

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

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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

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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

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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 Hoelt, 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, Jeremy Smith, Brandon Teel, Robert Weekly, Channing Wong, Jeremy Zechar.

ED31A-06 0925h

Effectiveness of Geowall Technology in Conceptualizing the Earth-Moon System

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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

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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 be 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

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A sample of K-12 South Dakota teachers was investigated to discover if they held alternative conceptions in the geosciences. Data were collected through surveys (n=38), questionnaires (n=49), individual interviews (n=8) and a 30 item multiple-choice instrument called the geoscience concept test (n=44). Information about teachers' personal interests, classroom occurrence of basic geoscience topics and teachers' personal conceptions about these same topics were gathered. According to the survey results, the study of volcanoes generated both high interest and high classroom occurrence ratings. In contrast, the study of plate tectonics generated low ratings for both interest and occurrence. In fact, only 30% of teachers were able to correctly identify the location of the Earth's tectonic plates. Taking into consideration the important relationships between these two topics, it may suggest that plate tectonics is a subject that teachers do not feel adequately prepared to teach. Additionally, a large number of teachers (79%) perceive the Earth as having a "liquid" or "molten" core. Consequently, 38 of 49 teachers questioned attributed the source of magma to the Earth's core. Another unexpected finding, was the reluctance of teachers to participate in the interview phase. Eight teachers agreed to participate in face-to-face interviews. This is in contrast to 62 who declined.

ED31B-1167 0830h POSTER

Spatial Ability Development in the Geosciences

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We designed an experiment to evaluate change in students' spatial skills as a result of completing an earth science course. Our test subjects included high school students in earth science classes, college level non-science majors enrolled in large enrollment introductory geoscience courses and introductory level geoscience majors. They also varied as to whether their course had a hand-on laboratory experience or used supplemental Geographic Information System (GIS) based activities. We measured all students' ability to mentally rotate three-dimensional objects and to construct a three-dimensional object from a two-dimensional representation before and after taking the earth science course. Results show an improvement in spatial skills for all groups after completing the science course. We also observed a consistent improvement in spatial skills overall from high school level science to courses for majors, which is possibly related to their increased exposure to science. A subgroup of the test subjects among both high school and the college non-science majors completed supplementary GIS activities. The GIS implementation at the high school level was more extensive and resulted in significant improvements in both categories of spatial ability. At the college level, the non-science majors that used the GIS curriculum showed no significant difference from those that did not, probably because the time spent on the curriculum was too short. At the college level, the geoscience majors had nearly three times the improvement of non-science majors in both categories of spatial ability. This can most likely be attributed to hands-on, weekly laboratory experiences, which were not part of the course for non-science majors. Students choosing science majors typically have much higher spatial skills than the average first or second year non-science major, however there were large variations in spatial ability within all groups. These results suggest that we evaluate teaching strategies in all courses to ensure that students can interpret and understand the visual imagery used in lectures.

ED31B-1168 0830h POSTER

Understanding Models: An Explicit Path

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Models consist of representations of the "real" world (Giere, 1988). Visual models, including 3-D representations, diagrams, images and photos are a dominant feature of science courses. However, the use and limitations of models is seldom explicitly taught. Results from a survey assessing students' 1. knowledge of what models are, 2. ability to understand what a model illustrates as well as describe its specific parts, and 3. ability to discuss the use and limitations of models of a model, suggest students' do not have a fundamental understanding of models. In an undergraduate

Earth systems course and a science methods education course an explicit instructional approach is used which enhances students' abilities to understand and use models. The approach requires students to; 1. describe each component of a given model, 2. discuss what the model illustrates, 3. describe how the model is used and 4. discuss the limitations of the model. This approach aids the instructor in targeting specific areas of weakness in students' abilities to use models. Using this approach, students' abilities to understand and use models has increased. Additionally preservice teachers have an increased awareness that models can be misinterpreted by students which can lead to misconceptions.

ED31B-1169 0830h POSTER

Cognitive Assessment of GIS Technology in Education

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This multi-disciplinary research explores the cognitive and pedagogical implications of integrating marine science modules and GIS technology into an earth/environmental science curriculum. Four middle and high school earth/environmental science teachers implemented a 4-week marine science curriculum and followed a rigid implementation design. Traditional learning approaches were compared with technological learning approaches to assess student achievement and attitudes in science. Several important questions were considered: Does GIS improve science content knowledge and foster higher order analytical thinking skills? Are there certain science concepts or geographical spatial skills that the use of GIS technology is more appropriate for? Does the integration of technology in the classroom improve student's attitudes about learning? What is the best instructional approach to use when teaching science content and spatial skills? The results of this study will be preliminary. Examples of the marine science curriculum and GIS technology activities will be presented.

