There is a particular value in developing tools for assessing the "scientific operation" we attune to doing science. All too often, we instruct our students to gain scientific knowledge through a series of contrived labs, and even subject a few of them to performance assessments commonly known as "senior projects." If we are to begin using more performance related activities in our geoscience courses, we need evaluation and assessment methods rich enough to provide reliable information for course improvement. Scientists know that at the heart of science is the struggle with understanding data - learning how to make higher order data-based decisions that go beyond the ability to construct graphical representations. We will present an evaluation plan that evaluates a student's ability to conduct scientific operation focused upon three sub-categories, all of which are interdependent: scientific knowledge; scientific communication; and scientific data user ability. We will also present preliminary results from a focused study.

ED22F-06 1715h

Strategies for Assessing Learning Outcomes in an Online Oceanography Course

Donald L Reed (408-924-5036; dreed@sjsu.edu)

Dept. of Geology, San Jose State University, San Jose, CA 95192-0102, United States

All general education courses at the San Jose State University, including those in the sciences, must present a detailed assessment plan of student learning, prior to certification for offering. The assessment plan must state a clear methodology for acquiring data on student achievement of the learning outcomes for the specific course category, as well as demonstrate how students fulfill a strong writing requirement. For example, an online course in oceanography falls into the Area R category, the Earth and Environment, through which a student should be able to demonstrate an understanding of the methods and limits of scientific investigation; distinguish science from pseudo-science; and apply a scientific approach to answer questions about the Earth and environment. The desired learning outcomes are shared with students at the beginning of the course and subsequent assessments on achieving each outcome are embedded in the graded assignments, which include a critical thinking essay, mid-term exam, poster presentation in a symposium-style format, portfolio of web-based work, weekly discussions on an electronic bulletin board, and a take-home final exam, consisting of an original research grant proposal. The diverse nature of the graded assignments assures a comprehensive assessment of student learning from a variety of perspectives, such as quantitative, qualitative, and analytical. Formative assessment is also leveraged into learning opportunities, which students use to identify the acquisition of knowledge. For example, pre-tests are used to highlight preconceptions at the beginning of specific field studies and post-testing encourages students to present the results of small research projects. On a broader scale, the assessment results contradict common misperceptions of online and hybrid courses. Student demand for online courses is very high due to the self-paced nature of learning. Rates of enrollment attrition match those of classroom sections, if students are informed of the instructor's expectations at the beginning of the course. The level of faculty-student and student-student communication is very high, both in terms of quantity and quality, and exceeds that experienced in classroom sections. Student scores on graded assignments compare favorably to classroom sections. Overall, online courses offer a cost-effective means of addressing top priority issues, including increasing student access to learning, accelerating rates of graduation, and improving outreach to K-12 educators, especially those working on credential requirements.

ED22F-07 1730h

Prototypical Concepts and Misconceptions of Plate Tectonic Boundaries

Duncan F Sibley[1] (517-432-1614; sibley@msu.edu)

Lina C Patino[1] (517-432-5522; patinol@msu.edu)

Thomas A Vogel (517-353-9029; vogel@msu.edu)

[1]Dept. Geological Sciences, Michigan State University, East Lansing, MI 48824, United States

Students of geology encounter many prototypical/exemplar concepts* that include representative, but not necessarily defining, features and characteristics. This study of students' prototypical representations of plate tectonic boundaries indicates that their representations are rich sources of information about their misconceptions about plate tectonics. After lectures in plate tectonics and mountain building, 353 students in a general education geology class were asked to draw a continent-continent convergent boundary. For this study, a correct answer is defined as having the major features in correct proportions as depicted in the plate boundary diagrams on the USGS web. Fifty-two percent of the drawings were either incorrect or incomplete such that they could not be interpreted. Only 48% were readily interpretable, and of these 22% drew the boundary correctly, showing a thickening of crust where two continents collide. Thirty-three percent drew the boundary showing concave slabs of continental crust as one might imagine two pieces of firm rubber pushed together on a rigid surface and 45% depicted mountains as one might imagine inverted ice cream cones on a rigid plank. Twenty-one senior class geology majors and graduate students were given the same assignment. Forty-eight percent rendered a correct drawing, whereas 38% drew the same ice cream cone on a plank type picture that 45% of the general education students drew. In a second class of 12 geology majors, only 1 student drew a cross section of a continent-ocean boundary similar to standard representation. Four of 12 drew mountains on the top of continental crust over a subduction zone but did not draw a compensating mass within the crust or lithosphere. Prototypical drawings provide more information about students' concepts than do most multiple-choice questions. For example, sixty-two percent of theses students who drew mountains similar to foam rubber pads pushed together on a desk or ice cream cones on a plank correctly answered a multiple-choice question that would appear to indicate a better understanding than the drawings reveal. Furthermore, 12 interviewed students made statements that could be interpreted to indicate that they understood the concept of mountain building at plate tectonic boundaries better than their drawings suggest. Incoherence of multiple-choice responses, verbal statements and drawings may be common in novice learners. If cognitive scientists are correct in their model of multiple types of mental representations for the same term, then the fact that novices may hold inconsistent representations is not surprising. The fact that students at various academic levels draw very similar prototypes that are incorrect is evidence that students have distinct and persistent prototype misconceptions. * Cognitive scientists define a prototypical/exemplar concept as a mental representation of the best examples or central tendencies of a term.

