

CyberSTEM: Making Discovery Visible Through Digital Games

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Abstract: The purpose of this demonstration is to present how video games can communicate cutting-edge science research topics to a new generation of players. Researchers in the Games, Learning, and Society Center (GLS) at the University of Wisconsin-Madison collaborated with partners at the Wisconsin Institutes of Discovery (WIDs) to develop and refine a suite of educational video games to explore topics such as limnology, virology, regenerative medicine, and ecological science rarely studied in the realm of educational spaces. Several games develop collaborative participatory science skills while expanding games based learning into adult informal learning. The presentation will begin with brief history of CyberSTEM implementation, followed with a hands-on demonstration of the iterations in the most current form, and will close with a audience discussion of the direction of CyberSTEM and its social network.

The Project

CyberSTEM: Making Discovery Visible Through Digital Games is a NSF-funded project designed to build science based educational video games, a social network, and learning community that will transform STEM learning experiences and enhance player abilities and interests in STEM fields. It contains three main components: 1) a suite of video games designed to improve player understanding of cutting-edge science research; 2) an assessment model designed to use collaborative game play as evidence for learning; and 3) a social network and distribution environment designed to engage many players in collaborative play and problem-solving.

CyberSTEM games have been designed and developed with researchers from the Games, Learning, and Society (GLS) research center in the Wisconsin Institutes of Discovery (WIDs). The GLS strategy is to work with science research teams to identify the key ideas and techniques in the research domains that would enhance the public understanding of the science. GLS design teams include game programmers, graphic designers, content area experts, and Learning Scientists who determine which aspects of the key ideas lend themselves to interaction in which kinds of game genres. The games are iterately designed and tested, with both content experts, educators, players, and learning scientists, to measure both playability and fidelity of the play model to the content model.

Theoretical Background

The GLS approach to design for learning is anchored in four key concepts: situated learning and cognition, intrinsic motivation, transformational play, and objectives and assessment (Van Eck, 2009; Barab, Greslfi, & Arici, 2009).

Situated learning theory states that knowledge and transferability is strongly tied to context, domain, authentic activity, and culture. Learning is effective when it is presented in a meaningful context. Games embed knowledge, give feedback and guidance, and present instructional events within the context of the game narrative. Intrinsic motivation derives from internal events, such as personal goals and rewards. Learning is maximized when students are intrinsically motivated without external rewards and punishments. GLS designs align and extend the game content (role-playing, fantasy, narrative, and context) to content that is outside of the game (Van Eck, 2009). In transformational play, the player is a protagonist who must use the curricular content knowledge, skills, and concepts to understand a fictional situation and make choices to transform that situation. Transformational play leads to a greater engagement with immersive activities and simulations as students experience accountability and consequentiality (Barab, et al., 2009).

Gee (2005) supports how gaming contributes to situated learning, intrinsic motivation, transformational play, and assessment. He states that educators need to make learning in the classroom and outside of school, more game-like by using these learning principles, incorporated in games, both reflectively and strategically in our practice with or without using games in the classroom. Effective GLS instruction builds opportunities for collaborative application of what is learned with feedback to help the learners monitor their own learning. Indirect and direct communication of objectives are common in the establishment of objectives in games.

The epistemologies of GBL lay a foundation for new forms of assessment, i.e. extending the game play to additional instructional activities and how they are organized by problem and challenge, and comparing them to relevant real scenarios (Schaffer & Gee, 2009).

Gee (2008) argues that gaming can impact learning and assessment. Gaming is one set of collaborative digital tools in the 21st Century Skills toolbox (that includes situated learning and communities of practice). As learning becomes more online, GBL can change the culture and ethic of education to be organized around collaborative learning communities of practice rather than a form of organized top-down social control of students (Squire, 2005).

The Design Challenges

Games for Participatory Science (GPS), developed at WIDs is an approach developed to make inquiry and discovery visible in games. This is accomplished through collaboration with domain scientists, modeling of physical and social scientific systems, position players as goal focused members, constructing of knowledge, and creation of opportunities for participation in authentic science practices (Shapiro & Squire, in press).

The GPS approach seeks to build upon traditional inquiry-based learning with an emphasis on aesthetics and flow in immersive scenarios to foster understanding of science, increase learner involvement and participation in science practice. "Basic research on learning through games (and in learning sciences more generally) emphasizes that much knowledge production, integration, and reflection (often described as metacognition) arises through social interaction" (Shapiro & Squire, in press). By seeking to connect learning through interaction and science practice, CyberSTEM games are not only designed for schools, but also for engaging players in informal learning situations and work settings.

To increase player social interactions, CyberSTEM is building a social gaming network to create opportunities for players to participate in a gaming community. This will allow for new models of engagement and interaction within and across the CyberSTEM games.

CyberSTEM using the GPS approach is fostering engagement, problem solving, and deep critical thinking skills with domain content interest dilemmas, experiences, and user interactions. By concentrating on domain content through the collaboration with the content experts, CyberSTEM designing and developing games for play across spaces and for systems that can scale, attempting to understand learners activity temporally and spatially (B. Shapiro, personal communication, November 8, 2012).

The Games

The CyberSTEM project is developing five games that introduce students and adults to different cutting edge science content and concepts. Video introductions to the games may be found at <http://bit.ly/VEanJB>.

