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Games and Immersive Participatory Simulations for Science Education: An Emerging Type of Curricula

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The manuscripts that comprise this special issue are focused on understanding how games and immersive participatory simulations, with their focus on doing science (not receiving science), are becoming an emerging type of curricula for supporting science education. The environments discussed here build on theoretical frameworks positing that "knowing" is a contextual and participatory act, and that the context in which one learns any particular content shapes the resultant understandings of that content (Barab *et al*., 1999). Central to this perspective is that, rather than simply telling students about science facts or even socio-scientific issues, knowledge and skills in science should be situated as an inquiry process and that new technologies and design methodologies can facilitate this process. The various articles that comprise this special issue are inquiry-based, leverage multiple media, and integrate game-design principles and scenarios to establish rich inquiry-based contexts for engaging scientific issues.

Over the last two decades, a growing movement is documenting that science education is more meaningful to learners and more effective when the learning context utilizes information and communication technologies (ICT), is grounded in important societal issues (Zeidler *et al*., 2005), and places student inquiry at the core. This stance is consistent with policy recommendations from a variety of respected sources (AAAS, 1993; Goodrum *et al*., 2001; Millar and Osborne, 1998; NRC, 1996;) as well as what it means to participate in science outside of school contexts (Lemke, 1990). We believe that a primary goal for science education is to help students develop the knowledge, skills, and epistemologies necessary for dealing with 21st century, real world scientific issues. Toward this end, the curricula discussed here are inquiry-based, involve new forms of technology, and have a game-based scenario at their core.

Such curricula are not based on the underlying cultural logic of "print-based" literacies and pedagogies, in which the learning process is controlled by the teacher or even the computer (Lemke, 1990; Squire and Jan, this issue). Instead, they are narratively driven, experientially immersive, and muti-media rich. We view information communication technologies as having the potential to greatly aid both in fostering students' inquiry and in providing richly situated learning experiences despite the relative isolation of many school classrooms (Dede, 2000). As guest co-editors, we have collected research articles for this special issue of JSET that explore the potential of videogames and immersive participatory simulations for engaging children in rich socio-technical contexts, where they address meaningful problems, and through which they can learn and collaboratively experience all stages of scientific inquiry.

Further, as documented in these articles, game-like virtual learning experiences can provide a strong sense of engagement and opportunities to learn for all students, even helping learners with low self-efficacy start afresh with a new "identity" not tagged as an academic loser. They also have the potential to establish participatory narratives that can aid learners in developing a contextual understanding of what are all too often presented as decontextualized scientific facts, concepts, or principles. To contribute to this proposed special issue, we have assembled a group of researchers who are designing and studying the potential of videogames and immersive participatory simulations for supporting motivation and

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learning in science. As such, and consistent with design-based methodologies (Barab and Squire, 2004), these researchers are not simply examining existing games or simply proving that the curricular designs they are developing work.

Rather, their research (1) elucidates the impact of these learning experiences on various types of learners, (2) advances underlying theory about using game-contexts for supporting science learning, and (3) develops design, implementation, and methodological heuristics to help the field scale up this powerful type of curriculum. Thus, these peer-reviewed articles are both theoretical and empirical, providing illuminative cases for readers to see the potential of game-based technologies and methodologies at the same time the authors articulate theoretical frameworks and design/research heuristics. Also of significance is that all these researchers have designed and studied game-like learning contexts that support *interacting socially* (not just individualized learning) and *doing science* (not simply memorizing information), as well as *involving socio-scientific inquiry* (not just learning science facts and recipe-like processes).

Given that each research group is drawing upon a medium initially designed for entertainment purposes, a key goal for each article is to illuminate the tensions among repurposing the medium towards academic ends. Many researchers have argued that, even as an entertainment medium, videogames support rich discursive and inquiry-based practices (for example, Gee, 2004, Steinkuehler, 2006; or Squire, 2006). The linguist James Gee (2003), in particular, has described the discursive richness, complexity of game play, depth of collaborative inquiry, opportunities for consequentiality, rich perception-action cycles, exploration of situated identities, and complex forms of learning and participation that can occur during game play. However, enlisting this same medium and repurposing it as a curricular context to support academic science learning is a new opportunity with a host of challenges. At the core of each of the articles in this special issue is the belief that leveraging the affordances of game-based technologies and methodologies provides a powerful potential for supporting deep and engaging science learning.