ED22F-08 1745h

Evaluating an Introductory Geoscience Classroom Exercise using Pre- and Post-Exercise Assessments

Stephanie Shipp[2] (281-486-2109; shipp@lpi.usra.edu)

Alison T Henning[1] (713-348-2515; ahenning@rice.edu)

Dale S Sawyer[1] (713-348-4880; dale@rice.edu)

[1]Rice University, Department of Earth Science, MS - 126 6100 Main St., Houston, TX 77005, United States

[2]Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058, United States

Discovering Plate Boundaries is a data-rich classroom exercise that has been used successfully in middle school, high school, and college-level science classes. It is an active learning exercise that encourages students to discover the theory of plate tectonics based on their observations of maps containing earthquake, volcano, topography, and seafloor age data. Students and educators have responded with enthusiasm to this exercise, especially the jigsaw component that promotes random group interaction. We now focus our attention on assessing the impact of the exercise on student learning in order to determine whether it conveys sufficient content knowledge. We designed a pre-exercise assessment consisting of questions relating to introductory geoscience concepts, with particular emphasis on plate tectonics. These questions were based on student learning goals for introductory geoscience courses that utilize the Discovering Plate Boundaries exercise. The questions have evolved with repeated use in order to more effectively gauge student knowledge. The pre-exercise assessments have been completed by middle school, high school, and college students, and have identified some common student misconceptions about geoscience. For example, many students believe that earthquakes are a key component of mountain-building, while volcanoes are not. This type of information should be used by the instructor to stress certain concepts during the course in order to address these preconceived notions. A post-exercise assessment consisting of the same questions was administered at the end of the courses and we found that some of the initial misconceptions remained. We conclude that more pre-exercise assessments should be administered in order to establish a database of student misconceptions so that educators can focus instruction in these areas.

ED31A MCC: 3012 Wednesday 0800h

The GeoWall in the Earth Science Classroom I *(joint with P, SM)*

Presiding: **P J Morin,** University of Minnesota**; P van Keken,** University of Michigan

ED31A-01 0800h

The State of the GeoWall

Paul J Morin[1] (612-626-0505; lpaul@umn.edu)

Jason Leigh[2] (spiff@evl.uic.edu)

Peter van Keken[3] (keken@umich.edu)

Andrew Johnson[2] (ajohnson@evl.uic.edu)

. The GeoWall Consortium

[1]University of Minnesota Department of Geology and Geophysics, 310 Pillsbury Drive, Minneapolis, MN 55455, United States

[2]Electronic Visualizaton Lab, (M/C 152) University of Illinois at Chicago 851 S. Morgan St. Room 1120 SEO, Chicago, IL 60607-7053, United States

[3]University of Michigan Department of Geological Sciences, 2534 C. C. Little Building, 425 East University, Ann Arbor, MI 48109-1063, United States

