Bridging STEM to STEAM: Developing New Frameworks for ART/SCIENCE Pedagogy

Project Description

Introduction

The Rhode Island School of Design (RISD) requests support to plan and carry out a two-day workshop at RISD in January 2011 to develop an innovative educational agenda that forges relationships between art and design disciplines and science, technology, engineering, and mathematics (STEM). The workshop will bring together four constituent communities: scientific researchers; information technology experts and creative technologists; artists and designers; and education researchers interested in enhancing cyber-enabled STEM education through interdisciplinary collaboration with artists and designers (STEAM). This workshop will be designed specifically as a process of inquiry aimed at discovering and communicating shared insights within one intensive event that will provide a platform and a network for the further development of this initiative among the participants and as a replicable model.

The long-term goals motivating the event are to:

- Develop strategies for enhancing STEM education through the integration of art and design thinking (STEM + ART = STEAM).

- Invent and share techniques that take advantage of simple, freely available IT systems and applications to support enhanced observation, analysis and understanding of pictorial and numerical data.

- Build new connections between art and design disciplines and scientific fields to advance understanding of complex systems, e.g., through improved strategies and techniques for the shared perception and visualization of scientific data.

The proposed workshop will initiate a discussion of how to bridge STEM education practices and creative problem solving (STEM to STEAM) as an innovative educational approach. In addition to this intensive engagement around questions of art/science pedagogy, this workshop will begin to examine quantitative evaluation methods for determining the efficacy of involving creative practices and their associated research strategies in problem-based STEM teaching and research methods.

Rationale

Artists and designers can make vital contributions to meeting important challenges facing 21st century educational practices and the STEM agenda. The last decade has seen an explosion in both the quantity and complexity of scientific data in fields ranging from genomics to astronomy. Researchers and educators need new means of visualizing and interrogating scientific information, both to understand data and to communicate the aims, accomplishments, methods and importance of STEM disciplines to broad audiences, including policy makers, educators, K-12 students, and the general public. Artists and designers can play essential roles in improving STEM education and effectively communicating scientific information and ideas. More broadly, the tools and methods of design offer new models for creative problem-solving and interdisciplinary partnership, introducing innovative

practices of design thinking into STEM education and research.

To realize this potential, scientists, artists, and designers must develop new ways of working together, new modes of research, and a shared language for collaboration. The emerging research on "multiple intelligences,"[1] the "situated" and "embodied" character of learning and cognition[2], and the critical contributions that studio-thinking and studio practice can make to learning in other domains[3] provides a starting point for developing new frameworks for pedagogical approaches that bridge the gulf between art and science and support effective cross-disciplinary research initiatives in art/science pedagogy. The interactions between so-called objective and subjective responses to complex information and bodies of data must be brought out and understood by means of effective art/science collaborations whose aim is to promote trans-disciplinary insights and shared language around questions of teaching, learning, and pedagogy that will promote core research activities and enhance public engagement with science.

Pioneering events bringing together scientists, artists, and designers to explore areas of potential collaboration are crucial to developing both the practices of research and inquiry and a language supporting cross-discipline research activities. The creation of temporary events and spaces to promote insights that transcend disciplinary borders is becoming a social, cultural and disciplinary imperative where communities of different researchers need to develop their work, either in parallel with related topics or in new or unexpected conjunctions that can motivate and inspire new developments in research practices. As with the EPSCoR workshop described below, such "encounter spaces" can have a transforming effect, both in terms of cross-disciplinary communication and research and in terms of public engagement with science. The workshop at RISD for which support is requested will serve as a strategic event advancing these goals, with specific benefit to interdisciplinary research interests.

The innovative use of available technologies in the context of cross-disciplinary knowledge building will be central to the success of the art/science collaborations envisioned. RISD is known for exploratory combinations of digital media and visual communication strategies in a wide range of art and design disciplines, each with their own technical specialties. Equally important, information technologies have the potential to network and disseminate interdisciplinary encounters, providing an emergent and continuing feedback and multiplying the potential associations of ideas back to a variety of sources of focus and achievement. For educational institutions interested in developing "event-based" teaching and learning strategies that support research, the event proposed here will provide a demonstration of the potential for cross-disciplinary and inter-institutional collaboration.

