Designing an Augmented Reality Game-based Curriculum

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Abstract: This research investigates the potential of using Augmented Reality Games on Handheld Computers (ARGH) in inquiry-based science learning. This paper presents the design and study of a game-based curriculum for scientific argumentation and conceptual change. The result suggests that the desired learning outcome have been partially achieved and most students were positive about the designed experience. We conclude with informed design decisions for the next design iteration.

Introduction and Conceptual Framework

Augmented reality games are augmented reality simulations designed with game-based pedagogies, such as role-playing. In our games players carry a Personal Digital Assistant (PDA) that displays items such as photos, video clips, and text documents. These items, which appear on a GPS-guided (Global Positioning System) map in the PDA, are triggered when players walk near pre-determined physical locations. For example, students playing an ecological game can trigger data related to runoff as they walk near a storm sewer. Players use the information they gather from the game to identify points of view, develop hypotheses, and defend conclusions. Though Augmented Reality Games on Handheld Computer (ARGH) demonstrate great potential in teaching inquiry-based science (Squire and Klopfer, 2007), its potential in facilitating conceptual change is less explored.

Teaching for conceptual change is a shared challenge for many science educators because misconception is resilient to change and can be found in students and well-educated adults. One way to facilitate conceptual change is to design authentic experience that challenges students' erroneous beliefs. The designed experience provides opportunities for students to reevaluate personal belief against alternative theories. However, in order to evaluate personal beliefs, one must be able to coordinate theory and evidence. Kuhn (1989) argues that the coordination of theory and evidence, or scientific argumentation, is essential for conceptual change to take root.

ARGH provides opportunities to design experience that may lead to conceptual change in authentic problem-solving context. To investigate the potential of ARGH for facilitating conceptual change, we enacted Mad City Mystery (Squire and Jan, 2007), an augmented reality game designed to facilitate scientific argumentation. Mad City Mystery (MCM) is designed as a 3-4 hours field trip that consists of three components: briefing, game play and debriefing. While playing MCM, each participant takes on one of three professional roles in a team to investigate the mysterious death of Ivan. The investigation unveils Ivan's life history which is intertwined with local environmental issues. Looking for justifiable account for Ivan's death, participants need to develop evidence-based hypotheses and revise their hypotheses as new evidence emerges. The results of this study indicate that the game system challenges participants' prior knowledge and participants are motivated to modify their beliefs and theories based on emerging evidence. MCM falls short in two major aspects. First, as a game that lasts 3-4 hours, it fails to engage learners in a deep enough experience through which conceptual change can be grounded. Second, it excludes the reality of schooling. Since our ultimate goal is to generate domain-specific instructional theories (diSessa and Cobb, 2004), we need to tackle curricular standards, logistics, reading difficulties and school culture.

Research Questions

Following a design-based research methodology (Brown, 1992), we designed the Saving Lake Wingra (SLW) game-based curriculum to teach scientific argumentation and conceptual change. Viewing the SLW curriculum as an intermediate product in the design iteration, we wish to understand how the curriculum functions as an integrated system so that informed decisions can be made at the next design iteration. With these in mind, we ask: (1) What are the major design principles informed by MCM in the game-based curriculum? (2) How may the design principles be translated to curricular units to facilitate scientific argumentation/conceptual change? (3) What have students learned (i.e. content knowledge, concept change) as the result of the curricular enactment? (4) What changes can be made in the next design iteration?

Design and Research Method

We identify the following design features from MCM as the guiding design principles for SLW: role-playing, place-based learning, creating cognitive conflict, field research and team work. By integrating these principles with inquiry-based learning, we wish to design an authentic science inquiry curriculum that focuses on scientific argumentation and conceptual change. Organized around the central inquiry question "Is Lake Wingra Healthy," the SLW curriculum is a 10-15 days curriculum designed for middle school science. Students spend forty-five minutes a day to investigate the environmental and sociocultural issues around Lake Wingra, a mixed-recreational lake. The curricular unit begins with a discussion about “what makes a lake unhealthy” in order to make explicit students’ prior knowledge/misconception. In day 3, much effort is devoted to shaping students’ identity as a team of three professionals hired by a stakeholder group to promote its vision for the future of Lake Wingra. Students apply for jobs and name their teams. In day 4, students play SLW game for 2-3 hours by Lake Wingra. In the game, students visit virtual people and collect virtual artifacts that reveal the ecological and sociocultural issues around Lake Wingra, such as invasive species, road salt and stormwater runoff. In day 5 and 6, students reconvene with their team to debrief findings in game, develop theories and conduct research if they find the data acquired via game is insufficient. No frameworks are yet provided to the students regarding how the health of a lake can be judged. Our design seeks to provide contextualized and situated understanding before imposing expert frameworks that tell students how information should be organized. At day 7 students receive an “ecological indicators” handout that provides a framework for organizing their thinking and research. Students are asked to synthesize their research based on the ecological indicators in a “technical report” to their stakeholders at day 8. At day 9 and 10, students look into the future by proposing an articulated plan for the future of Lake Wingra in a mock city council meeting.

The implementation and study included twenty-four 8th graders from a private middle school and a science teacher with three-years teaching experience. The sample was chosen for convenience. A researcher videorecorded each class and kept field notes to code for emerging themes. The researcher also met briefly with the teacher before and after each class for planning and reflection. Pre and post-curriculum performance assessments were administered to investigate student learning. A post-game survey and a post-curriculum survey were also administered.

Findings and Implications for Re-Design

The primary goal of this study is to reflect on our design so that informed decisions can be made for the next design iteration. With that in mind, we interpret the learning and affective outcome as indicators of how well the curriculum was designed and executed as well as what redesign decisions should be foregrounded.

The pre- and post-performance assessments indicated that most students’ content knowledge grew much richer compared with their prior knowledge. Naïve conceptions (Kuhn, 1989) (such as “the lake is dirty because there is litter”) were replaced by new concepts (“the water was polluted by runoffs and chemicals”) provided by the SLW game. We also witnessed that students’ misconception were reinforced by the curriculum. Students who argued that Lake Wingra was unhealthy at the beginning had a tendency to emphasize negative data instead of developing a more balanced and critical view of the data they received. The affective survey indicated that role-playing, field research and team work made the entire curriculum more meaningful to students. Many students expressed that they cared about Lake Wingra and complained that no actions were taken during the curriculum. Over all, most students were motivated to learn more about the lake and their reaction can be represented from the comment of a student: “Lake Wingra has always been an important place to me, but now I see how it affects EVERYONE, and the game helped me realize how delicate it really is.”

Though the desired learning outcome might have been partially achieved by our design and most students were positive about the experience, we feel that our design can be improved with the following modifications.

1. Challenge students’ prior knowledge by asking students to develop and modify personal theories at different stages. Students may propose theories about the health of the lake after they play the game. Then we will provide a different data set and ask students to modify their theories based on the data.
2. Expand the place-based nature of the game beyond the one-day field experience: The game provided an embodied experience that contextualized the rest of the curriculum. Students’ first-hand experience during the game increased their awareness of issues affecting the lake. The rest of the curriculum could leverage this connection to place through additional site visits, local history, photography, and field observations.
3. Provide opportunities for students to turn their learning into action. Providing students with opportunities (perhaps as extensions to the game) to develop real-life strategies for improving the health of the lake may be a better end of the unit activity than the City Council meeting.

References

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