Citizen Science is an adventure game that teaches limnology (the study of the life and phenomena of fresh water) and scientific literacy. Players travel back through time to uncover and solve pollution problems faced by Lake Mendota. Learning from the past and working together, players address the continuing eutrophication threats and attempt to restore Lake Mendota to conditions suitable for human use. *Citizen Science* is designed to develop an understanding current ecological conditions and issues. Players learn to use science inquiry and working together to enact change in the legislative process. CyberSTEM supports the iterative development and collaboration in adapting the game for classroom use. Preliminary investigations were conducted of how teachers used the game in their classrooms with different respective pedagogies ("ERIA Interactive - Citizen Science," n.d.).

Progenitor X is a narrative-driven, turn-based, puzzle game in which players assume the role of a regenerative biologist to prevent a zombie apocalypse. The game was developed in partnership with the Wisconsin Institutes for Discovery Regenerative Medicine research team to present core ideas of cutting edge stem cell science in context of a game. *Progenitor X* players are challenged to cultivate and differentiate stem cells, assemble tissues, and replace organs that have been contaminated with a zombie virus. Game play requires players to solve cell, tissue, and organ puzzle cycles while learning about their relationships and the scientific principles of stem cell research and concepts ("ERIA Interactive - Progenitor X," n.d.).

Trails Forward is a multi-player, turn-based, strategy simulation game that invites players to make ecological and economic decisions about land use in rural Wisconsin. *Trails Forward* simulates the emergent economic and environmental effects of users' decisions on a robust multi-agent model of land and forest economy and ecology, coupled with human and animal population dynamics. *Trails Forward* is iteratively designed and developed with extensive input from stakeholders including UW Madison faculty in forest and wildlife ecology and agricultural economics, the Wisconsin Department of Natural Resources, and the Menominee tribe.

Trails Forward allows players to take on roles in buying land and determining land use. Each role emphasizes certain kinds of land use, and is designed to collaborate and conflict in specific ways with other roles. Currently, players may choose the roles of a housing development company, a timber company, or conservation nonprofit. Players learn that each role have competing land management interests, philosophies, and goals. Players develop an understanding of the environmental costs and benefits of their decisions and actions. With each turn, players learn that these roles can hinder or help one another. Game play allows players understand how to make decisions about maximizing scarce resources in contested environments. Game play

allows researchers the opportunity to observe collaboration and competition (“ERIA Interactive - Trails Forward,” n.d.).

FairPlay is a game designed to give players the opportunity to experience some of the biases encountered by individuals from underrepresented groups in academic science, technology, engineering, mathematics, and medicine. The game invites players to assume the role of a young researcher trying to achieve academic success. As they progress through the game, they encounter examples of bias from peers, superiors, and even strangers, and can reflect on their experiences and try to decrease their own biased behaviors. To complete the journey to renowned professorship, players must successfully operate a university research lab and maintain a diverse collaborative academic social network (“ERIA Interactive - Fair Play,” n.d.).

Virulent is a strategy action game designed and developed to teach the principles of virology. Be the Virus! In *Virulent*, players take on the role of a virus attempting to break into a cell and to take over cell reproductive structures to manufacture more viruses. Players strategize on the proper course of action in infecting, manipulating, and escaping from host cells and their cellular immune responses.

Virulent was designed in collaboration with the Systems Biology research group and faculty from the Medical Microbiology and Immunology department at the University of Wisconsin - Madison. Current research indicates that the engaging game play of *Virulent* as supplemental curricular material increases the social interaction of students and the temporal relationships in the viral replication process (“ERIA Interactive - *Virulent*,” n.d.).

CSCL Interactive Event

The interactive event we are planning for the conference has several main goals.

- We will showcase the CyberSTEM games, allowing the participants to experience cutting edge science based educational video games in a hands on environment.
- Through video footage and session presenters, you will receive firsthand accounts of the CyberSTEM implementation and the research based iterative process.
- Participants will receive a demonstration of the social network and will provide usability feedback.
- Event participants will be part of a research project and will be able to provide feedback on each of the models.

In the proposed demonstration, we will first describe and facilitate a discussion on the CyberSTEM approach by presenting on the science and game design. Alexander, Eaton, & Egan (2010) suggest that there are three general strategies for educational gaming practices with formal and informal learning situations. The first approach focuses on the skills and abilities that players acquire by playing the games, i.e. analysis, deduction and discrimination. The second approach to game based learning is using games to teach curricular content. The third approach is the transfer of learning. The aim is to structure the content and design of the game to make them engaging for the player in new meaningful ways. Players are engaged and motivated through features such as narrative structure, heroic human qualities, emotion, role-playing, conflicts, and the extreme and the exotic. Participants will discover the intrinsic motivation and behavioral self monitoring of the collaborative transformative play.

Our demonstration will allow participants the opportunity for hands-on interaction to explore our collaborative educational video games. We will feature all five games described above: Citizen Science, Trails Forward, *Virulent*, Progenitor X, and Fair Play. We will focus on Trails Forward and Fair Play, unique game based simulation models with interdisciplinary content, as examples of expanding GBL into the adult workplace and community decision making/learning space.

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Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. 1119383. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Appendix

CyberSTEM is a three-pronged strategy for designing and developing collaborative educational video games and a social learning network. Our demonstration will allow participants the opportunity for hands-on interaction to explore and discover our collaborative educational video games. We will have five featured games that will include Citizen Science, Trails Forward, Virulent, Progenitor X, and Fair Play.

We will be able to supply the computers to facilitate the demonstration. Special requirements will include a room with the capacity and space to handle up to 30 or more computers. We will need a projector and possibly additional power strips.