Under the leadership of President John Maeda, a renowned artist and computer scientist, RISD is well positioned to play a leading role in developing new models for art/science collaboration, and brings unique resources to this effort. RISD is one of the premier art and design schools in the United States, and has deep strength in closely relevant fields, including Digital Media, Industrial Design, Graphic Design, and Illustration. The School has a long record of collaboration with leading universities and research centers, including MIT, Brown University, the University of Rhode Island, Harvard, Massachusetts General Hospital, and the Yale School of Medicine.

This history of collaboration among leading research centers in the region provides an already existing organizational network for the development and dissemination of the type of research activity proposed here.

RISD-based artists and designers currently collaborate successfully with scientists and engineers on a range of innovative projects. For example, RISD illustration professor Fritz Drury has partnered with scientists at Brown to understand how bats fly by developing three-dimensional visualizations of bat

flight in a virtual reality environment, incorporating highly complex datasets. RISD was recently selected by Oblong Industries to help beta-test and explore applications for *g-speak* (gesture speak), the world's first three-dimensional, gesture-based operating system. Using a system of cameras and sensor-equipped gloves, *g-speak* Studios at RISD are exploring the potential of embodied interaction with highly complex, three-dimensional data arrays. This work has clear implications for the development of new interfaces and new methods of data acquisition and visualization in support of data-intensive scientific research. RISD's Edna Lawrence Nature Lab includes more than 80,000 natural history objects, including live animals, and a computer and camera workstation, with dissecting and compound microscopes. Within the Lab, the Arthur Loeb Design Science Collection comprises hundreds of polyhedra and two-dimensional patterns that permit hands-on investigation by artists and designers of underlying formal and structural relationships inherent in the natural world. RISD's Continuing Education division also offers a certificate program in Natural Science Illustration that helps students develop observational skills needed for the realistic depiction of science information across a variety of media.

RISD is one of eight collaborating institutions in the Rhode Island NSF EPSCoR, including the state's pending Research Infrastructure Improvement proposal to the NSF (RII-Track 1). The grant aims to advance research on the effects of climate change and build appropriate institutional, technological and communications infrastructure. RISD's involvement will help develop visual techniques and communication strategies for scientists, and facilitate successful interdisciplinary research at the intersection of science, art and design.

In 2009-10, as part of the School's participation in EPSCoR, RISD pioneered two events of a more general nature under the banner of "Making Science Visible[4,5]."Attendees and participants were drawn from a variety of scientific, arts, and design disciplines. The current workshop proposal will apply the insights and techniques gained from these multi-discipline events to the problem of developing innovative educational opportunities at the intersections of the arts and sciences.

Activities

With the requested grant, RISD will plan and carry out a two-day intensive workshop/seminar focused on developing a framework for STEAM pedagogy. This workshop will provide a critical impetus to expanding current discussions taking place and opening new areas of exploration at the interface of art, science, technology and design education. Questions to be explored include:

- What is the role of creativity in the arts and sciences, and how can these creative practices be translated into educational materials, models, and practices?
- What common skills, methods, and practices exist in the arts and sciences, and how can their teaching benefit from interdisciplinary, STEAM pedagogies? Similarly, what are the forms of knowledge that exist in one area that could be useful to teach in the other?
- How can pedagogical approaches in the arts (e.g., the studio critique) and STEM disciplines (e.g., inquiry learning) be combined to produce effective strategies for STEAM instruction?
- How can informal learning institutions like art museums and science centers contribute to the lifelong pursuit of STEAM learning?
- What forms of professional development do we need to prepare teachers and other educators to design and enact STEAM curricula?
- What computational supports can be borrowed and/or need to be created to support STEAM learning?

President Maeda and RISD faculty will draw upon RISD networks and existing external partnerships to convene leading researchers, technologists, artists and designers, and educators, and make the event a success. The final participant list and workshop agenda will be developed and approved in consultation with the National Science Foundation sponsoring Program Director as the activities align with CreativeIT, Human Centered Computing and Cyberlearning Transforming Education programs.

Participants from the following four constituent communities will represent a national perspective in their respective fields. RISD anticipates approximately 60 participants.

1/ Education researchers providing a foundation for effective methods that bridge STEM and STEAM pedagogical goals;

2/ Artists and designers possessing a high level of observational skills and expertise in the cultural and pedagogical role of "critique" in processes of teaching and learning;

3/ Scientists working in areas requiring understanding and dissemination of complex structures and processes and with research interests in exploring science pedagogy from a multidisciplinary and process oriented perspective; and

4/ IT and creative technologists.

