# Media Arts in Support of Science Education

Daria Tsoupikova *1, Julieta Aguilera *2, Helen-Nicole Kostis *3, Tina Shah *4, Brenda Lopez Silva *1
*1 University of Illinois at Chicago, IL *2 Adler Planetarium, Chicago, IL, *3 NASA Goddard Space Flight Center, MD. *4 The Field Museum of Natural History, Chicago, IL

**Keywords:** Media Arts, STEM, Science Education, art-science, visualization, interactive applications

## Abstract

This paper examines the role of media arts in the development of interactive learning environments for science, technology, engineering, and mathematics (STEM). The use of technology-mediated interactive environments already provides greater access for science learning to wider, more diverse, and especially younger audiences. Since children typically enjoy playing computer games and interacting with new technology, media art provides a motivating setting for science education. The movement to integrate science and art to examine convergence points, and how the fields can empower each other, has already begun. However, the role of arts and artists in the design of advanced applications for STEM education has yet to become subject for research and implementation in mainstream cultural institutions and educational programs. Collaborative, interdisciplinary teams of artists, technologists and scientists developed novel interactive learning projects that educate the public on fundamental science (STEM) disciplines. Five interactive educational applications were designed based on the leading art and design concepts with a focus on user engagement, interactive design, and aesthetics principles. With these principles at their center, these applications and their educational content were designed to create interactive and engaging learning experiences. We describe the role of art in the development of these projects and examine how artists can cross disciplinary borders to collaborate in the development of innovative educational STEM learning applications.

## Introduction

Interactive 3D applications and visual storytelling are of increasing relevance in our dynamic contemporary culture. Results of art/science/technology collaborations directly can affect educational and pedagogical practice and society at large. In the last few years, there have been a number of meetings that studied art and science convergences supported by efforts of the National Science Foundation (NSF), National Endowment of the Arts (NEA), the Association for Computing Machinery (ACM), the Conference on Human Factors in Computing Systems (HCI), as well as other institutions (Comer 2011; STEAM 2011). Despite these efforts, the integration of arts in science education has yet to become subject for research and implementation in mainstream cultural institutions and educational programs. To date, little research has been conducted to investigate the role of art, aesthetics, and creative storytelling in the design of advanced technologies for education. In this paper, five professional artists involved in contemporary practice examine how media art applications influence informal science education. Each of the authors led the artistic development of the independent interdisciplinary interactive learning applications that educate the public on fundamental science disciplines. We describe our case studies and the role of artists in the design of STEM educational projects.

### Case studies

**The Cryptoclub: Cryptography and Mathematics Afterschool and Online** is an NSF funded interdisciplinary research project introducing cryptography and mathematics to middle school students across the country through the encryption and decryption of codes. Project objectives include increased awareness of cryptography as a STEM topic with connections to mathematics as well a greater understanding of effective strategies for integrating and supporting online and offline activities within informal learning settings (Beissinger). The project's team is from the University of Illinois at Chicago and includes two mathematicians with extensive experience in math education; one artist, whose research is in visualization, interactive animation, and educational multimedia; a cognitive psychologist with extensive experience in research, development, and evaluation of multimedia mathematics and science materials for middle schools; and expert teachers who pilot the project materials. Project partners include the Young Peoples Project (YPP), a national afterschool program; Eduweb, an award-winning educational software design and development firm; and American Institute For Research (AIR), an evaluation firm with experience in afterschool evaluation. The artist’s role focuses on the development of the art and design portion of the project. Artist collaborates in the design of the website, the online games and other digital activities, and develops concept designs for 3D environments of the computer games. The artist leads the development of historic cryptography comics. As part of this effort, the artist is responsible for researching historical information about the environment, architecture, clothing, and other details in order to achieve convincing and historically accurate visualizations. Project materials include afterschool and online activities that will enable students to learn and apply cryptography and mathematics skills. This includes a Cryptoclub website, challenges, treasure hunt clue generator, cryptography adventure games (2D single-user games and 3D multi-user games), and offline games and activities that involve active participation, a leader's manual, and training workshops for afterschool leaders. In addition the project is developing historic crypto comics, a series of stories in graphic-novel format that are based on historical events related to cryptography (Fig. 1). The project materials were developed and tested in afterschool programs in Chicago and will be field tested in approximately fifty sites around the country.

**The Gravitational Simulator** was part of the exhibit gallery "Gravity Shapes the Universe" at the Adler Planetarium. It used embodied interaction as degrees of power and intensity in force gestalts (Johnson, 1987) and as a means to bypass the “representational bottleneck” by reducing the cognitive workload (Wilson, 2002) through visual and proprioceptive senses in order to explore the complexity of multi-body gravitational interactions in the Universe.


**Figure 1.** *Mary Queen of Scots* graphic novel: Queen Elizabeth's cipher secretary analyzing Mary's encrypted message. **Figure 2**. *The Gravitational Simulator*.

