

Visualizing Math Art Activities at the GameLab

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Abstract

I share recent projects at the GameLab, a new facility at the University of Baltimore that uses math-art to visualize and engage students in mathematical concepts and real-world problem solving using a virtual reality system. I highlight the importance of this collaborative space, inspired by the yearly Bridges conference, to students and the university community.

Introduction: How Bridges Inspired GameLab

Reza Sarhangi (1952–2016), founder of the Bridges Organization, had a vision of crafting an educational model connecting the fields of mathematics and art. GameLab, a center for interdisciplinary research in STEAM (Science, Technology, Engineering, Arts and Mathematics) education, is a tribute to Reza’s visionary endeavors, his passion for exploring interdisciplinary crossroads, realized in a shared experimental space. While hosting and organizing the Bridges Conferences for 18 years around the world, Reza understood the importance of developing innovative ideas for mathematics and science education via the arts and technology. Reza also understood the value of creating innovative collaborations between scholars and the community, offering hands-on activities and developing programs that use art as a medium to engage students in mathematical concepts. For more details about the history of Bridges, see the *Mathematical Intelligencer* article by Kristóf Fenyvesi [1].

The concept of “A Bridges Center” was introduced in 2007 during a workshop titled “Innovations in Mathematics Education via the Arts” at the Banff International Research Station for Mathematical Innovation and Discovery [3]. It envisioned a multi-purpose center to facilitate collaboration between mathematicians, scientists, educators, scholars and artists, providing support for the development of innovative educational tools, software, and textbooks.

In recent years, Reza was working towards his future vision of establishing a Bridges Center in Baltimore, Maryland. He foresaw the center becoming a remarkable educational umbrella, providing support for every aspect of STEAM education. This paper extends the proposal for “A Bridges Center for Mathematical Connection in Arts and Science” from the 2016 Bridges Proceedings that envisioned an educational space for interdisciplinary work in mathematics and its connection to the arts and science [2].

The shaping of “Bridges Center” into reality gained momentum after the Bridges 2015 conference in Baltimore. Reza’s passing on July 1, 2016, stunned the worldwide mathematical art community [7]. The GameLab was established in celebration of Reza’s life, his passion and his inspiring obsession for connecting mathematics, art and science.

The GameLab

GameLab [4] at the University of Baltimore (UB) is a multipurpose research facility that supports students, faculty, and the local community in interdisciplinary research in STEAM education. With a dedicated space of approximately 1400 square feet, the center complements classroom learning for students and allows faculty to engage in research and creative exploration through experiments in science, math and art.

The GameLab is currently used as:

- a) an exhibition space to support STEAM education. It provides partnership opportunities with local and regional institutes to develop creative and scholarly initiatives for students and faculty. Students and public are receptive to mathematical and scientific ideas when presented in the context of a fine art display. This initiative has benefited students in developing their critical thinking skills in a subject matter. The display of scientific process as an art exhibition has shown significant impact in the community.
- b) the workshop space in interdisciplinary research for mathematicians, scientists, students, artists and scholars with an interest in education and the arts. The center supports new initiatives in developing mathematical and scientific ideas into hands-on activities throughout the year.
- c) an experimental studio for creative practitioners working in diverse media, including painting and sculpture, movies and theater, computer images and software development, games and interactive media. It supplements classroom learning and prepares students to transform their knowledge into meaningful applied research.

GameLab supports artists and scholars from inside and outside academia. It has been used to develop educational tools, such as software utilities, movies, games and other types of productions. The collaborative relationship between faculty and students at the GameLab has inspired many types of teaching and learning opportunities, including some new initiatives within the Baltimore community. The center is equipped with immersive visualization and interactive game technologies such as the CAVE virtual reality system.

Virtual Reality and Visualization

To aid in visualizing math-art activities, the U-Shaped CAVE virtual reality system was designed and constructed. Inspired by various types of display technologies and CAVE design – particularly superior in field-of-view and visual acuity [5] – we used modular walls and low-cost hardware electronics (Figure 1). The system relies on a multi-projection positioning system to achieve 3D stereoscopic viewer-centered perspective, synchronized with an active shutter glass. The active shutter glass converts the 2D images generated by the projectors into a three-dimensional stereoscopic display. To attain interactivity, haptic devices such as Xbox 360 and PS3 wireless game controllers were interfaced with a host workstation. The controllers were also used as tracking devices for navigation and user position.

