CILT99: Visualization & Modeling Abstracts

Presentations

Growing CyberPlants for Fun and Learning

Marie Bienkowski
http://www.viz.ctl.sri.com/cyberplants

In the Hall of Biodiversity at the American Museum of Natural History, a rain forest has been grown from artificial leaves that were hand-crafted by thousands of students. Now, imagine a rain forest built by students in cyberspace where they craft their leaves and vines and trees using plant generation algorithms that run on video game machines, thereby creating a massively shared virtual reality. This is the vision our seed grant is helping to realize.

The technical foundation of this vision is already laid through the invention and continuing development of techniques for plant generation and rendering (Prusinkiewicz and Lindenmayer, 1990). Furthermore, next-generation game machines will have Internet connectivity and sufficient computational speed to render millions of polygons per second. Thus, the provocative possibility is that the next big breakthrough in educational technology will be through high-speed visualizations and game machines.
In our CILT seed grant we have been mapping out the components needed to realize this breakthrough. This involves experimenting with the algorithmic plant software used for rendering, identifying potential partners, and characterizing the tasks that students will find both entertaining and educational. One possible game has students setting up an environment and then designing plants to fit it. This involves students in "growing" plants, designing collaborative landscapes, and studying how a plants' distinctive morphology adapts it to certain climates.

We are using the xfrog (www.greenworks.de) plant generation system to create wireframe models of plants. These models are then rendered and made accessible as VRML models. Important issues are how to adapt the interfaces of algorithmic plant tools for students and how to provide case libraries that will eliminate the difficulties of starting from scratch but will still preserve the challenge and excitement of creating plants algorithmically.

References
Przemyslaw Prusinkiewicz and Astrid Lindenmayer. "The Algorithmic Beauty of Plants."

Integrating Modeling and Visualization within Teacher Education

Lisa Bievenue

Part of the EOT-PACI (Education, Outreach and Training for the Partnerships for an Advanced Computing Infrastructure) mission is to provide teacher training on computer-based modeling and scientific visualization. The EOT-PACI intends to, through collaborations with LIS partners and schools of education, and by leveraging the power of their alliance, including regional PACS (Partners for Advanced Computational Services), target critical points at which to support the use of computer-based modeling and scientific visualization. One such critical point is teacher education. Thus the EOT-PACI group plans to host a national workshop to understand how EOT-PACI partners, in collaboration with their parent organizations, National Computational Science Alliance and the National Partnership for an Advanced Computational Infrastructure, can work with colleges of education to incorporate computer-based modeling and scientific visualization in their science education courses.

Specifically, the EOT-PACI partnership proposes to contribute to teacher education in two ways: 1. Technology transfer of visualization and modeling tools, learning environments, and knowledge mining tools. This would include adapting technology for educational settings that have known barriers, such as low bandwidth or low-end computers. 2. Bridge scientific and education communities by developing and supporting an infrastructure to support relationships among scientists and educators. This infrastructure might include 1-to-1 mentoring relationships, but would more likely build on teleapprenticeship relationships. These relationships might consist of teachers, undergraduates and graduate students participating in special programs and internships with scientists. These teachers, undergraduates and graduate students then become intermediate links between scientists and educators. In addition, EOT-PACI partners will often assist in mediating communication among communities. This infrastructure would not just aid teacher educators in learning to use modeling and visualization, but also in why to use it.

Founding SciCentr: a Multiuser, Interactive 3D Virtual Science Center

Margaret Corbit
http://www.tc.cornell.edu/Exhibits/Worlds

Just three years ago, virtual reality on the desktop was a dim fantasy. Today, anyone on the Internet can download a free 3D browser. The appeal of 3D mulituser environments is well known in gaming and entertainment. The teenaged and young adult audiences for this technology is growing exponentially. The Cornell Theory Center's exploration of this new medium is natural to the evolution of CTC's use of the Internet for research communication, training, and informal science education.