The Gravitational Simulator was developed by Mark SubbaRao. It was enabled by a Microsoft Kinect, which allowed users to create their own n-body simulation of gravitational dynamics. Interaction originally happened in two phases: first, visitors could set up the initial conditions of the simulation, and second, the simulation run the full n-body calculation in the two dimensions of a projection screen. Aesthetic aspects such as active free-drawing and color served to focus the attention of visitors. Software used was Processing, OpenCV, and Dan Shiffman's Kinect Library. When hands were still, clusters of particles were created, and when moving, they would input an initial velocity for the particles. As their gravity and speed interacted with other particles, clusters of them accumulated and exerted greater gravity, similar to how galaxies form and interact.

The exhibit was open for several months during which we assessed its effectiveness. We experimented with a continuous particle generation state that supported quick gallery engagement. A series of video tutorials were also presented to visitors and showed how to draw simulations of different scales such as star clusters, galactic mergers and the Cosmic Web. Finally, a version on a display was placed next to the projection and Kinect system. This version allowed for more control but was found to not be as good in emphasizing the initial speed that would allow or prevent particles to orbit clusters of particles. In conclusion, these simulations seem to be better understood in real time for museum visitors, and the aesthetic and embodiment aspects support the exploration. Projects like the Gravitational Simulator suggest interesting questions in the area of informal science education, where we can learn about physics within representations we can aesthetically inhabit today.

**NASA Visualization Explorer (NASAViz)** is an intuitive and interactive free iPad application available via the iTunes store that delivers bi-weekly science stories about NASA's exploration of the Earth and its moon, the Sun and its planets, and the Universe. The app was released to the public on July 26, 2011 and as of May 2012 has achieved more than 700,000 downloads by users worldwide. The stories emerge from produced and visualized satellite data (animations and images) with the purpose of educating the public about NASA's science research in an informal and visually rich environment. Sample stories include hurricanes, ocean currents, daily snow cover, solar eruptions, discoveries of new planets and the orbits of satellites of NASA missions. The app is an in-house production of the NASA Goddard Space Flight Center and the broader team is divided into three groups: the Editorial Board, the App Development Team and the Content Development Team. The Editorial Board and the App Development Team make up the core multidisciplinary team of the NASAViz project where members include science writers, data visualizers, software developers, producers and interactive designers. The roles and skills required in each of these groups are described in the following diagram:

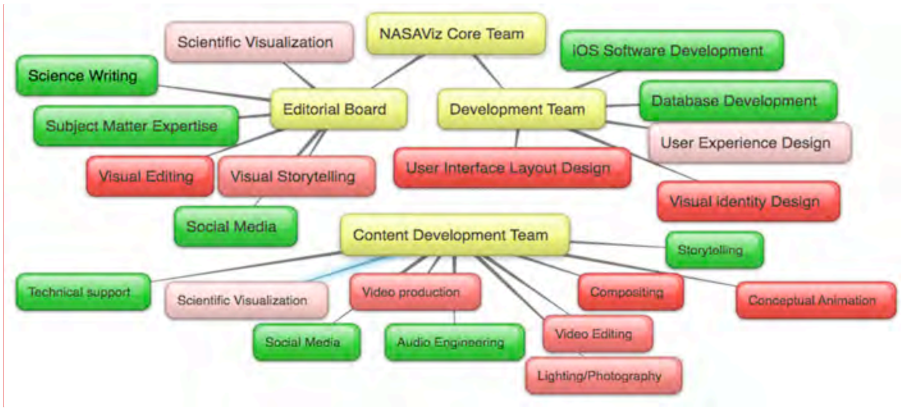


**Figure 3.** Skill sets available in the teams involved in the production of *NASAViz* stories. Skill sets in red hues signify a higher proportion of media arts.

alex 5/31/12 2:04 PM
**Comment:** Eleni , storytelling is mentioned in paper as arts. (in abstract)Can you change color to red? How about audio?

Even though the app is developed for the general public it is also used by teachers in the classroom as an informal education medium for curriculum support. For this reason the NASAViz team is working closely with the NASA Office of Education and plans to launch the NASAViz Teacher Pilot project in September 2012. The purpose of this effort is to: 1) learn more about how teachers use the app in the classroom by creating a virtual community for the teachers to share their lesson plans, story playlists and tips, 2) receive input on new features which may assist the teachers and 3) receive feedback from teachers about the content, especially about stories on hard-to-explain scientific and natural phenomena that are part of the curriculum.

