Supporting Practice, Integrating Research in Immersive Technologies into Educational Designs (SPIRITED): Technology to Support Co-located Collaborative Learning

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Abstract: Supporting Practice, Integrating Research in Immersive Technologies into Educational Designs (SPIRITED) is a recently funded project investigating how immersive, interactive projection technology might be used to support teaching and learning. Beginning with a planetarium-style dome and software that enables interactivity using Wii-motes, we explore ways to support collaborative inquiry learning before, during, and after an immersive experience.

Current research interests

Supporting Practice, Integrating Research in Immersive Technologies into Educational Designs (SPIRITED) Seeks to identify affordances and constraints of immersive, interactive technologies (Figure 1) to provide context for inquiry and provoke scientific activity structures, and to shed light on how blending these might support inquiry practices. To achieve these objectives, SPIRITED will develop technology, codesign projects with teachers, and study implementation and student learning. Building upon recent innovations in interactive and immersive digital environments developed under the auspices of an NSF PFI grant *Consortium for Fulldome and Immersive Technology Development* (Sen, PI, 2009-2012), SPIRITED will extend immersive interactive simulations that allow students to pose questions and analyze data. SPIRITED places a focus on answering preliminary research questions:

- Q1) How might we support teachers to design and implement inquiry in which context is provided and scientific activity structures are provoked using immersive, interactive technology?
- Q2) In what ways might an immersive experience reconfigure inquiry learning, both before and after the experience?

SPIRITED begins by addressing preliminary questions to support the team's long-term goal of developing affordable, feasible classroom-based immersive projection systems paired with understanding of how the use of such technologies might engage students in the same types of inquiry that professional scientists carry out. We hope to develop a first order understanding of how students might learn and participate in scientific inquiry as a result of immersive media, as well as an articulated understanding of ways to design curricula that incorporate immersive media.

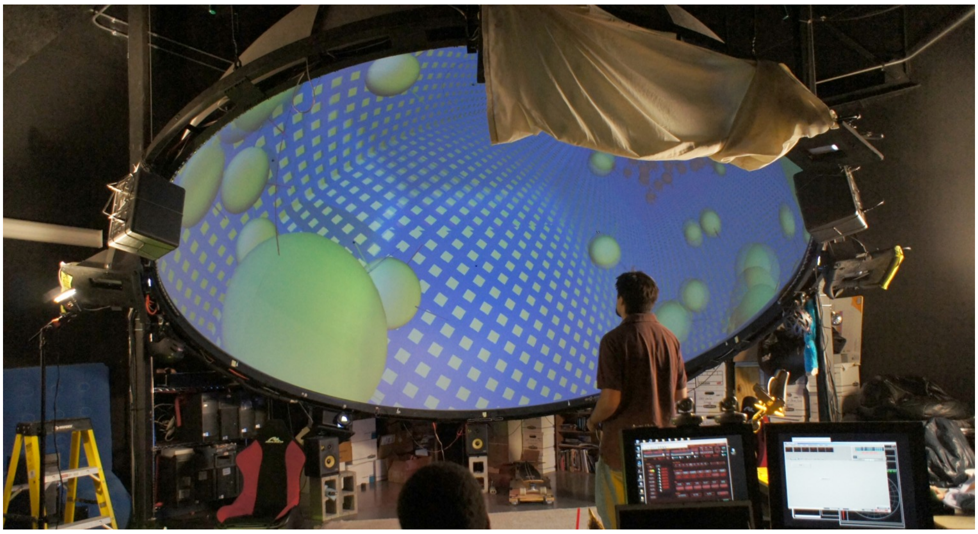

Figure 1. The fulldome system at UNM's ARTS Lab is a 15-foot diameter immersive media research facility employing six video projectors to create a high resolution image enveloping the audience's vision. Here, a research assistant explores a simulation of a theoretical cooling system.

Theoretical perspective about collaborative learning

SPIRITED is grounded in the notion that learning disciplinary activity, such as scientific practice, should reflect and engage learners in disciplinary practices. Science is a collaborative endeavor. Professional scientists engage in *designerly* activity as they find problems, pose questions, and plan investigations (Cross, 2001); school inquiry rarely reflects these practices. SPIRITED will explore how design framing and immersive technology might provide opportunities for more authentic and collaborative inquiry practices. Design has been used previously to support science learning (e.g., Fortus, Dershimer, Krajcik, Marx, & Mamlok-Naaman, 2004; Hmelo, Holton, & Kolodner, 2000), but we view design as an authentic component of professional STEM practice. 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. One of the affordances of immersive learning environments is the provocation of problem finding and posing activities, (Dunleavy, Dede, & Mitchell, 2009), but this finding is not well understood, suggesting a need for further research.