The GeoWall stereo projection technology has been widely adopted within Earth Science. Over 20,000 undergraduate students per year use a GeoWall in classroom and lab settings at over 80 institutions around the world using over 200 GeoWalls. We believe that critical mass for this technology has been reached in the Earth Science. Many collaborations have been initiated. With Iris, GeoWall is exploring new ways to monitor seismic networks in real-time and to visualize extremely large, whole Earth seismic simulations. We are also working with a number of drilling organizations including JOI, DOSECC and LacCore to bring modern visualization technology to core interpretation and drill site selection. Also, over 15 museums now have or are building GeoWalls for informal education. Much of the science that is being performed on the GeoWall is finding its way directly into the classroom and science museum. One of the success stories has been the GeoWall Consortium's interaction with industry. The basic hardware for the GeoWall has been spun off to companies that now sell variations of the hardware. In addition, many software companies including ESRI and Dynamic Graphics have added support for the GeoWall in their products. The future of GeoWall is four fold. Curriculum development will bring more material to all GeoWall users. Assessment of the curriculum and educational psychology will give us GeoWall best practices. In technology development, the GeoWall 2 is a 20+ million pixel, tiled display which brings more resolution to the Earth Sciences than ever. To support research the consortium is developing a volume rendering application to visualize extremely large datasets.

URL: http://www.geowall.org

ED31A-02 0825h

ENHANCEMENT OF SPATIAL UNDERSTANDING IN AN INTRODUCTORY FIELD METHODS PROJECT THROUGH A GEOWALL INTERVENTION

Nancy R Riggs[1] (928 523-9362; nancy.riggs@nau.edu)

Michael M Kelly[2] (928 214-7374; design@mmkaa.com)

[1]Northern Arizona University, Dept. of Geology PO Box 4099, Flagstaff, AZ 86011, United States

[2]MMKAA Inc., 3354 N. Crest, Flagstaff, AZ 86001, United States

The implementation of the GeoWall (www.geowall.org) in introductory geology labs as a visualization tool is on the increase at the undergraduate level. We report on a new project that examines how introductory field students' understanding of basic mapping skills may change after a GeoWall intervention. GLG 240 is a required field methods course for students majoring in Geology at Northern Arizona University. In this class, students learn to describe different kinds of rocks, self locate on a topographic map, use a Brunton compass, and map relatively simple geologic structures. The class is a prerequisite to upper-division classes (mineralogy, petrology, structure, etc) and is open to any student who has completed physical and historical geology. In

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the Fall semester 2003, we will implement the GeoWall 3D visualization technology in critical sections of GLG 240 dealing with students' perception of terrain and geologic relations. In this study we examine one of these GeoWall interventions that centers on a field exercise done on SP Crater, a young cinder cone and flow north of Flagstaff, Arizona. The goals of the exercise are an increase in student confidence in self location, a sense of how scale varies between different media (aerial photographs, topographic sheets) and distance on the ground, and an ability to follow and map contacts between Paleozoic bedrock, old and young volcanic rocks, and alluvium. This exercise has been relatively unchanged with the same instructor over the last five years. Assessment of student learning has also remained steady: rubrics were established early and applied to a student written report comprising maps, figures, and written geologic analysis. The GeoWall intervention will occur during a pre-field exercise that occurs in the laboratory. Students map contacts and describe the geologic setting of SP Crater using black and white, stereo, 1:25000 aerial photographs and mylar overlays. The intervention adds to this instruction by requiring the students to individually use a stereo 3D visualization of SP Crater rendered with the commercially available ROMA software in the GeoWall. The intervention includes an assessment instrument delivered inside the GeoWall that requires students to "fly" to various predetermined points of interest and describe the geologic setting at those points using well-defined rules. The lab exercise is followed by a day-long field trip to SP Crater, where the students complete a field mapping day. Additionally, we will make the GeoWall available to students during the report-writing phase of this exercise in the following week. We will analyze previous student spatial performance as measured by previous written reports over the last five years, and compare them with this group. Additionally we will report on qualitative measures of students' interest and motivation in field geology and perceptions of the usefulness of spatial technology in their learning and future careers in geology.

ED31A-03 0840h

GeoWall Experiences in K-12 Education

Andrew E Johnson (312-996-3002; ajohnson@uic.edu)

University of Illinois at Chicago, Electronic Visualization Laboratory M/C 152, Chicago, IL 60607, United States

Since the mid 1990s the Electronic Visualization Laboratory at the University of Illinois at Chicago has been investigating how advanced visualization technology such as CAVEs, ImmersaDesks, PCs, and plasma panels can be used effectively in K-12 education. The creation of the GeoWall has given us more flexibility in deploying these technologies, and conducting these investigations outside the laboratory. Over the two years we have been using GeoWalls in a variety of educational settings around the Chicago area. Since the Fall of 2002, the SciTech Museum in Aurora, IL has used a GeoWall to show a variety of educational content. In February 2002 the Museum of Science and Industry in Chicago, IL set up a GeoWall to show 'Virtual Harlem' which allowed museum patrons to walk the streets of Harlem NY in the 1930s to learn about the place and the people. Since 1999 we have been working with Abraham Lincoln Elementary School in Oak Park, IL using a variety of display devices to teach the scientific method and investigate the use of multiple perspectives in learning. We began using a GeoWall there in the spring of 2002 and in the spring of 2003 we expanded our work in Oak Park to include Gwendolyn Brooks Middle School.