CTC is in the early stages of developing a virtual science center, SciCentr, built by and for young adults and the young at heart. SciCentr will encompass hands-on exhibits, lab spaces, science fairs, and communication spaces. These will include interactive interfaces to simulations and visualizations created to communicate key concepts in science and technology to a general audience, for example a space based on Mars topographic data from the Soujourner rover (Cornell/NASA/USGS collaboration). Using Active Worlds technology, we hope to incorporate simulations with visualized results in a multiuser context. Imagine, for example, a singing fountain that responds to notes played by many users, sends them back a chord of the composite sounds and simultaneously provides a visualization of the waveform in a Web window. Cornell programmers are working with artists at Art Center College for Design in Pasadena, CA, to create this as a focal feature for an area centered on wave science.

Exhibit content will be created by teams of students and professionals from a wide range of disciplines. At Cornell, SciCentr initially will involve students and faculty from the departments of Fine Arts, Communications, Electrical Eng., Computer Science, Plant Sciences, Astronomy, Geology, and Molecular Biology. These teams are directly involved in national and international collaborations with other institutions through our involvement with the Contact Consortium and Questacon, Australia's national science center.

Learning Science through Multisensory Immersion via Virtual Reality

Chris Dede
http://www.virtual.gmu.edu

Imagine launching and catching balls in an environment with neither gravity nor friction. Imagine creating and altering electrostatic fields, releasing charged particles to be propelled through those fields. Imagine manipulating atoms and observing the forces created when molecules bond. Then, as a giant step further, imagine being able to directly experience these phenomena by becoming a part of them “inside” a virtual world: being a ball as it bounces, riding on a test charge as it moves through an electrostatic field, becoming an atom as it bonds. These are the kinds of learning activities enabled in the virtual worlds of ScienceSpace. Our NSF-funded research suggests that such immersive, multisensory experiences enhance students’ abilities to conceptualize and integrate complex, abstract scientific ideas.

Many groups are developing sophisticated instructional designs with well-understood, conventional technologies, such as today’s personal computing and telecommunications devices. In contrast, our work explores the strengths and limits for learning of a very powerful emerging technology, virtual reality (VR). However, Project ScienceSpace does not focus solely on developing educational worlds using an interface that enables multisensory immersion. In addition, our studies are exploring new ideas about the nature of learning based on the unique capabilities for research that virtual reality provides. ScienceSpace worlds enable extraordinary educational experiences that help learners challenge their intuitions and construct new understandings of science. Our evaluations are designed to examine various aspects of this learning experience, process, and outcomes. Sophisticated experimentation along these dimensions is critical to determining the educational potential of three-dimensional, sensorily immersive virtual environments, a medium that the entertainment industry will place “under the Christmas tree” within the next decade.

Interactive Mathematical Biology's Role in Curricular Reform: BioQUEST Simulations and Mathematics for Problem-Solving

John R. Jungck
http://bioquest.org

Mathematics has played exceptionally important roles throughout the history of biology. More biology students take Calculus than any other single constituency. Too frequently, textbook authors have unappreciated mathematics in biology curricula because they assume that biology students have an inadequate mathematical preparation. This practice: (1) deskills many biology students, (2) is inconsistent with our requirements, (3) misrepresents contemporary biological research, and, (4) underprepares students to read many articles or to contribute to many areas of biology. However, the recent calculus and biology reform movements have empowered students to actively investigate the behavior of many famous mathematical models in biology. While numerous recent publications are replete with numerous models, there is a need to identify a succinct list of achievements that represent the power of mathematics in biology. Hence, ten equations that changed biology and a brief description of their historical importance are presented here with BioQUEST software instantiations in order to draw attention to a variety of mathematical models that have been intrinsic to significant discoveries in biology and to illustrate that the tools are currently available for engaging students in active investigation of biological phenomena and the development of systematic strategies for biological problem solving.

