VIRTUAL FIELD TRIP TO MARS: EXPERIENCES WITH A VIRTUAL REALITY LAB FOR UNDERGRADUATE STUDENTS. Prabhat[1], A. Forsberg[2], G. Morgan[3], N. Petro[3], J. Levy[3] and J.W. Head[3], [1]Center for Computation and Visualization, [2]Department of Computer Science, [3]Department of Geological Sciences, Brown University, Providence, RI USA 02912. (prabhat@cs.brown.edu)

Introduction: We are developing ADVISER (Advanced Visualization for Solar System Exploration and Research); a problem-solving environment for planetary geosciences. ADVISER provides a set of tools that enables scientists to virtually explore and analyze planetary data as if they were on or near the surface of a planet. Previous work by our group [1, 2] presents the vision and specific instances of usage of ADVISER in research activities. In this work, we focus on the Education and Public Outreach aspects of the project. Specifically, we describe the system and the experiences of undergraduate students using it for a planetary geological sciences lab session.

System: Our Immersive VR environment consists of a 4-wall Cave (Cave Automated Virtual Environment) system. We use Polhemus trackers for head tracking and a Wanda device is used for providing 3D input for navigation. The system is driven by a 4 node linux cluster. The data utilized are in the form of digital elevation models (DEMs) with 8192x8192 sample arrays. We use ROAM-2 [3] to achieve real-time rendering performance of 20-30 stereo frames per second. ADVISER also runs on a conventional desktop system using keyboard-controls for navigation.

Geological Sciences 005 (Earth, Moon and Mars) Lab: The VR Lab was conducted for 120 students in Geo 005, an introductory planetary geology course on Mars, Moon and Earth. Prior to conducting the lab, the students were instructed (through conventional lectures, see Fig. 1) on the general concepts related to planetary surface characteristics, formation and evolution, etc. Students have access to standard text books [4, 5] and planetary images. The goal of the Lab is to further the understanding of the subject material by allowing students to explore an area of their interest in the Cave. For the purposes of this Lab, the students were asked to choose an area on Mars.

The students were instructed to prepare a set of 3 questions about their chosen area and asked to work in groups of three. Students then used desktop and Cave systems to explore the area under the supervision of teaching assistants. Half the groups started the exercise working in the Cave, and half started on the desktop system. Students typically spent 15 minutes at the desktop and Cave systems before switching.

Fig.1: Conventional Lectures for Geo 005.

Fig. 2 shows students working on the desktop version of ADVISER. Fig. 3 shows students utilizing the Cave to address their questions. In order to optimize the experience in the short time of exposure, the exercise was kept relatively simple in that students only navigated the environments looking for features and did not learn or use any of ADVISER's tools for geological research [1, 2]. For example, ADVISER supports draping satellite camera imagery over the DEM, but that feature was disabled for the Lab exercise.

Fig. 2: A group exploring Mars on the desktop.

Fig. 3: A group exploring Mars in the Cave.

Following the completion of their laboratory and the written exercise, students were also asked to respond to a questionnaire about their experience as a guide to future development and use of the facility.

Results: Over the past several years, several hundred undergraduates have participated in the VR Lab exercise. Although our purpose is not to conduct a controlled user study, we report on the general patterns and feedback that we have observed.

Typically, we see that students tend to choose the Polar regions, Tharsis Montes and Valles Marineris areas for inspection. Typical questions raised by the students prior to the exercise are:

- How did region form? Was the formation related to tectonics (or water/ice/wind)? How old is the region? Is there more superposed cratering compared to surrounding regions?
- What is the morphology of this region? How does it compare to places on Earth/Moon?
- Could water have been present in the region? Is there any evidence for liquid water having played a role?
- Did life exist on Mars? If so, where would the favorable locations be?

We found that students were easily able to discern surface features and patterns related to smoothness and cratering activity using solely DEM data. There were numerous comments such as "this region has sharp features; it's unlikely that there was any water or wind activity". Students were forthcoming with ideas for vantage points and perspectives, some commented "let's go to the bottom of Valles Marineris, maybe we should see smooth features if there was water flowing", "Could the formation of Valles Marineris be related to the adjacent volcanic activity of Tharsis Montes?".

Samples of typical responses to the specific questions formulated by the students were as follows:

- There are hardly any craters on the North polar cap and thus it appears that the ice caps are very young.
- The South Polar cap is fairly smooth and appears to have flowed out over the surrounding cratered terrain.
- The Olympus Mons caldera contains multiple smaller calderas, probably form sequential eruptive phases. The lava flows from Olympus definitely smoothed out the rough surrounding terrain.
- From an aerial view, the main canyon (Valles Marineris) floor seems to have numerous lineated channel like features. Perhaps they were formed by tectonic extension. We zoomed in to the floor where we observed channels running though the rock debris. That maybe formed from a glacier or river.

Students were very enthusiastic about the VR experience and commented that the Lab helped them in appreciating the true 3D nature of the topography. Some comments were:

- "VR was just like visiting a foreign country rather than reading about it in a book"
- "What really changed in my perception of Mars was the degree of realism of its features. Before, it was difficult to picture what the terrain really looked like; my vision of the planet was relatively flat even though I understood that many features had incredibly high or low elevations, etc. Now it is easier to think of Mars as a real place with a wide variety of surface features in any region"
- "The Cave gave us a glimpse of a terrain that would be very hard to imagine otherwise. The various processes – cracks, craters, deposits, etc. – became tangible features and not just terms from a book"
- "I am much better able to understand how these features actually exist of Mars instead of just trying to piece together an image from somewhat technical terms and black and white photographs. It made me really aware of how unique the surface formations are instead of just imagining equivalents on earth"

The most common feedback (in terms of features to add to the system) was the need to represent scale and map information. Often students would ask how tall or wide a certain feature was and wanted to get a better sense of scale. They also wanted to have a map or compass handy to find out about their position on the globe. Students also wanted to look at real images overlaid on the topography. Students were able to use the wand for 3D navigation quite easily; they mentioned preferring a joystick or game-controller based interaction over a keyboard/mouse implementation. Lastly, some students wanted to return to the Cave to spend more time exploring different regions.

Future Work: We are planning on conducting the VR Lab exercise for other planetary bodies (e.g. Venus, the Moon) in the future. Presenting users with additional functionality and allowing them to complete the exercise in a short duration is a challenging user interface design problem. We are also hoping to conduct a more controlled user study to more formally determine the benefits of using a VR environment for learning and exploration tasks. In addition to use in the classroom and research environments, the system is being designed to facilitate future astronaut training.

References:

[1] Head J. W. et al. (2005) *PE&RS*, 1219-1225 [2] Forsberg A. et al. (2006) *IEEE CG&A*, to appear [3] Hwa L. et al. (2005) *IEEE TVCG* 11(4): 355-368 [4] Hamblin W. K. and Christiansen E. H, (2003) Prentice Hall [5] Christiansen E. H. and Hamblin W. K. (1995) Prentice Hall