ED31A-04 0855h

Visualizations and Mental Models - The Educational Implications of GEOWALL

David Rapp[1] (612-624-2920; rappx009@umn.edu)

Panayiota Kendeou[1]

[1]Educational Psychology University of Minnesota, 206A Burton Hall 178 Pillsbury Drive S.E., Minneapolis, MN 55455, United States

Work in the earth sciences has outlined many of the faulty beliefs that students possess concerning particular geological systems and processes. Evidence from educational and cognitive psychology has demonstrated that students often have difficulty overcoming their naïve beliefs about science. Prior knowledge is often remarkably resistant to change, particularly when students' existing mental models for geological principles may be faulty or inaccurate. Figuring out how to help students revise their mental models to include appropriate information is a major challenge. Up until this point, research has tended to focus on whether 2-dimensional computer visualizations are useful tools for helping students develop scientifically correct models. Research suggests that when students are given the opportunity to use dynamic computer-based visualizations, they are more likely to recall the learned information, and are more likely to transfer that knowledge to novel settings. Unfortunately, 2-dimensional visualization systems are often inadequate representations of the material that educators would like students to learn. For example, a 2-dimensional image of the Earth's surface does not adequately convey particular features that are critical for visualizing the geological environment. This may limit the models that students can construct following these visualizations. GEOWALL is a stereo projection system that has attempted to address this issue. It can display multidimensional static geologic images and dynamic geologic animations in a 3-dimensional format. Our current research examines whether multidimensional visualization systems such as GEOWALL may facilitate learning by helping students to develop more complex mental models. This talk will address some of the cognitive issues that influence the construction of mental models, and the difficulty of updating existing mental models. We will also discuss our current work that seeks to examine whether GEOWALL is an effective tool for helping students to learn geological information (and potentially restructure their naïve conceptions of geologic principles).

ED31A-05 0910h

Using Geowall to Promote Undergraduate Research

. SCEC EIT Intern Team[1] (213.821.6340; perry@usc.edu)

Sue Perry[1] (213.821.6340; perry@usc.edu)

Thomas Jordan[1] (tjordan@usc.edu)

[1]Southern California Earthquake Center, USC, 3651 Trousdale Parkway SCI 169, Los Angeles, CA 90089, United States

The principal use of our Geowall system is to showcase the 3-D visualizations created by SCEC/EITR (Southern California Earthquake Center/Earthquake Information Technology Research) interns. These visualizations, called LA3D, are devised to educate the public, assist researchers, inspire students, and attract new interns. With the design criteria that LA3D code must be object-oriented and open-source, and that all datasets should be in internet-accessible databases, our interns have made interactive visualizations of southern California's earthquakes, faults, landforms, and other topographic features, that allow unlimited additions of new datasets and map objects. The interns built our Geowall system, and made a unique contribution to the Geowall consortium when they devised a simple way to use Java3D to create and send images to Geowall's projectors. The EIT interns are enormously proud of their accomplishments, and for most, working on LA3D has been the high point of their college careers. Their efforts have become central to testbed development of the system level science that SCEC is orchestrating in its Community Modeling Environment. In addition, SCEC's Communication, Education and Outreach Program uses LA3D on Geowall to communicate concepts about earthquakes and earthquake processes. Then, projecting LA3D on Geowall, it becomes easy to impress students from elementary to high school ages with what can be accomplished if they keep learning math and science. Finally, we bring Geowall to undergraduate research symposia and career-day open houses, to project LA3D and attract additional students to our intern program, which to date has united students in computer science, engineering, geoscience, mathematics, communication, pre-law, and cinema. (Note: distribution copies of LA3D will be available in early 2004.) The Southern California Earthquake Center Earthquake Information Technology Intern Team on this project: Adam Bongarzone, Hunter Francoeur, Lindsay Gordon, Nitin Gupta, Vipin Gupta, Jeff Hoeft, Shalini Jhatakia, Leonard Jimenez, Gideon Juve, Douglas Lam, Jed Link, Gavin Locke, Deepak Mehtani, Bill Paetzke, Nick Palmer, Brandee Pierce, Ryan Prose, Nitin Sharma, Ghunghroo Sinha, Jeremie Smith, Brandon Teel, Robert Weekly, Channing Wong, Jeremy Zechar.