The design of the event will be based on selected knowledge-building strategies and will incorporate appropriate elements derived from aspects of embodied cognition and studio practice to assist cross-disciplinary work. These strategies have been successfully applied previously, the most recent example being "Making Science Visible," a broad networking seminar event held at RISD and devised specifically for the occasion by RISD EPSCoR PI, Christopher Rose. The detail design of "Making Science Visible" was established following a six-week research and preparation period intended to prepare an in-depth understanding of the criteria and objectives for the event. A similar strategy will be used for this workshop.

Many faculty from EPSCoR partner institutions who attended "Making Science Visible" at RISD in April 2010 have already expressed interest in partnering or contributing to the type of work addressed by this project, including David Farmer, Dean, Graduate School of Oceanography (GSO), Dwight Coleman, Director of the Inner Space Center, and David Smith, Associate Dean, GSO, (University of Rhode Island); and Michael Paradiso, Professor of Neuroscience, John Donoghue, Director of the Brain Science program and John Davenport, Associate Director, Bio-Medical Institute for Brain Science (Brown University).

Expected Outcomes

Building upon RISD's experience of hosting special events, this ambitious model will lay an intellectual foundation for effective art/design and science/technology cross-disciplinary educational research activities (STEM to STEAM) potentially extending beyond the immediate event to other national applications. RISD, the host institution will build capacity in supporting applied research in interdisciplinary domains. The event will also serve as a springboard for developing methods to advance cross-disciplinary insight, and extend the language of discovery across a developing network of researchers, educators, and technologists.

Concrete outcomes of the workshop will be a white paper report and web-based publication of

presentations and a summary of event outcomes and other resources and their contributors. The report will be disseminated to the National Science Foundation and will be made available for general public dissemination. The workshop is tentatively scheduled for January 2011 and will take place on the RISD campus in downtown Providence.

Costs

The requested funding will cover the following main activities: detail planning and preparatory stage involving consultation with partners and contributors and the production of briefing materials; identification of and communication with event attendees and participants; event design, facilitation, management and hosting arrangements including space and administrative personnel; gathering of outcomes and resources for post-event dissemination; and establishing online documentation and resource tools for further development.

The Principal Investigator for the project is Christopher Rose, Interim Principal Investigator of NSF EPSCoR at RISD. Brian Smith, Dean of Continuing Education at RISD, will assist Professor Rose in planning the workshop and disseminating its findings.

Intellectual Merit

A primary goal of the workshop is to begin developing educational practices to support interdisciplinary, STEAM learning. This activity will provide participants with direct access to shared processes of inquiry into art/science pedagogy with the immediate goal of achieving a high level of comprehensibility and knowledge sharing, broadening the accessibility and appeal of science, and transforming the discourse on STEM discovery and learning.

The proposed activity also has the goal of enhancing observation and analysis techniques and their shared usage with state-of-the-art, freely available IT. Methods and practices that promote shared ideas, insight, and language have the potential to alter STEM education and research practices in formal and informal settings. The availability of low-cost, high-quality means for analysis and dissemination of scientific ideas now promises to revolutionize methods for communicating, disseminating and publishing science.

The proposed workshop advances the broad goals of the CreativeIT Program and STEM education initiatives, presenting potentially transformative early-stage work and novel interdisciplinary collaboration.

Broader Impacts

The proposed event, including the preparatory research and subsequent analysis of outcomes, will broaden participation of individuals bringing new specialties into working in STEM. Results from the workshop will be used to generate educational materials that exemplify interdisciplinary couplings between the arts and sciences. For example, we will develop and run a new prototype course of one semester aimed at graduate students and their research activities provisionally titled "Creative Insight: Preparation for effective Arts/Design/Science collaboration." The course design is based on a mixed group drawn from, in the first instance, biology and life sciences and arts and design specialties. Its theme is the challenge of investigation, understanding, representation and communication of examples of complex systems.

We will also develop STEAM course offerings for high school students through a Pre-College summer program offered through RISD's Continuing Education division. The broader intention of the prototype course is to provide a tangible example that can prompt parallel developments at other institutions. Possible departure points for such interdisciplinary collaborations were established at the April 2010 "Making Science Visible" NSF EPSCoR event at RISD. With three or more such developments occurring in parallel there will be sufficient critical mass to develop a "STEAM" pedagogy.

Results from the workshop will be used to develop STEAM education and research models that if successful, will have the potential to be replicated in many educational and scientific communities. As art thinking influences scientific thinking and vice versa, there is potential for an increased public understanding of science and the scientific challenges facing our nation and the world.