Intellectual Effects of Model Building

Clayton Lewis

The intellectual effects of model building Model building by adult scientists is richly rewarding intellectually. Can the intellectual benefits be reaped by young children who build animated computer models as part of their science study? Experience in the Science Theater/Teatro de Ciencias project, in which children used novel rule-based programming systems, provides some indications of how model building works and fails to work intellectually.

Introducing Social Cues in Multimedia Learning Environments: Theoretical and Empirical Perspectives on the Role of Pedagogic Agents

Roxana Moreno

The hypothesis that animated pedagogical agents can promote constructivist learning in a discovery-based learning environment was tested. Discovery-based environments offer the greatest potential for fostering learning, but based on the learner's freedom to explore, it threatens to be overwhelming. One way to combat this problem, is to provide students with individualized scaffolding. Especially relevant to multimedia learning is the emerging technology of animated pedagogical agents--lifelike on-screen characters who provide contextualized advice and feedback throughout a learning episode. Can animated pedagogic agents help students' understanding of a computer lesson? In order to help answer this question, the following set of experiments was conducted. In Experiment 1, students who learned about environmental science in a microworld with an agent outperformed students who learned the material in a hypertext environment, on transfer and motivation tests but not on retention tests. Experiment 2 showed two findings. First, students who learned with words spoken by a synthetic pedagogical agent outperformed students who received identical verbal material as on-screen text on transfer and retention tests but not on motivation tests. Second, students who learned with the image of the synthetic animated agent on the computer screen did not differ in their performance or motivation from those who learned without the image. In Experiment 3 the synthetic agent was replaced by a real-life agent video. The results replicated the pattern found in Experiment 2. Finally, in Experiment 4, the performance and motivation of students who learned with an agent through a bi-directional or dialogue-style language was compared to the performance and motivation of those who learned with an agent that provided uni-directional or monologue-style language. Students in the dialogue group outperformed and were more motivated than those in the monologue group.

Welcome to SimPlayer: Web-Based, Interactive Data Visualization

Henry Olds

Introduction: The Web before SimPlayer
The web is a treasure of information, but much of the information on the web is not easy to access or to understand. The data itself is in tables of numbers and text. Most representations of such data amount to no more than a static picture. When people cruise the web to get information about something, the journey is more likey to be daunting than enlightening.

Enter SimPlayer
SimPlayer provides direct access to any web-based data. It reads that data and restructures it in a format that can be interpreted by a large set of visualization and manipulation components. It shows the data in a wide range of graphical representations.

Any graphical representation can be animated so that the user is able to see the flow of the data over time.

Multiple representations can be seen at the same time. For example, the path of a hurricane can be seen on a map. Simultaneously, a graph can show the varying wind speed of the hurricane over time compared with its changing pressure.

All representations of the data are connected to the data itself, which can be viewed in connection with its representations. The user can see what data is being represented and how it is being represented.

On the same web page, the user can choose multiple examples of a phenomenon to explore and compare (e.g. the paths of several hurricanes from different years can be animated and displayed on the same map).

The user can interact with the data. When a pattern or trend is discovered, the user can make predictions, observe a visualization of the predictions, and then compare predictions with real data.

In summary, SimPlayer turns common web pages into powerful, compelling applications that can convert incomprehensible, raw data into dynamic visualizations that enable individuals to make crucial insights, solve problems, and gain real knowledge. SimPlayer makes the common use of dynamic visualizations regularly "thinkable".

The WISE Malaria curriculum: Connecting students to an international scientific controversy through Internet-based activities.

Jim Slotta, Doris Jorde, Alex Stromme, and Marcia Linn UC Berkeley, School of Education
http://wise.berkeley.edu

The Web-based Integrated Science Environment (WISE) provides a powerful new form of on-line curriculum activities. Each curriculum project consists of a series of activities that involve diverse materials from the Internet, as well as from classroom discussions and even hands-on experiments. Students typically work in pairs or small groups and perform a wide range of on-line activities, including the use of unique new visualizations. All student work is managed by our central server, and incorporated into assessments that are integral to the curriculum design. The design of WISE software and curriculum follows our theoretical framework of Scaffolded Knowledge Integration (Linn, 1995).