To demonstrate the projection ability and visualization technology to achieve virtual reality (VR) research goals, students worked with construction materials. PVC pipes were used to design the modular CAVE structure. Shower curtains were fabricated into a rear-projection stereoscopic display (Figure 2).

Once constructed, a research project “*The Preservation of Cultural and Historical Artifacts*” was conceptualized to examine and analyze the CAVE system. In this project, students converted a physical historical environment, the *Bungamati Temple* (Figure 3a) in Nepal, which was destroyed in the April 2015 earthquake (Figure 3b), into an interactive 3D projection using the CAVE system. All historical artifacts were developed using 3D modeling techniques. The environment was mapped using historical archives and video footage. To accomplish the visualization and accuracy of the 3D interactive artifacts,

students worked with museums and the national archives of Nepal. To learn more about the details and a pilot study that was carried out to examine the user preference to identify, navigate and locate historical artifacts in the CAVE virtual reality system, see [6].

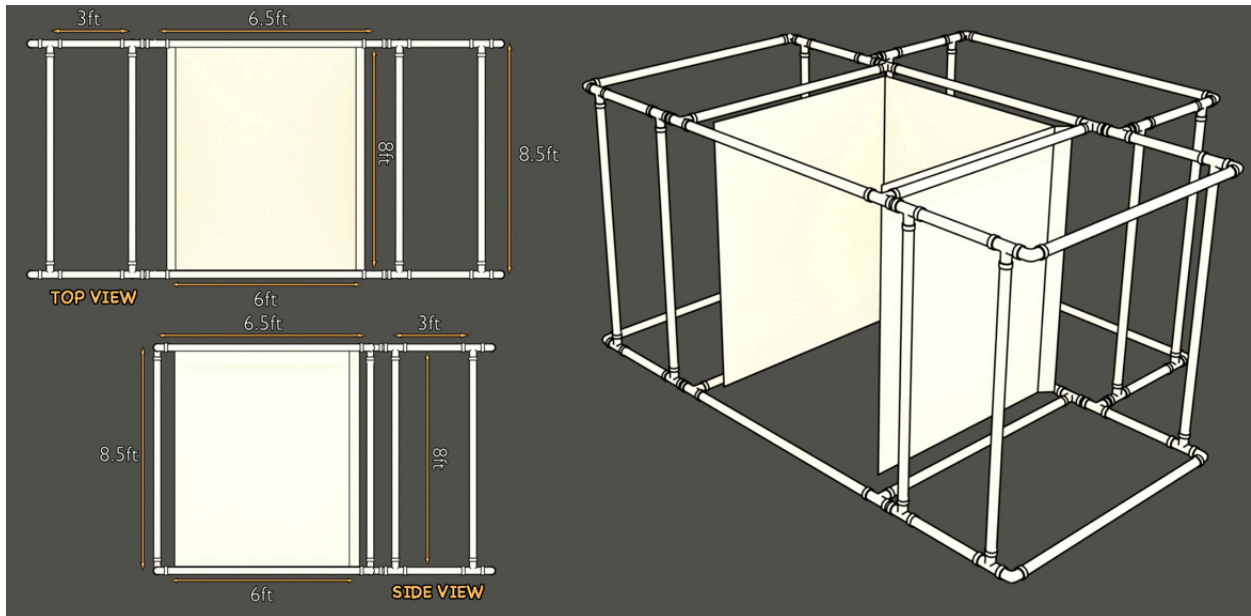


Figure 1: The schematic view of the CAVE virtual reality system. Illustrated by Cristian Villalobos.



Figure 2: Students at the GameLab constructing CAVE structure using PVC pipes and shower curtain.



Figure 3: a) Bungamati Temple. b) After the April 2015 earthquake. c) “Bungamati Temple” in CAVE system.

Documented student accomplishments that contributed to learning:

- Empowered students in participating and collaborating in an interdisciplinary research design.
- Material understanding of objects by the physical construction of CAVE structure.
- Involving students in mathematical and scientific concepts.
- Integration of historical physical environments into a 3D interactive VR application.



Figure 4: The CAVE system setup at the GameLab, University of Baltimore.

The Future of GameLab

GameLab offers a way to continue Reza Sarhangi's vision for hosting various types of STEAM-related collaborative activities throughout the year. The ongoing collaboration at the GameLab incorporates Reza's vision in developing educational tools to teach foundational mathematics, environmental sustainability and audio games. As a creative and experimental space, GameLab will continue to promote collaboration among students, faculty and community to develop and discover new ideas for classroom teaching and learning.

References

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