Using Coordination Classes to Interpret Conceptual Change in Astronomical Thinking

Brett E. Shelton & Reed R. Stevens
Instructional Technology, Utah State University; Cognitive Studies, University of Washington
brett.shelton@usu.edu; reedstev@u.washington.edu

Students traditionally have difficulty learning Earth-Sun relationships. Although many have investigated why this is the case, the fact remains that traditional 2D methods of instruction have drawbacks when presenting 3D spatial content. This research project investigated augmented reality (AR), an interface technology that augments the real environment with virtual 3D objects. It allows the user to manipulate the orientation and position of virtual 3D objects through a first-person view of the environment. It normally consists of a display (worn as a visor in this case), a tracking system, and accompanying hardware and software. Students manipulate the virtual objects by changing the position of a square piece of foam core. Using previous work as instructional design resources, a learning activity was designed and implemented to teach students the reasons for the seasons. The learning activity included students' interaction with six virtual models. The investigator instructed students to ask questions while they explored the virtual content.

Our research involved analyzing interactions through videotaped recordings of students' AR activities. To analyze the specific interactions and how the interactions related to students' learning, we identified and followed visual and physical actions of students. We inductively generated inferences about patterns from multiple sets of observations of students' videotaped activity. By tracing specific student actions and building codes over multiple sets of students, we created a system of connections. How did students learn about Earth-Sun relationships? What kinds of things did they learn? Our work builds on a perspective on conceptual change and knowledge in-use that suggests any single "answer" to a problem (such as in physics) will be generated by the activation of an ensemble of knowledge elements called a coordination class (diSessa & Sherin, 1998). Coordination classes supply inferences that link perception to understanding and inference, thereby characterizing a systemic model of individual knowledge organization. The hypothesis behind the characterization of a coordination class is that one is able to explain how one "sees something" in the world, whether it is an object, process, event, or idea (cf. Stevens & Hall, 1998). Using the coordination class approach helped us identify how students "see" Earth-Sun relationships without relying on their ability to define vocabulary terms of the field. We analyzed students' changes in understanding of 3D events without relying on their abilities to translate 3D mental images to 2D text and diagrams. This was relevant because students often have difficulty representing their understanding of spatial relationships using language and writing.

With the idea of coordination classes as a basis for tracking changes in understanding, we identified specific changes during the AR activity of 43 students who took part in the learning exercise by delineating when students used familiar *readout strategies* in new ways or created new readout strategies. Similarly, we identified instances of conceptual change by identifying when students used existing *causal nets* in new ways or when they created new ones. Some readout strategies found across the student sample included simple left, right, up, and down movements of the virtual objects to change viewing perspectives. Students used a strategy of inspecting the continents on the rotating virtual objects to determine which parts of the Earth received more light. Students also expressed a number of "new" inferences they acquired during their AR activity, each inference indicating a modification to their causal net. For example, students inferred the approximate circular shape of Earth's orbit and that the Earth's angle remains consistent for each of the four positions of solstice and equinox through their inspection of Model #2. Students' re-inspection of Model #2 led to an inference about the "big picture" for the position of the Earth as it revolves around the Sun. Another inference was that seasonal variation of light and temperature is due to the way the Earth moves relative to the Sun, combined with its consistent angle of rotation.

In summary, the coordination class approach holds general promise for exploring conceptual change and learning.