Successful authoring of WISE curriculum requires a partnership of natural scientists, teachers, and educational researchers. The WISE Malaria partnership was formed to create a curriculum project that helped students build connections to one of the World's major health issues. Malaria was chosen as a topic because it involves ongoing controversy among scientists concerning how to control the spread of the disease. Previous research in the KIE and WISE Projects has explored the use of such controversies from science in the making as an effective source of science curriculum.

While the disease of Malaria affects populations mainly in the central latitudes of our planet, it is truly a global issue. The WISE Cycles of Malaria project helps students understand the controversial choice (e.g., in allocation of funding) between pursuing vaccine and drug treatment research, pesticide development, or social programs for controlling Malaria's spread. The conceptual content of this project provides a wealth of opportunity for students to develop rich and multidisciplinary understanding of this controversy. Two international members of the Malaria partnership are translating the project into Norwegian for implementation in their own country.

Exploring Scaffolded Integrated Tool Environments for Learners

Chris Quintana

Computer technology is becoming more pervasive in everyday work activities. Consider, for example, the work of scientists. Scientists perform a wide range of activities when they investigate problems: they do research, collect and visualize data, build models, etc., all in a self-coordinated, dynamic manner. As such, there is now an array of computational tools and search engines, databases, graphing, animation, and modeling tools to support experts in scientific inquiry.

Aside from expert scientists, though, it is also important for students to engage in and understand the science inquiry process. However, the science inquiry process is not so straightforward for students. Science problems have characteristics of so-called ""wicked"" problems. Thus the science inquiry process can be considered to be complex, chaotic, and opportunistic. Novice learners trying to negotiate the complex inquiry process encounter several difficulties: (1) determining: the set of possible process activities and their rationales, (2) seeing how to perform the different process activities, and (3) planning and tracking activities and artifacts.

With Symphony, we are addressing these difficulties to make complex processes like the science inquiry process accessible to learners. While our recent work has involved developing individual learner-centered tools, we are now moving to the next level in learner-centered support. We are putting the tools together in a single environment: a scaffolded integrated tool environment (or SITE) that offers tools plus process scaffolding. Thus for example, Symphony incorporates graphical process and activity maps, structured activity workspaces, and task and artifact management tools to help visualize and structure the science inquiry.

The aim of Symphony, then, is not so much to lead a student through an artificial step-by-step path through the investigative process, but to provide enough guidance and information so that students can negotiate the inquiry process, exploring different investigative possibilities for arriving at solutions to meaningful, complex problems.

Posters

Simulations as Bridging Scaffolds for Intuitive Conceptions
Doug Clark & Marcia Linn
http://wise.berkeley.edu/WISE/demos/13probe

"Probing Your Surroundings" expands Clement's idea of bridging analogies using simulations to facilitate student construction of intermediate bridging scaffolds between normative instructed models and the intuitive experiential models. The project is based on WISE Internet software with custom simulation modeling, electronic peer critique, and laboratory components integrated to support students as they investigate thermal equilibrium. The project has already been piloted with 300 students in the Bay Area and will be translated at the University of Oslo for implementation in Norway via Internet next year. Students build strong intuitive conceptions and models around their experiences that overshadow normative models instructed in school. Our simulation promotes students' construction of useful connections between these elements of their conceptual ecologies.

Preceding the simulation, students make predictions about the temperature of everyday objects around them. Students then use thermal probes to investigate the temperature of these objects and construct principles to describe the patterns encountered. The software then places students in groups with students who have constructed alternative principles. The actual student-constructed principles are seeded as the discussion topics that the groups critique and discuss working toward consensus.