ED31B-1170 0830h POSTER

Students' Misconceptions About the Correspondences Between a Map and the Terrain Represented by the Map

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Skillful use of maps is a prerequisite for success in many fields of geoscience. Geoscience instructors find that many high school and undergraduate students are not skilled at using maps and other spatial representations to obtain or convey information. In an attempt to understand why so many students come to their study of geoscience with such poor map skills, we are studying map comprehension and map curricula in elementary schools. An analysis of published K-5 map skills curriculum materials shows that students are rarely explicitly instructed on the crucial skill of translating from map to reality and vice versa. Instead they are asked questions that can be answered entirely within the frame of reference of the map without thinking about the terrain represented by the map. We have developed a field-based test of map skills that requires students to transfer information from a map into the real world and from the real world onto a map. In the world-to-map task, students place stickers on a map to show where colored flags are located in the real world, just as a field geologist places colored pencil marks on a map to show where specific rock units are located. In the map-to-world test, students use a map to go to locations specified by stickers on a map and place markers on the ground at each location. This is the same skill required by an environmental scientist who follows a map to go to specific sampling locations. Approximately a fifth of 4th graders produce deeply-flawed answers on these tasks, showing a lack of understanding of the basic correspondences between features on the map and the represented terrain. Flaws include placing round stickers arbitrarily on round map symbols, and placing a sticker on a built object that should have been on a natural feature or vice versa. Another category of mistake is to reverse west/east and/or north/south; this mistake tends to be associated with poor performance on a standard psychometric test of mental rotations ability.

ED31B-1171 0830h POSTER

Faces of the Sun and Cognitive Phases

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We designed an untraditional laboratory that focuses on students' conceptual changes as they view images and movies of the Sun. At the beginning and throughout the laboratory students are asked what they expect to see, and are quizzed on how seeing the real images changed their perception. Guiding questions assure that the students think through individual steps. In the first exercises they look at the sun in projection and do a short exercise to get a feel for the scale of the Sun and the Earth. In the second exercise they look at images of the Sun taken with Halph and special XRay filters and identify features they cannot normally see with their eyes. And in the third part they watch movies to get a feel about the dynamic activity of the Sun. The results of how students respond to these exercises will be presented, including how their perception of the Sun has changed.

ED31B-1172 0830h POSTER

Enhancing Spatial Cognition Using Mapping Technologies in Earth Science Education

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The importance of the visual-spatial aspect of science is widely known yet seldom addressed in science instruction. The ability to view the world from multiple perspectives is fundamental to the development of many important scientific concepts (Baker & Piburn, 1997). Earth Science education and the use of emerging mapping technologies such as Geographic Information Systems (GIS) is an effective tool for supporting student learning, inquiry, and problem solving as envisioned by the National Science Education Standards, the Benchmarks for Science Literacy (AAAS, 1993), the Standards For Technological Literacy (2000), and the National Council of Teachers of Mathematics Standards (1986). A mixed method approach studied the potential of using mapping techniques and technologies to enhance teachers' and students' thinking about earth and environmental science concepts: such as landforms, the distribution of rock and soil types, and the relationship between abiotic and biotic factors. Using clinical interviews, analysis of artifacts, test scores, spatial reasoning inventory, survey and instrument, the results suggest that mapping and related technologies can provide improved earth and environmental science content learning, enhance spatial cognition skills and promote successful scientific problem solving for teachers and students.

URL: <http://www.ncsu.edu/scilink/studysite>

ED31B-1173 0830h POSTER

Reasons for Seasons Assessment Outcomes For Diverse Students

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Abstract National systemic reform initiatives point to the need for a more focused science curriculum and better curriculum materials for teachers to use (aligned with science standards, instructional methods, and assessment/accountability measures). Assessment developers face the difficult task of identifying and revealing what students actually know that is relevant to curricular goals. The SCALE-uP Project at the George Washington University has attempted to create such assessments using an adapted rigorous set of criteria based on an assessment item analysis procedure developed by the American Association for the Advancement of Science Project 2061. The procedure evaluates an assessment task's potential to reveal whether students

