EvoRoom & HelioRoom: Designing Learning Experiences for Collective Inquiry

Abstract
Collective inquiry engages students in whole class investigations, jointly negotiating problems and working towards a common goal. A new approach, reported here, leverages mixed-reality environments with ubiquitous technologies. This paper describes two case studies of collective inquiry that use classroom-sized, embedded simulations with networked tablet computers and interactive whiteboards. We describe interactions from both cases and discuss cross-cutting issues related to the design of collective inquiry activities.

Keywords
Smart classrooms, science inquiry learning, collaboration, experience design, interaction design.

ACM Classification Keywords
H5 Information interfaces and presentation; K.3.1 Computer Uses in Education.

Introduction
The design and research of new technologies, in combination with improved understanding of how people learn, offers numerous opportunities to engage students in transformative ways of learning. In inquiry-based learning (IBL), students typically investigate a phenomenon and draw conclusions about it. Instead of mastering disconnected facts, the approach places a heavy emphasis on posing questions, gathering and analyzing data, and constructing evidence-based arguments (e.g., [1]). However, in traditional IBL students typically work autonomously as individuals, pairs or, at most, small groups.

With the emergence of mobile and ubiquitous technologies, as well as Web 2.0 notions of social networking and semantic aggregation, more complex and participatory forms of scientific inquiry may be envisioned. For example, in “collective inquiry” [2] students are engaged in scientific inquiry as a whole class, jointly negotiating problems and working towards a common goal. Students are encouraged to think deeply about materials and develop their own
understandings, but with an emphasis on negotiating and building upon each other's ideas, drawing from a community knowledge base [3]. Collective inquiry may also utilize a mixed-reality environment that incorporates digital content with real-world physical spaces, affording more opportunities to augment face-to-face interactions with pertinent awareness and aggregated information, in addition to storing and representing emergent learning artifacts.

In the following sections, we present two case studies where classroom-sized, embedded simulations provided the scientific context, while networked tablet computers and interactive whiteboards supported students in the investigation process. Designed for different age groups and subject matter, the two studies each offer a set of design issues and challenges that inform our discussion on the resultant patterns of interaction. In the final section, we compare the two cases in terms of those issues and challenges in order to capture any common principles and highlight interesting differences.

**Case 1: EvoRoom**

The study was conducted in a single two-hour session, with eight high-school student volunteers. The simulation situated students within a rainforest environment and engaged them in an inquiry activity, where their mission, as “field researchers”, was to gather evidence of evolution by comparing life forms in Sundaland, Sumatra, and Borneo rainforests. The inquiry activity consisted of three steps.

*Step 1: Observations*

The large displays were populated with the flora and fauna of Sundaland, a region in Southeast Asia, two million years ago. Students were instructed to observe individual species and use the field guide application to capture their observations (Figures 1, 2). The teacher then “accelerated time” and showed resulting geologic events in the Sundaland landscape, over the span of two million years. Sea level changes broke Sundaland’s central landmass into a peninsula and several islands, including Borneo and Sumatra. Setting the room’s timeline to 200 years ago, one side of the room showed Borneo’s ecosystem, while the other side showed Sumatra’s flora and fauna. Students then made observations about the changes in life forms.

*Step 2: Borneo & Sumatra "researcher meetings"*

Students were divided into two field researcher teams – Borneo and Sumatra. Each group answered a set of questions designed encourage students to review and compare notes about their individual observations (e.g., in the Borneo group, students were asked *What common species were found in both Sundaland and Borneo?*).

*Step 3: Collaborative team meeting*

In the final step, the two teams came together to collectively document evidence of evolution. Students were encouraged to discuss their ideas with others and to make posts about evolution concepts. The posts were aggregated to the interactive white board, which served to visibly represent the collective knowledge base of the students at the end of the activity. The teacher was able to use the content of this display to lead a synthesis discussion to close the activity.
Study results & interpretations

To investigate how students interacted with multiple displays and devices at their disposal, we analyzed their gaze targets during the observation phase (Step 1). We found that gazes to the tablet most often alternated with that to the simulation, which indicated to us that students were able to maintain attention to the task at hand, that is writing down observations, without being distracted by visually rich media objects in their field of vision.

In terms of student-to-student interactions, they were not explicitly designed into the task in Step 1, and although they were never told that they must work individually, students had few interactions with each other. In the “Researcher Meetings” of Step 2, students within each group worked closely with one another, with one recording answers while others reviewed the notes on the tablets and consulted the field guide application. This pattern of interaction was evident in both groups, although no specific roles were assigned. In Step 3, although all of the students’ ideas were aggregated in the interactive whiteboard, and ideas were discussed as a class, there was still little interaction between the two “research groups” – due in part to the group being on opposite sides of the room.

From this, we learned that physical space and configuration of student seating is another important factor in determining the quality of student interactions across groups.

Case 2: HelioRoom

HelioRoom, a simulation created from the Embedded Phenomena framework, maps simplified representations of the Solar System onto classroom walls [4]. We augmented previous implementations with networked tablets and an interactive whiteboard to support student observations and hypotheses creation, replacing paper worksheets and charts.

The study was conducted in two 90-minute sessions (one per class), with a total of 23 Grade 6 students participating. Students worked in dyads, with each pair of students sharing one tablet to record findings. Students collected and shared data about the spheres’ occlusion relationships (i.e., one colored circle moving in front of a different color), and stated their hypotheses about the identities of the planets. Both the tablet and the interactive whiteboard aggregated student contributions, showing a running tally of the observation counts and a list of hypotheses (Figure 3). Students viewed and responded to other students’ notes through the same tablet application. On the interactive whiteboard, teachers manipulated color-coded hypotheses and corresponding evidence to guide class-wide discussions.

Study results & interpretations

As with the EvoRoom results, analyzing students’ gaze targets revealed that the multiple displays and devices
did not present a distraction to students, even at the elementary school level. In terms of student-tablet interactions, the tablet often acted as shared referent for the students, with both students focused on it at the same time. The tablet was frequently passed back and forth between partners, without much apparent negotiation or difficulty. While some dyads employed a turn-taking strategy in sharing the tablets, some pairs adopted a “divide and conquer” strategy by having one act as the “observer” and the other student act as the “recorder.” Students commented that it was easy for them to co-ordinate turn-taking when contributing their hypotheses and discussion comments into the tablet.

**Discussion & Concluding Remarks**

*Digitally augmented physical spaces*

In both cases, simulations embedded in classroom walls provided the context for student inquiry. One of our concerns about multiple large displays being embedded in the room was the cognitive load being presented to students. Based on the gaze-target analyses, students remained on-task and were able to appropriately manage their attention.

*Augmenting face-to-face interactions*

One potential benefit of conducting inquiry within physical spaces versus purely virtual spaces is that face-to-face interactions enable awareness of other students in the room. In the case of HelioRoom, students took notice of the aggregated responses on their tablets, as well as the interactive white board, as they appeared in real-time. When students realized that this was happening, they often monitored the responses made by peers to their original notes, which resulted in many synchronous exchanges.

*Interaction patterns for learning*

In both cases, there were few occurrences of direct student-teacher interactions. Towards the end of both activities, however, when more notes were present on the interactive whiteboards, all three teachers managed the information on the screen and used student artifacts to guide closing discussions.

Overall, we were able to gain important insights about students’ experience in collective inquiry by analyzing their various interactions (with tools and materials, as well as with peers and teachers). In future iterations, we will be more explicit about designing for student experience, considering various factors and dimensions that bear upon harder-to-control social interactions. We will explore other technology and form factors for supporting face-to-face interactions, and design opportunities for such interactions to influence student inquiry.

**References**