ED31A-06 0925h

Effectiveness of Geowall Technology in Conceptualizing the Earth-Moon System

Niescja E Turner[1] (neturner@utep.edu)

Ramon E Lopez[1] (relopez@utep.edu)

Kastro M Hamed[1] (kastro@utep.edu)

[1]University of Texas El Paso, Dept. of Physics, El Paso, TX 79912, United States

One persistent difficulty many students of earth and planetary science face is the lack of 3-dimensional mental model of the Earth-Moon system. Students without such a mental model can have a very hard time conceptualizing the geometric relationships that cause the cycle of lunar phases. We present results from a study using a 3-D Geowall with a simulated sunlit Earth-Moon system on undergraduate students' ability to understand the origins of lunar phases. We test three groups of students: some with traditional in-class instruction, some with a laboratory exercise using the Geowall Earth-Moon simulation, and some students who were exposed to both. Students are given pre and post tests using the Lunar Phase Concept Inventory (LPCI) diagnostic. In addition to the diagnostic tests, free response comments are solicited from the students, and their responses are presented as well. We will discuss the effectiveness of this technology as a teaching tool and explore student reactions to the experience.

ED31A-07 0940h

GeoWall use in an Introductory Geology laboratory: Impacts in Student Understanding of Field Mapping Concepts

Lanya E. Ross[1] (ler8@dana.ucc.nau.edu)

Michael Kelly[2] (928-214-7374; mkellyaz@earthlink.net)

Abe E. Springer[1] (928-523-7198; abe.springer@nau.edu)

[1]Northern Arizona University, PO Box #4099, Flagstaff, AZ 86011, United States

[2]MMKAA Incorporated, 3354 North Crest Street, Flagstaff, AZ 86001, United States

In the Fall semester of 2003, Northern Arizona University will introduce the GeoWall to its introductory geology courses. This presents an opportunity to assess the impact of this new technology on students' understanding of basic topographic concepts and the spatial relationships between geology, topography, and hydrology on a field trip. Introductory Geology fulfills the Lab Science component of the Liberal Studies Program at Northern Arizona University. The class is open to all Northern Arizona University students, and is most commonly taken by non-science majors. In this class students learn to: locate their position using maps, identify common minerals and rocks, recognize the relationship between geology and geomorphology, visualize how rocks exposed at the surface continue into the subsurface, and to draw conclusions about possible geologic hazards in different settings. In this study we will report how a GeoWall 3D visualization technology was used in a field study of a graben south of Flagstaff. The goal of the field exercise is to improve students' ability to synthesize data collected at field stops into a conceptual model of the graben, linking geology, geomorphology and hydrology. We plan to present a quantitative assessment of the GeoWall learning objectives from data collected from a paired test and control group of students. Teaching assistants (TAs) with two or more lab classes have been identified; these TAs will participate in both GeoWall and non-GeoWall lab exercises. The GeoWall use will occur outside of normal lab hours to avoid disrupting the lab schedule during the eighth week of lab. This field preparation exercise includes a 3D visualization of the Lake Mary graben rendered with the ROMA software. The following week, all students attend the graben field trip; immediately following the trip, students will interviewed about their gain in understanding of the geologic features illustrated during the field trip. The results of the post-fieldtrip interviews will also be presented to quantitatively assess how students perceive the use of the GeoWall in this introductory geology setting, and how it affected their understanding.

ED31B MCC: Level 2 Wednesday 0830h

Conceptions, Cognition, and Change: Student Thinking About the Earth II Posters

Presiding: **J C Libarkin,** Ohio University**; S Anderson,** Black Hills State University

ED31B-1166 0830h POSTER

Digging Into Earth Science: Teachers' Alternative Conceptions in the Geosciences

Julie A. Dahl[1] (julie.dahl@k12.sd.us)

Steven W. Anderson[2] (steveanderson@bhsu.edu)

Julie Libarkin[3] (jlibarki@cfa.harvard.edu)