policy and entrepreneurship. The objective is to focus creative thought from engineering and the liberal arts on new ideas that are changing the landscape of global society, and to engage students in interdisciplinary approaches to science and technology [9].

3. The Sci/Art Jam at the Franklin Institute, Philadelphia, PA, USA

A novel way to reach the public with their interdisciplinary agenda presented itself in a "Call for Interest" both authors received in spring 2005. The Franklin Institute, the premier science museum in Philadelphia, was preparing a new exhibition hall cleverly named "Sir Isaac's Loft," featuring hands-on exhibitions that demonstrate laws of physics. Some of the exhibitions were created in collaboration with artists. To inaugurate the space in July 2005, the Institute called for artists to participate in an event they called "Sci/Art Jam." The artists were to create work illustrating a scientific concept, to be constructed in plain view of the public and completed within a 28-hour period. The authors submitted a proposal that was among six that were commissioned.

Both Sir Isaac's Loft and the Sci/Art Jam featured six themes:

- **Changing The Light:** Changing the light changes what you see.
- **Chain Reactions:** Chain reactions need a push to get started and then keep going.
- **Combining Motions:** Combining simple motions creates complex patterns.
- **Physics Feats Of Strength:** Knowing physics allows you to do things that you could not before.
- **Energy Transfer:** Energy can be transferred from one thing to another or from one form to another.
- **Illusions:** Artists use science to fool with your brain

4. “Flush with Excitement”

We selected to demonstrate chain reactions. Chain reactions often have an element of suspense – we wait in anticipation of the trigger event and then enjoy the consequent actions. The flushing action of a toilet is simple physics and a chain of events. In our project, we employ the same method by which we dispose of waste to demonstrate the physics of air pressure, gravity, and potential and kinetic energy. We hoped that the analogy to a toilet would amuse and intrigue viewers, reminding them of the science and technology they encounter every day. In the piece we hold the viewer’s interest through a sequence of fill and flush actions, moving brightly colored water through interlaced connective tubing. [10]

“Flush with Excitement” consists of a sturdy tower (4’x4’x9’high), constructed of steel pipe built with slide-on pipe fittings (Kee Industrial Products). (See Figure 1.) At the base of the tower are large laboratory glass reservoirs filled with colored water. Supported high within the structure are three Vitax 2- gallon percolators – essentially large glass funnels. (See Figure 2.) Submersible pumps force water through plastic tubing to fill the percolators. When the water level exceeds the highest point of the drain tube leading from each percolator, a chain reaction is set off which rapidly empties the vessel.

Figure 1: “Flush with Excitement” at the Franklin Institute.

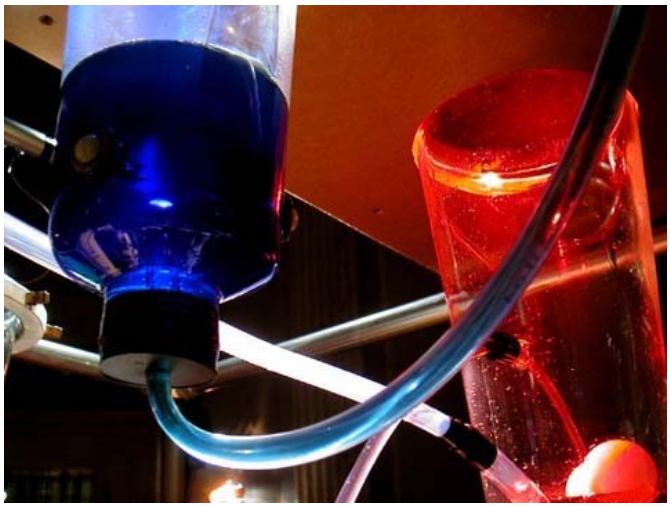

Figure 2: Detail of Vitax percolators filling and draining.