The first two articles research the use of place-based augmented realities in which participants use palm-based devices to explore either environmental or health problems. The perceptual blending of the real and the virtual world with its place-based authenticity make these two studies a unique contribution to understanding the value of game spaces for science education. In the first study, Squire and Jan (this issue) investigate how these new technologies and game-based methodologies engage elementary, middle, and high school students in scientific thinking. Similarly, in the second study, Rosenbaum, Klopfer, and Perry (this issue) use a medical narrative and physical space to engage children in roles through which they engage in scientific practices. Of particular interest is how both research groups (1) use multiple layers of narratives and tasks, to (2) situate activity in a contested game locale/physical space and (3) engage players in professional roles, (4) to scaffold learning through multimodal representations, that lead to (5) social interactions that promote collaboration, competition, and reflection-in-action.

Following these articles, Neulight, Kafai, and Kao (this issue) studied students who participated in a virtual epidemic within a multi-user virtual environment. Rather than designing a world explicitly to support science learning, these investigators leveraged an existing environment, injecting a virtual disease that affected student-created avatars. The results from their analyses reveal that engagement with the integrated curriculum impacted students' conceptual understanding of the causality of natural infectious disease. Further, students perceived the simulation as similar to a natural infectious disease, with the immersive components of the simulation creating an opportunity for participants to discuss their understandings of natural disease and to compare them to their experiences with the virtual disease.

In the next article, Barab, Sadler, Heiselt, Hickey, and Zuiker (this issue) design and research a multi-user virtual environment designed to simulate a park aquatic watershed in which fish are dying. Students are positioned as environmental scientists who are charged with interviewing non-player characters and collecting data to investigate the water quality problem. Unlike the augmented reality studies, the entire investigation takes place in a 3D multi-user virtual environment, in which students navigate around and collect data, develop hypotheses, and pose solutions by way of an in-game avatar. Key to this context is the balancing of explicit domain formalisms and concepts with engaging students in a larger narrative designed to embody the domain content. Data showed that through participation in this narrative, students developed a rich perceptual, conceptual, and ethical understanding of science.

The next two studies similarly research a multi-user environment with a water quality problem, although there is also a strong connection to medical

diagnoses. In the first study, Nelson examined the role of a guidance system embedded within a MUVE-based scientific inquiry curriculum to support science learning. Findings suggested that there was a correlation between use of the guidance system and content test score gains. Additionally, girls were found to outperform boys in terms of guidance system use, indicating that these technology-rich platforms are engaging for girls. In the second study on the same environment, Ketelhut investigated the relationship between self-efficacy and data gathering behaviors, also looking at gender differences. Of significance is her finding that, while self-efficacy initially predicted scientific inquiry behaviors, over time as students returned to the environment this initial attribute was no longer a significant predictor. This suggests that immersive, collaborative simulations may act as a catalyst for change in students' self-efficacy and learning processes.

As a collection, these studies provide an illuminating lens into an emerging type of curricula that has become available to science educators. These various projects each put students at the center of the learning process, while at the same time setting up clear scenarios in which "success" requires using practices associated with scientific literacy. More radically, these studies leverage game-based methodologies and technologies to make available a rich, yet grounded form of inquiry that allows young children, even in the context of schools, to engage in inquiry activities similar to those of experts. As a set, the studies demonstrate that game-based technologies are not simply for entertainment purposes, but can be additionally leveraged to support academic content learning.

We hope readers will find this collection of studies as intriguing as we have and hope that the resonances among them help to deepen our collective understanding of games and immersive participatory simulations in science education. In contrast to one-shot special issues in JSET and other journals, we will elucidate the theme of games and immersive participatory simulations for science education across a span of time. We will add to this initial set of articles as other relevant studies are available, and we hope through this to foster dialogue among research groups and with the JSET readership. We look forward to the future, at times with guarded anticipation and at others with tenacious curiosity and optimism, as we experiment with using games and immersive participatory simulations for science education.

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