Technology experiences or interests

The team, lead by Drs. Svihla and Kniss, includes experience designing technology to integrate learning and assessment (Phillips et al., 2009; Svihla et al., 2009), units for the Web-based Inquiry Science Environment (Svihla, 2011; Svihla & Linn, 2012), as well as interactive immersive media (e.g., http://artslab.unm.edu/category/videos; http://watch.discoverychannel.ca/daily-planet/september-2011/daily-planet---september-06-2011/#clip527472). SPIRITED builds on these past experiences, bringing together expertise in computer science, teacher education, and learning sciences, and leveraging resources from UNM's Art, Research, Technology & Science Laboratory (ARTS Lab)-- a highly equipped 4,000SF new media lab. ARTS Lab's 'gDome,' a 15-ft diameter dome theater system will be a principal asset for this project. The 350SF dome accommodates about 12 people and employs six video projectors tiled together to create a seamless image of about 2000x2000 pixels. The dome is powered by a system developed as part of an NSF awarded project, and uses a single Mac Pro with multiple graphic cards to project. The gDome includes surround sound, IR emitters for Wii-mote locators, and a series of novel interface devices including active and passive skateboard interfaces (Figure 2; 'skate' to move through a digital environment), and an armchair interface ('sit and tilt' to control).

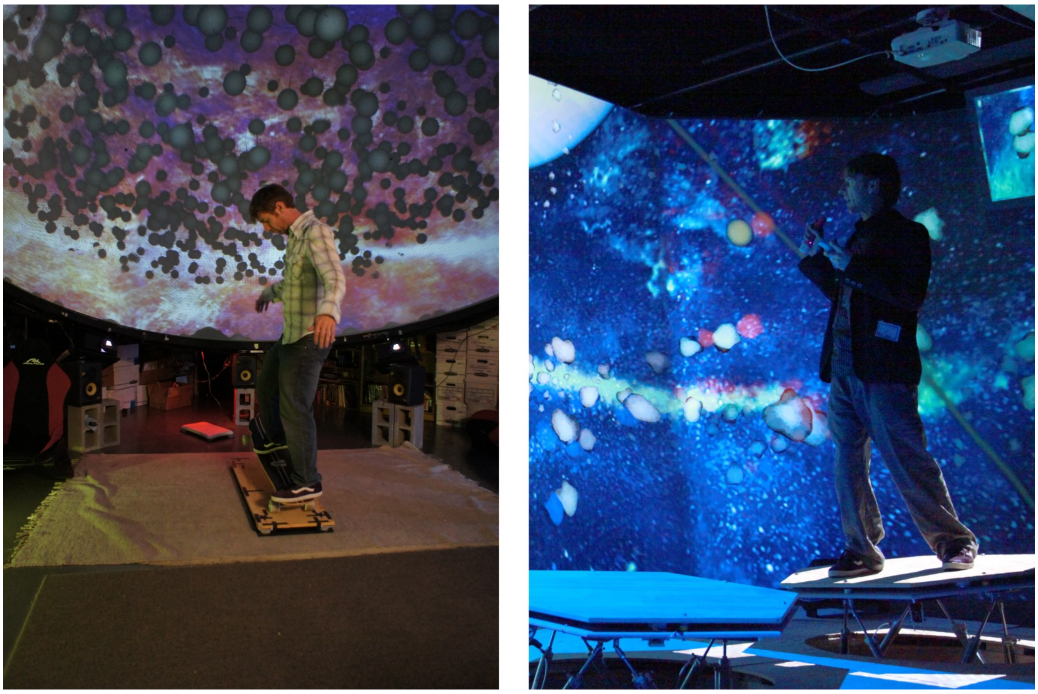

Figure 2. Novel control devices allow for interactivity, increasing presence when added to immersive technologies and opening up questions about the opportunity for increased learning. On the left, Prof. Joe Kniss controls a physics simulation with a skateboard interface device. On the right, he flies through the rings of Saturn on a full-body haptics system – a 'hex deck' that has pneumatic cylinders creating force feedback while his motions control navigation.

Methodological experiences or interests

We apply integrated methods (qualitative analysis, statistical modeling, visual analysis, temporal analysis, and network analysis) towards understanding learning. This study uses a design-based approach (Brown, 1992; The Design-Based Research Collective, 2003), leveraging findings for refinements to the inquiry lessons and technology, and leading to design guidelines –affordances and constraints—for supporting inquiry practices with immersive technology. SPIRITED includes four participant types (Table 1), with two primary study goals, tied to the research questions.

Table 1. SPIRITED participants tied to questions

Participant abbreviation -- description (approximate n)	*provides data on:*
D-PBL – design students enrolled in Dr. Svihla's *Project Based Learning* (PBL) course, Spring 2012 (n=9) and Fall 2012 (n~10)	Research Q1) design learning
D-CC -- design students active in Dr. Kniss's *code camp*, a weekly meeting of students working on designs for the dome; or otherwise supervised by Dr. Kniss to develop immersive media (n~5)	Research Q1) design learning
L-UNM – Learners from UNM, students enrolled in one of the other courses included in Dr. Svihla's IRB, recruited as volunteers (n~30)	Research Q2) role of immersive media in inquiry learning
L-HS – Learners drawn from home school network and recruited via PBL teachers (n~30)	Research Q2) role of immersive media in inquiry learning

In order to answer the research questions, various types of data will be collected and analyzed (Table 2). Most data are qualitative, and intended to document how and what participants learn as they engage in design or inquiry activity. The primary focus is on the participants designing inquiry units incorporating immersive technology, but those designing units incorporating other technologies will serve as comparison cases; additionally, data will be collected to document how computer science students involved in programming design immersive media for educational purposes. Interviews will focus on design process and disciplinary understanding. Artifacts of design process include sketches and notes, drafts, ideation activities, customer needs assessments, and lesson plans. The Design Skills Tests and the Design and Interaction Survey are given as pre/post measures only to the PBL class participants. Versions of these instruments have been used previously (Svihla, 2009, 2010).