have attained "a well-defined component of knowledge or acquired a particular skill" (Stern and Ahlgren, 2002). To determine students' scientific understanding of what causes the Earth's seasons, the SCALE-up Project focuses on a single Benchmark from Benchmarks for Science Literacy (AAAS, 1993) that include both empirical observations and theoretical statements related to the target concept (Earth's seasons). In the conceptual model guiding our assessment development, we believe the target concept, articulated through the Benchmark (4B,6-8, #4), represents a single coherent knowledge structure and mental model stored in memory that students can recall or access when needed to explain relevant phenomena or solve tasks. Therefore, students that possess the concept of the Earth's seasons would be expected to respond to phenomena related to seasons with consistent and coherent responses to probes and representations related to the Benchmark idea. The instrument development procedure compares assessment outcomes (cognitive model/framework) of about 30 general 7th grade students with little previous classroom exposure to learning about the seasons, to high achieving 8th graders who have studied the seasons, and to introductory astronomy college students, who presumably understand the reasons for Earth's seasons. In this paper, we report on the results of the initial administrations of the instrument for these three groups.

ED31B-1174 0830h POSTER

Student interpretation of space science imagery and representations

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Space science uses a great deal of imagery, such as X-ray pictures of the solar corona, to convey information. It also deals with complex, three-dimensional structures, such as the substorm current wedge, that are generally rendered in two dimensions. In this study we will discuss naive student interpretations of SOHO EIT images of the Sun, and point out broadly-based misconceptions. We will also discuss student interpretation of 2-D renderings of 3-D concepts, and place those findings in the context of research into Expert-Novice differences. This work is an initial investigation in a long-term research program in understanding viewer response to visualizations involving stills, movies, 2-D and 3-D images.

ED31C MCC: Level 2 Wednesday 0830h

Computer Modeling in Earth Science Education Posters (*joint with P, NG*)

Presiding: K M Menking, Vassar College; J T Snow, University of Oklahoma; D Bice, Carleton College

ED31C-1175 0830h INVITED POSTER

Introducing Earth Sciences Students to Modeling Using MATLAB Exercises

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While we subject our students to math and physics and chemistry courses to complement their geological studies, we rarely allow them to experience the joys of modeling earth systems. Given the degree to which modern earth sciences relies upon models of complex systems, it seems appropriate to allow our students to develop some experience with this activity. In addition, as modeling is an unforgivingly logical exercise, it demands the student absorb the fundamental concepts, the assumptions behind them, and the means of constraining the relevant parameters in a problem. These concepts commonly include conservation of some quantity, the fluxes of that quantity, and careful prescription of the boundary and initial conditions. I have used MATLAB as an entrance to this world, and will illustrate the products of the exercises we have worked. This software is platform-independent, and has a wonderful graphics package (including movies) that is embedded intimately as one-to-several line calls. The exercises should follow a progression from simple to complex, and serve to introduce the many discrete tasks within modeling. I advocate full immersion in the first

exercise. Example exercises include: growth of spatter cones (summation of parabolic trajectories of lava bombs); response of thermal profiles in the earth to varying surface temperature (thermal conduction); hill-slope or fault scarp evolution (topographic diffusion); growth and subsidence of volcanoes (flexure); and coral growth on a subsiding platform in the face of sealevel fluctuations (coral biology and light extinction). These exercises can be motivated by reading a piece in the classical or modern literature that either describes a model, or better yet serves to describe the system well, but does not present a model. I have found that the generation of movies from even the early simulation exercises serves as an additional motivator for students. We discuss the models in each class meeting, and learn that there are many ways to accomplish the exercise, some more efficient than others. One of the more satisfying outcomes of this teaching is that a community of modelers is born, all speaking the same language. The networking among these students well after the end of the class greatly increases the leverage of the class as a learning experience.

ED31C-1176 0830h POSTER

Creation of a Course in Computer Methods and Modeling for Undergraduate Earth Science Programs

