Extending Inquiry: Collaborative Learning with Immersive, Interactive Projection

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Abstract: We report two studies that highlight how immersive, interactive projection technology supported collaborative STEM inquiry learning. The immersive experience was brief (15 minutes) but inquiry extended well beyond. In study 1, this extension was provoked by a student noticing a pattern and leading the class to derive a formula. In study 2, students graphed data from the dome, provoking questions about superficially-understood phenomena. We found pairing immersive, interactive projection with problem-based lessons provoked generative learning.

Major issues addressed and potential significance

Engaging and inspiring *all* students to participate in STEM learning is a major challenge; with new standards focused on STEM *practices*, our understanding of how to support all learners is limited. Our research investigates the potential of immersive, interactive projection to support inquiry. Our research team has the capacity to develop low-cost immersive, interactive projection kits for use in classrooms. We are interested in considering how our designs can transform corners of classrooms into the Rings of Saturn, carbon nanotubes, field trips to the Devonian, etc., providing collaborative contexts for inquiry learning. In this paper, we present results from two pilot studies, which sought to explore how immersive, interactive technology (Figure 1) might provide context for inquiry teaching and learning. To achieve these objectives, we are developing technology, codesigning projects with teachers, and studying implementations and student learning. We are investigating, in what ways might an immersive experience provide a context for inquiry learning, before, during, and after the experience? We explore the design affordances for using immersive projection to support collaborative inquiry. The focus of this paper is to compare two designs that were tested. Virtual learning environments enhance learning when they offer a situated experience (Dede, 2009), which is an effective inquiry approach (Rivet & Krajcik, 2008). Although little research has explored the use of immersive projection technologies for learning (Apostolellis & Daradoumis, 2010), studies have found benefits for viewing immersive displays in terms of recall (e.g., Sumners, Reiff, & Weber, 2008). Open questions about the role of immersive environments for learning remain; in particular, Dede (2009) highlights that research is needed on supporting transfer by blending learning across virtual and real settings. We explore how learners proceeded through real and projected settings.

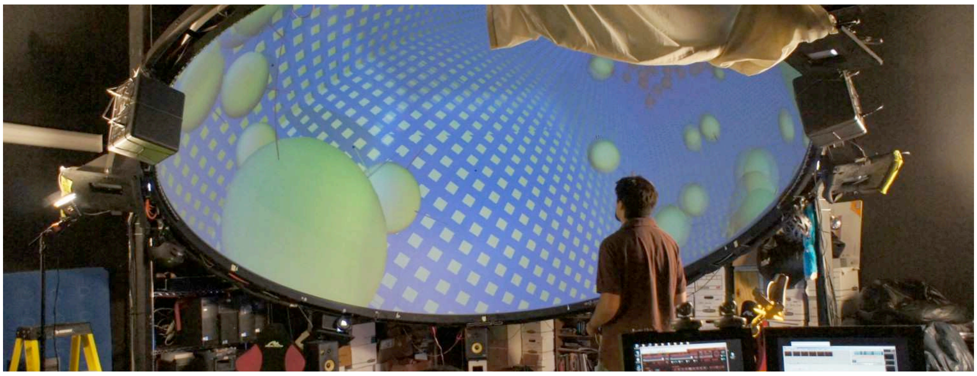

Figure 1. Our dome can accommodate about 12 people. Novel control devices allow for interactivity.

