SimQuabbin Project: Game-based Environmental Science Education in a Virtual World

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Abstract: SimQuabbin is a game-based environmental simulation generated from over four decades of research data collected in the Quabbin Reservoir management area. Quests will take the form of a problem in the ecosystem that players are recruited to help solve. Players collect and analyze data, and generate hypotheses about possible solutions to the problem. Proposed changes to the ecosystem are implemented through the collective action of all members of the group. Players travel into the future to view the state of the forest resulting from alterations they have made to the environment. The goal of SimQuabbin is to teach scientific thinking and integrate online learning, field research, and classroom-based instruction.

Background

Students' interest in science tends to decline during middle and high school (George, 2000). One strategy to reverse this trend is to emphasize inquiry-based learning. More recently games have been developed and deployed in an effort to address this deficit. Emerging research suggests that gaming environments, even those intended for entertainment, provide a context for players to employ and develop scientific thinking (Steinkuehler and Duncan, 2008). Investigations of inquiry-based learning in the game River City found that students who used the game exhibited more evidence of inquiry-based learning compared to students in the paper-based control condition (Ketelhut and Dede, 2006).

The SimQuabbin game connects the tasks to be solved in the game to the real world. The Quabbin Reservoir is a tightly controlled watershed that provides the drinking water to the greater Boston area and has been a focus of research for over four decades. Students will adopt a plot that they visit in the Quabbin Reservoir area used for the game. By collecting and analyzing data and drawing conclusions about the effects of different environmental influences on the state of an ecosystem almost in their backyards, students make connections between their science instruction and their personal lives, spark an interest in science, and ultimately result in improved learning. Ideally, schools will bring students on field trips to see their plots, thereby intimating their virtual experience with a physical reality.

SimQuabbin Game Design and Instructional Activities

The SimQuabbin world currently consists of a four square kilometer section from the Northeastern part of the Quabbin Reservoir management area in Massachusetts. Scattered throughout the Quabbin management area are 32x32 meter continuous forest inventory (CFI) plots. Since the 1960s, foresters working for the Department of Conservation and Recreation have been generating data for each of these plots on the number and types of tree species, soil quality and other factors thought to have potential impact on the water quality of the Quabbin Reservoir. An agent-based model functions as the "brain" and governs all interactions among elements in the SimQuabbin ecosystem. The SimQuabbin terrain is geo-referenced, enabling students to access the GPS coordinates of the corresponding point in the actual Quabbin for any location in the game, as well as all other data associated their virtual location. The game world is initialized and populated with trees from a database of tree and undergrowth data.

In each instance of SimQuabbin, a student is introduced to a simulated environment based on actual data from 1960. Students can make changes to environmental variables such as winter and summer temperature variance, deer population, etc., then travel forward in time to view the effects of these changes. For instance, students could ban deer hunting in the year 2000 and travel to 2020 to investigate the growth in the deer population and the consequential impact on the forest. Future worlds' environmental states are calculated using an agent-based model of the historical data from the Quabbin Reservoir records.

SimQuabbin is designed to be a quest-based game. NCPs will give students new quests and the scientific instruments they need for collecting and analyzing soil, water, tree cores, etc. Quests will take the form of a problem in the ecosystem students are recruited to help solve. For instance, a park ranger (NPC) could say, "Some of the hemlock trees appear to be dying. Can you figure out what is causing this?" Students will first need to locate hemlock trees and examine them to discover that there are little white insects on the underside of the needles.

Using the data visualization and forecasting tool located in each ranger station, students can formulate and test hypotheses about the long-term effects a loss of hemlock trees would have on the health of the forest. Based on these analyses, each student will formulate a plan for stemming the spread of this invasive species. After they have implemented in the virtual environment their solution, the students can travel forward in time to see the effects of their choices on the SimQuabbin ecosystem.

Quests will be designed as instructional modules that target specific learning objectives in the Massachusetts science framework and instructional units already included in the curriculum. This will ensure maximum integration into science curriculum.

A unique characteristic of the SimQuabbin game that has potentially broad impact for learning game design is the use of scientific data to render the virtual world and the use of an agent-based model to govern the interactions between elements in the world. Similar to the Quabbin Reservoir, researchers have amassed tomes of environmental and biological data from environmentally significant areas all over the world. A longer-term goal is to use the framework being developed for SimQuabbin to generate game-based simulations of very different ecosystems (e.g. Jornada Basin in NM, Luquillo Experimental Forest in Puerto Rico). This would enable students to study ecosystems in the remote areas of the United States or even other countries. Such projects could include partner schools at those sites and support collaboration between students in different parts of the world as they study each other's ecosystems.

Future Work

Unlike pure entertainment games, SimQuabbin needs to serve a research function. In support of the research agenda for the project, SimQuabbin will collect detailed behavior-tracking data from users as they perform quests and interact in the game. The game will record completed quests, the number of attempts at each quest, and amount of assistance requested from the park ranger NPCs. These data will be analyzed to identify patterns of use associated with different outcomes in order to generate learner models and map learner trajectories. A reporting interface in the game will provide students and teachers with a summary of their progress.

We are planning on conducting the first pilots in the fall of 2014 in local elementary schools. The project team will have numerous opportunities to user test the game with students, receive feedback, and adjust the design.

References

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