**Create Your Own Mosaic:** Creating engaging and educational experiences is quite a challenge no matter how shiny or new your platform is. For example, we knew we wouldn't have much trouble attracting people to the *Create Your Own Mosaic* multi-touch table interactive, part of the *Natural Wonders: A Roman Mosaic from Lod, Israel* exhibit at The Field Museum in Chicago. Visitors were able to design their own mosaic using digital versions of the drawings they saw in the real mosaic positioned near the interactive table. It was already an engaging experience - one person (or more) was able to select/touch a graphic from the bullpen, and then drag, rotate, and scale it on a blank canvas, beginning their creative process. Just like painting or any other craft, you eventually became immersed in the experience. Teaching the history behind the various drawings of birds, fish, and other animals and objects was the bigger task. Scientists at The Field Museum wanted to tell the story behind the imagery and its relationship to Roman culture, and eventually, that’s exactly what they did. When a visitor selected an icon, a short video of one of our scientists appeared, sharing interesting facts about the object. The visitor/creator of the mosaic, and the audience around, were able to either pause, watch and listen to the scientist, or just listen as they manipulated their object. The video clips were kept short, about 20 seconds, in order to provide easy to digest information. User experience and design were also key in the ability to educate. We wanted to make sure the creating of a mosaic was not disrupted by a playing video, but enhanced with learning. Small things like fading in the video and its placement made for smoother absorption. Placing smaller versions of the icons in the top right corner of the videos reinforced what the scientists were speaking about. The ability to replay the video made sure you could watch and listen again in case you missed it the first time. Text was also provided in case reading was preferred. The whole experience was not happening only on the multi-touch table, but in the larger space, with speakers and a large projection on one of the walls. This way you could interact or just observe, either way walking away with some new bit of knowledge.


**Figure 4.** *Create Your Own Mosaic* at the Field Museum**. Figure 5**. Users experiencing *A Mile in My Paws* immersive environment.

**A Mile In My Paws** is an interactive 3D application designed to raise awareness of the affects of climate change for the Polar Bear population. It introduces zoo visitors to concepts of ice melting in the North Pole by giving them the opportunity to traverse and explore a visualized area of the Beaufort Sea – a terrain based on historical data, and on projections of ice coverage in the future.  The main goal is to teach that the longer the polar bears swim, the more energy they consume for hunting. The navigation and interaction requires users’ physical effort and embodiment to support learning. For swimming, users wear a pair of polar bear paws with an embedded iPod touch that sends the acceleration data to the system.  For walking, users step on a step-pad with pressure sensors connected to the system. The virtual environment is complemented with an iPad application that displays real-time information related to users’ performance and climate change facts. Our research looks at factors related to user experience, embodiment and learning outcomes about climate change.  At this point we have done formative studies about system calibration and user experience/interaction (Lyons, 2012) that includes: 1) judgments about different levels of efforts; 2) attention focus and degree of immersion; 3) degree of personalization of the experience; 4) individual approach to using the embodied controls. The design process included a series of discussions with experts in climate science, education, computing and design. The purpose of the group's research has been to accurately inform the general public about current research on climate science and to make it engaging through graphics, immersion, and embodiment. The first revisions in the design process were content driven –guided by science experts. The latest phases were influenced by the results of the formative studies, resulting on the redesign of the system interfaces –replacement of wiiMote for iPods, weight addition to the globes; and changes to graphic elements. They also lead to the creation of an additional iPad interface to display users' progress, performance graphs, and to showcase facts triggered by the user's location in the virtual environment. The development team fueled the creative process, and it has driven content changes, visuals, and aesthetics of the virtual environment. It has been an informed design that perhaps without the team's feedback, could have introduced misconceptions and led to undesired results.

## Conclusion

The process of identifying elements of a successful art/science development that focuses on creative engagement and incorporates practices and theories from media arts and STEM education is just beginning. There are growing opportunities for artists for innovative ways of collaborating with scientists in the design of interactive learning applications. The differences and similarities of art and science research methods, creative discoveries, evaluation methods, and the challenges in the development of STEM applications will be covered in future research of this group.

**Acknowledgements**
Thanks to the Electronic Visualization Laboratory (EVL), the NASAViz App Development, Editorial and Story Development teams ("*NASA Visualization Explorer for the iPad – Credits"),* Cryptoclub team, Janet Beissinger, Mark SubbaRao, SVL at Adler Planetarium, Andrea Barbarin and Deepika Yuvaraj from ASB 2012 at University of Michigan, The Field Museum of Natural History, Israel Antiquities Authority, Tom Moher, Leilah Lyons, Brian Slattery, Priscilla Jimenez, Learning Technologies Group, UIC.

**References**

1. Chris Comer, "SymBIOtic ART & Science: An Investigation at the Intersection of Life Sciences and the Arts", *Final Report for the NSF Art and Science Workshop, NSF and the NEA*, Arlington, VA, pub. 2012
2. The STEM to STEAM Briefing, *Rhode Island School of Design*, September 2011, http://stemtosteam.org/
3. Janet Beissinger et al., "The Cryptoclub: Cryptography and Mathematics Afterschool and Online", DRL, NSF, <http://www.nsf.gov/awardsearch/showAward.do?AwardNumber=0840313&version=noscript>
4. Johnson, M.,"The Body in the Mind", *Chicago: University of Chicago Press*, 1987
5. Wilson, M., "Six views of embodied cognition", *Psychonomic Bulletin and Review*, 9, pp. 625-636, 2002
6. *NASA Visualization Explorer for the iPad - Credits*. NASA SVS, n. d. Web. 27 May 2012, <http://svs.gsfc.nasa.gov/nasaviz/credits.html>
7. Lyons, L. et al, "Don't forget about the sweat: effortful embodied interaction in support of learning." in *Proceedings of the Sixth International Conference on Tangible, Embedded and Embodied Interaction* (TEI '12), ACM, New York, NY, USA, pp.77-84, 2012