Methodological approach

These studies use a design-based approach (The Design-Based Research Collective, 2003), leveraging findings for refinements to the inquiry lessons and technology, and leading to design guidelines for supporting inquiry with immersive technology. This project brings together expertise in computer science, mathematics, science, teacher education, and learning sciences. We examine learning through interaction analysis (Jordan & Henderson, 1995) and as evidenced in assessments and artifacts. Two teachers (co-authors MD and NK) were recruited to design and implement highly-scaffolded problem-based lessons incorporating immersive, interactive media. Mr. Dahlgren co-designed a lesson on arithmetic and geometric sequences with a narrative context of asteroids threatening to destroy all life on Earth; *DomeStroids* (DS) allows users to navigate through space with a skateboard and use the Wii-mote to blow up asteroids into a pre-specified number of pieces. Mr. Kvam co-designed a lesson that used a short version of a previously tested unit on Global Climate Change (Svihla & Linn, 2012). *ClimateDome* (CD) was used to reinforce understanding of the greenhouse effect, allowing the users to control the level of CO_2 with the Wii-mote, and then export data. In both cases, students took on roles (e.g., pilot, asteroid spotter, model engineer, CO_2 specialist). Participants included pre-service elementary teachers (DS, n=9) and pre-service secondary science teachers (CD, n=8). In both studies, students completed a 60 minute pre-dome activity that introduced a challenge; they began solving related problems. The dome session involved 15 minutes of immersive, interactive projection and additional 40 minutes of collaborative problem solving. A post-dome session involved whole class discussion.

Findings and Implications

In both studies, student work shows evidence of learning; whereas previously, only 10% of students developed understanding of sequences, in this case, 66% of students reached a medium or high level of understanding of sequences using *DomeStroids*; on the pretest, half of the students provided a normative explanation of the greenhouse effect, but after using *ClimateDome*, all students provided a detailed, normative explanation.

In *DomeStroids*, Mr. D guided students with prompts that helped them to notice specific details, such as how many strikes it took to break the asteroids up into small enough pieces, or how many pieces resulted from each strike. We observed a transition point when Ignacio - a student who rarely participated in class and who struggled with the math content --answered one of Mr. D's questions by posing his own question about whether there would "be a formula" for what they were seeing. We see this as a critical moment for two reasons: 1) it marks a change from Mr. D primarily asking procedural questions to primarily prompting the students to help each other; and 2) Ignacio engaged the class more deeply with the math and led them to write an abstract formula. We conjecture that the activity in the dome was different enough from school experience that it may have enabled connections to informal experiences (such as video game play), allowing a student to find purchase on an activity that – had it been conducted in a more traditional manner—he may not have.

Students returned from *ClimateDome* with data sets exported from their experiments in the dome; they explored these data during class, constructing graphs. They struggled to interpret them, provoking numerous questions and discussion about how variables related to one another (e.g., why did infrared radiation increase when the level of CO_2 was increased?). In prior experiences with the non-immersive version, when a teacher projected a visualization, student learning was typically narrow and worse (as compared to allowing student pairs to interact with the visualizations on their own). In this case, there may be an advantage for the immersive component, which affords pointing and gesturing by all present, and supporting the development of shared understanding.

While our studies are exploratory and findings tentative, we can report that the dome sessions engaged students and supported learning beyond the brief immersive, interactive experience. Although the problem-based lessons were designed with a high degree of scaffolding, students engaged in a more generative manner.

References

Apostolellis, P., & Daradoumis, T. (2010). Exploring Learning through Audience Interaction in Virtual Reality Dome Theaters. *Knowledge Management, Information Systems, E-Learning, and Sustainability Research*, 444-448.

Dede, C. (2009). Immersive interfaces for engagement and learning. *Science, 323*(5910), 66.

Jordan, B., & Henderson, A. (1995). Interaction Analysis: Foundations and Practice. *Journal of the Learning Sciences, 4*(1), 39 - 103.

Rivet, A. E., & Krajcik, J. S. (2008). Contextualizing instruction: Leveraging students' prior knowledge and experiences to foster understanding of middle school science. *Journal of Research in Science Teaching, 45*(1), 79-100.

Sumners, C., Reiff, P., & Weber, W. (2008). Learning in an immersive digital theater. *Advances in Space Research, 42*(11), 1848-1854.

Svihla, V., & Linn, M. C. (2012). A Design-based Approach to Fostering Understanding of Global Climate Change. *International Journal of Science Education, 34*(5), 651-676.

The Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher, 32*(1), 5–8.

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