In appearance, the piece is predominantly a tall rectangle defined by steel pipe containing glass vessels and randomly interlaced clear plastic tubing. At intervals, colored water courses through the tubing.

The Franklin Institute chose a site for the Sci/Art Jam that ensured maximum visibility. The chosen site was the museum's lofty rotunda-shaped entrance hall, which features a mammoth seated figure of Benjamin Franklin. In each case an artist or team shipped in their materials and tools and began to construct their projects. The terms for participation were intentionally bizarre. Artists agreed to stay in the museum throughout the 28-hour period, with meals and sleeping accommodations provided by the museum. The museum was open for extended hours during which visitors could watch and discuss the process of making the art. It was incumbent upon the artists to be able to knowledgably discuss the science ideas their work illustrated. We prepared a handout (see Appendix 1) for distribution and happily answered questions. We also prepared a small hands-on model to demonstrate the principle of siphons, so that visitors could understand our intent while the large project was under construction.

The event was a remarkably successful and innovative example of education on science and technology through the arts. Throughout the period of construction, crowds were drawn to the projects, and dialogue ensued. We were pleased to draw interesting questions and were prepared to reply. Often we initiated the conversation.

Most of our audience consisted of children accompanied by their parents. We observed that when parents understood the science that was demonstrated in the piece, they chose to explain it to their children rather than rely on our explanation. (See Figure 3.) We surmise that parents are particularly eager to be their children's' guide to information, when they are able. They may genuinely be best able to communicate ideas, knowing the level of knowledge their children possess. We would advocate that institutions always provide this as an option; it is empowering for parents, who have the opportunity to reinforce the ideas even after a trip to the museum is over.

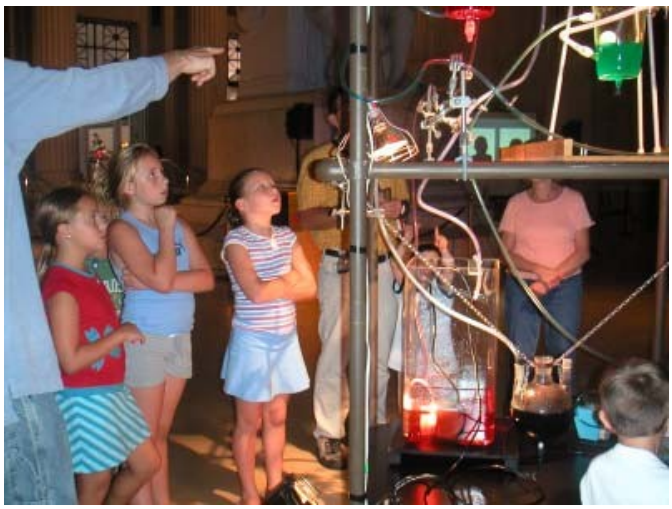

Figure 3: Parents instructing children.

5. Conclusion

"Flush with Excitement" represents one example of how concepts from science and technology can be conveyed through artistic means. Moreover, it represents one example of the creativity that can occur at the intersection of disciplines that have increasingly drifted apart. The drift, which in the eyes of C. P. Snow had become a gulf between two cultures precluding any meaningful communication, has begun to close. The 19th and 20th century trend toward increasingly narrow specialization is giving way to the recognition that specialists benefit from being able to see the bigger picture and to harness expertise from a variety of fields. There is an increasing recognition that interdisciplinary collaborations can produce creative solutions to difficult problems [11].

Whether we believe that we need to attract and retain students into science and technology to build up the economy, or to create the technically literate populace needed to rationally manage that science and technology, or to exploit the creative breakthroughs that can occur at disciplinary intersections, teaching science through the arts is an idea that seems to work. With its mixture of science and the arts, the San Francisco Exploratorium, for example, boasts more than half a million visitors each year.

Connecting technology and the arts has certainly provided artists with an exciting new palette of tools and techniques for their creative work. We have offered a glimpse of the flip side: using art to provide a new pedagogy for engaging the public's interest in science and technology.