For the second research question, interviews with will focus on understanding of disciplinary inquiry and experience in the dome. Artifacts of inquiry learning and assessments will be collected, as designed by the D-PBL participants. Videos of interactions before, during, and after the immersive session will be collected to better understand the ways of participating with immersive media. Video records will be collected in accordance with field standards (Derry et al., 2010). A measure of presence—the feeling of being present in a virtual space—will be used, modified for the specific contexts under study (Usoh, Catena, Arman, & Slater, 2000). Finally, comparisons will be sought between online versions and immersive versions of the curricula. Because of the exploratory nature of this work, controlled experiments are not warranted by current understanding; rather, we prioritize developing understanding of how immersive media might support inquiry learning.

Qualitative analysis, especially interaction analysis (Jordan & Henderson, 1995), will be used for interviews and video records. Artifacts of inquiry learning will be coded using grounded approach (Corbin & Strauss, 1990). Design artifacts will be coded using a mixed approach, beginning with grounded coding, and followed with a design schema. Regression modeling may be used, provided sufficient numbers of participants enroll. Triangulation will involve comparing findings for discrepancies and convergence. Iteration will allow evidence-based design decisions to be made while developing a grounded understanding of how immersive media might support inquiry, and what role design might have for teacher learning.

Table 2. Data for research questions 1 and 2.

Participant	*D-PBL*	*D-CC*	*L-UNM*	*L-HS*
Interviews	X	X	X	X
Artifacts of design work/process	X	X		
Design skills test	X			
Design and Interaction Survey	X			
Artifacts of inquiry learning			X	X
Assessments (designed by D-PBL)			X	X
Video of interactions			X	X
Modified SUS Measure of Presence			X	X

Workshop goals

Goals for this workshop include learning about current research, getting feedback on our approach, and meeting potential collaborators. 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 will ultimately fit into classrooms to reconfigure learning, transforming corners of classrooms into interactive rings of Saturn or carbon nanotubes.

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.

Brown, A. L. (1992). Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. *The Journal of the Learning Sciences, 2*(2), 141-178.

Corbin, J. M., & Strauss, A. (1990). Grounded theory research: Procedures, canons, and evaluative criteria. *Qualitative Sociology, 13*(1), 3-21.

Cross, N. (2001). Designerly Ways of Knowing: Design Discipline Versus Design Science. *Design Issues, 17*(3), 49-55.

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

Derry, S., Pea, R., Barron, B., Engle, R., Erickson, F., Goldman, R., . . . Sherin, B. (2010). Conducting Video Research in the Learning Sciences: Guidance on Selection, Analysis, Technology, and Ethics. *Journal of the Learning Sciences, 19*(1), 3-53.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7-22.

Fortus, D., Dershimer, R. C., Krajcik, J. S., Marx, R. W., & Mamlok-Naaman, R. (2004). Design-based science and student learning. *Journal of Research in Science Teaching, 41*(10), 1081-1110.

Hmelo, C. E., Holton, D. L., & Kolodner, J. L. (2000). Designing to Learn about Complex Systems. *Journal of the Learning Sciences, 9*(3), 247-298.

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

Phillips, R., Gawel, D. J., Svihla, V., Brown, M., Vye, N. J., & Bransford, J. D. (2009). *New technology supports for authentic science inquiry, practice, and assessment in the classroom.* Paper presented at the AERA, San Diego.

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. (2009). *How differences in interaction affect learning and development of design expertise in the context of biomedical engineering design.* (Ph.D.), The University of Texas, Austin.

Svihla, V. (2010). Collaboration as a dimension of design innovation. *CoDesign: International Journal of CoCreation in Design and the Arts, 6*(4), 245-262.

Svihla, V. (2011). Formulating WISE Learning Experiences. In H. Spada, G. Stahl, N. Miyake & N. Law (Eds.), *Connecting computer supported collaborative learning to policy and practice: Proceedings of the 9th International Conference on Computer Supported Collaborative Learning (CSCL2011)* (Vol. Volume I — Long Papers, pp. 232-239). Hong Kong: International Society of the Learning Sciences.

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. doi: 10.1080/09500693.2011.597453

Svihla, V., Vye, N. J., Brown, M., Phillips, R., Gawel, D. J., & Bransford, J. D. (2009). Interactive Learning Assessments for the 21st Century *Education Canada, 49*(3), 44-47.

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

Usoh, M., Catena, E., Arman, S., & Slater, M. (2000). Using presence questionnaires in reality. *Presence: Teleoperators & Virtual Environments, 9*(5), 497-503.

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