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In recent years computer modeling has gained importance in geological research as a means to generate and test hypotheses and to allow simulation of processes in places inaccessible to humans (e.g., outer core fluid dynamics), too slow to permit observation (e.g., erosionally-induced uplift of topography), or too large to facilitate construction of physical models (e.g., faulting on the San Andreas). Entire fields within the Earth sciences now exist in which computer modeling has become the core work of the discipline. Undergraduate geology/Earth science programs have been slow to adapt to this change, and computer science curricular offerings often do not meet geology students' needs. To address these problems, a course in Computer Methods and Modeling in the Earth Sciences is being developed at Vassar College. The course uses the STELLA iconographical box modeling software developed by High Performance Systems, Inc. to teach students the fundamentals of dynamical systems modeling and then builds on the knowledge students have constructed with STELLA to teach introductory computer programming in Fortran. Fully documented and debugged STELLA and Fortran models along with reading lists, answer keys, and course notes are being developed for distribution to anyone interested in teaching a course such as this. Modeling topics include U-Pb concordia/discordia dating techniques, the global phosphorus cycle, Earth's energy balance and temperature, the impact of climate change on a chain of lakes in eastern California, heat flow in permafrost, and flow of ice in glaciers by plastic deformation. The course has been taught twice at Vassar and has been enthusiastically received by students who reported not only that they enjoyed learning the process of modeling, but also that they had a newfound appreciation for the role of mathematics in geology and intended to enroll in more math courses in the future.

ED31C-1177 0830h POSTER

Teaching With Models: A Starting Point Resource Module

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The use of models in entry-level geoscience classes provides an ideal framework for the creation of interactive student-centered learning environments while providing opportunities to introduce students to an important and useful tool. To assist faculty in using models in entry-level courses, we have created a website "Teaching with Models" which is part of "Starting Point", a website aimed at supporting faculty teaching entry-level geoscience with information and materials. The "Teaching with Models" site provides: a definition/clarification of modeling in an introductory geoscience education context; a discussion of when and where different model types are useful and why one

would want to use them to promote student learning; a description of how to effectively use models, including pedagogical and technical issues; and specific modeling examples. This basic structure of what, when and why, how, and examples is repeated at various levels throughout the website. We define "model" very broadly to include five model types: conceptual or mental models; physical models; mathematical models; statistical models; and visualization models. We identify three key motivating factors supporting the usefulness of models in introductory geoscience education: 1) The extensive use of models by professional geoscientists suggests that introductory geoscience students should be exposed to the basic philosophy and usefulness of models; 2) Models provide an excellent framework for the creation of interactive student-centered learning environments; and 3) Many concepts from systems thinking and Earth-system science are ideally suited to the use of models. Our presentation will include assessment results based on student surveys for a Fall 2003 introductory Earth's Climate course and a description of several "Teaching with Models" modeling examples available online at: <http://serc.carleton.edu/introgeo/models/index.html>.

URL: <http://serc.carleton.edu/introgeo/>

ED31C-1178 0830h POSTER

The NCAR Modeling in the Geosciences Workshop for Middle and High School Educators

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The National Center for Atmospheric Research initiated a new workshop, "Modeling in the Geosciences," in the summer of 2003 with support from the NASA-funded Earth System Modeling Framework Project. This multi-part, multi-year effort, introduced 20 middle and high school educators from across the country to models and the modeling process. The workshop focused on what models are, how scientists use models in their research, and how models can be used for engaging, inquiry-based education in the middle and high school science classroom. Teachers received training on STELLA and ArcView software during the two-week workshop, as well as hands-on activities and demonstrations that illustrate concepts in modeling. Topical areas of emphasis for the workshop included the water cycle, the carbon cycle, population dynamics, and Earth energy balance. Participants are required to develop a unit for use in their own classrooms, based on the resources provided in the workshop, and to report back to the group through extension workshops this fall (facilitated on-line) and in the spring of 2004 (at the National Science Teachers Association Meeting in Atlanta, GA). In addition, participants were provided STELLA and ArcView site licenses for their schools, and are required to provide training to 40 educators per year based on the resources provided to them during the workshop.

URL: <http://www.ucar.edu/educ-outreach/mgw/index.html>

ED31C-1179 0830h POSTER

A Simple Numerical Model of the Global Carbon Cycle for the Classroom

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Using the STELLA programming software, a numerical model of the global carbon cycle has been developed for educational purposes. The basic model is a somewhat simplified version of box models developed by researchers in the 1980s to explore the cycling of carbon on time scales of years to centuries. The model contains four reservoirs (or "stocks") of carbon - atmosphere, ocean, and land plants - interconnected by a variety of processes (or "flows"). The presentation will demonstrate the model and cover three topics regarding its use in the classroom. 1) Construction of the model by lower division students, focusing on animating a static diagram of the carbon cycle and emphasizing the importance of the concepts of balance and conservation of carbon to continually check the work in progress. 2) Introduction of students to real-world model tuning to eliminate both starting transients and small imbalances introduced by representing continuous functions in finite difference form.