6. References

[1] The Science & the Arts / Science Outreach Series at the Graduate Center of the City University of New York is funded in part by a grant from the National Science Foundation.

[2] "Frans Johansson on the Medici Effect," *Ubiquity*, Volume 5, Issue 31, Oct. 6 - 12, 2004 http://www.acm.org/ubiquity/interviews/pf/v5i31_johansson.pdf. See also: http://www.themedicieffect.com/.

[3] Mihail C. Roco, and William Simms Bainbridge, National Science Foundation (2002). "Converging Technologies for Improving Human Performance." See: http://www.wtec.org/ConvergingTechnologies/.

[4] Ch. 11 in K. Eric Drexler, *Engines of Creation: The Coming Age of Nanotechnology*, 1986. See http://www.foresight.org/EOC/.

[5] Dalai Lama (2005). *The Universe in a Single Atom: The Convergence of Science and Spirituality*. (New York: Morgan Road Books), LP edition, p. 269.

[6] San Francisco Exploratorium web site: http://www.exploratorium.edu/about/index.html.

[7] For more information about the program, contact the Arts Center of the Capital Region, http://www.artscenteronline.org/. Documentation of several of the projects can be seen at: http://www.union.edu/PUBLIC/ECODEPT/kleind/today/albums/schalmont/index.htm.

[8] See the Science & the Arts web site: http://web.gc.cuny.edu/sciart.

[9] J. Douglass Klein (2005). "Converging Technologies at Union," http://www.union.edu/PUBLIC/ECODEPT/kleind/ct/images/CT_white_paper_Jan05_v7.doc.

[10] For additional documentation, see: http://www.adrienneklein.net/work/flush.htm.

[11] C. P. Snow (1993), *The Two Cultures*. (New York : Cambridge University Press). Reprint of Snow's 1959 Rede Lecture.

Appendix 1. Handout to accompany the installation.

Flush with Excitement

Adrienne Klein
co-Director, Science & the Arts, The Graduate Center of the City University of New York, USA
Doug Klein
Director, Center for Converging Technologies, Union College, Schenectady, NY, USA

Built for the 28-hour Sci/Art Jam
http://www.fi.edu/tfi/exhibits/jam.html
The Franklin Institute, Philadelphia, PA, USA
July 15-16, 2005

What's going on?

Pumps gradually lift water from the lower vessels to the upper vessels. At some point, the upper vessels begin to empty (flush) and the water level drops. The cycle repeats.

Why is it happening?

The filling of the upper vessels is done by the electric pumps. The draining of the upper vessels is caused by a "siphon." A siphon works by gravity. Watch the water in the drain tube as the upper vessel fills. The water level in the tube rises, roughly level with the water in the glass vessel. When the water level in the tube reaches the highest point, it spills over and begins to drain. When enough water fills the drain tube, it is pulled down by gravity and sucks more water out of the top vessel. A chain reaction is set off, and the suction continues until air gets into the drain tube, and the suction is broken. At this point, the chain reaction ends, and the vessel begins to fill again with water pumped from below.

Where have I seen this before?

As the title of the piece suggests, the action of rising water starting a siphon is most commonly observed in a toilet. The flush is initiated by rapidly emptying water in the tank into the bowl of the toilet. The rising water raises the level above the highest point in the "S" shaped drain, pushing water over the top. This has the effect of priming the siphon, and as water falls down the drain, the force of gravity sucks the remaining water out of the bowl, until air is introduced into the drain, breaking the siphon action.

For more information:

There are several excellent sources of information on the web about how siphons work. See, for example:
http://www.science.edu.sg/ssc/detailed.jsp?artid=6261&type=6&root=5&parent=5&cat=54
http://www.straightdope.com/columns/010105.html
http://www.madsci.org/posts/archives/dec99/944439574.Ph.r.html
http://home.howstuffworks.com/toilet1.htm