This first portion of the project cues conflicting elements of students' conceptual ecologies including students' experiential sense that objects are naturally different temperatures because "they feel that way "and students' logical sense that objects in the room should be the temperature of the room because what would make them something else?. The simulation encourages students to experiment with these conceptions about thermal equilibrium while allowing the students to "feel" the objects involved. This process facilitates students' construction of a model of "feel" that acts as a bridging scaffold connecting students' ideas about thermal equilibrium and insulation/conduction with their experiential sense of objects' temperatures. Early assessment outcomes posit significant outcome effects for this integrated simulation project.

The Achieving High Academic Standards Project (AHAS)
William Conrad
Submitted by: Zaritsky, Conrad, Munroe & Rudy

Based upon the experiences in the Collaboratory Visualization Program (CoVis, Pea & Gomez), it had become clear that building multi-page goal based scenarios via the web as explanation for the sciences like atmospheric science could be accomplished with web-based materials. However in focus groups it became clear that students misunderstood the meaning of a front in a weather map leading them to believe that the factor of change was the front rather than the front was a representation of the changes in the air masses. To the question why did it get cold in Chicago, students answered correctly, because the cold front passed through. And then elaborated further to explain that the cold front chills the air as it passes through. These initial results convinced the first author that students needed to work at a deeper level where they could develop ideas about the engines of change in a system.

While at the NCSA, the first author developed a series of inquiry based educational programs with a concentration on intermediate causal models pointing towards the higher end science models of the advanced sciences teams at the lab. The work described below developed out of a long series of professional development workshops using intermediate causal modeling.

The Achieving High Academic Standards (AHAS) Project is a student based collaborative inquiry project that partners for resources and professional development eight school districts across the state of Illinois with the North Central Regional Education Laboratory (NCREL) and the National Computational Science Alliance (NCSA). This collaborative group seeks to determine whether infusing concept organization and visualization software such as Stella and Model-It into schools with high percentages of low-income students, bilingual students, special education students, and mobility rates will improve 6th grade students' abilities to access and achieve math benchmarks related to data collection, representation, and interpretation. This project also seeks to identify successful staff development interventions that will assist low technology skilled teachers in effectively using math visualization software with students. In sum, the project is working in over seventy classrooms in eight school districts and three private schools.

The project engaged 11 teams of 6th grade teachers in four workshops throughout the year to work with curriculum and technology experts to plan and implement an engaged learning unit around the topic of electrical energy conservation within each school. Teachers learned how to use a toolbox for creating inquiry lessons around energy conservation. Software used to support these efforts included: Excel spreadsheets to create electrical energy audits; use of Stella and Model-It software to model the "As Is" electrical energy system of the school; and the use of Stella and Model-It software to test the effectiveness of possible energy conservation initiatives. Teachers were also supported with online professional development instruction, mailed instructional videotapes, e-mail, and just in-time visits from the third author a graduate student in Education from the University of Illinois.

Initial results determined from teacher survey, focus group meetings, and artifact collection include:

Software models demonstrating that students used technology to collect, represent, and interpret electrical energy data. * Teacher reported increased time on task by students. * Teacher reported increased level of confidence in their using technology in the classroom. * Student artifacts demonstrating data collection, representation and interpretation including student-generated web pages and videotapes.

Presenters: Mr. Raul Zaritsky, NCSA Dr. Dennis Rudy, University of Indiana Mr. Michael Munroe, College of Education, UIUC Dr. Bill Conrad, Director of Curriculum, Community Consolidated School District 15

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Emergent structures for conversations and communities: Helping students visualize where a discussion is going

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Innovation is not always the result of a mathematical dream about snakes eating their tails. More often innovation comes from applying accepted approaches to novel situations and gaining insights from how things work (or fail to work, as the case may be). The techniques presented here contribute to the field of educational research by refining advances in engineering design environments and applying them to communities of learners. The particular processes we chose to emphasize rely on the visualization of convergence within discussions. Helping students recognize and reconcile different perspectives on a problem has been a challenge in both engineering (Conklin, 1988; Nagy, Ullman, & Dietterich, 1992) and education (Scardemalia & Berieter, 1991). Creating visualizations that represent the trajectory of a discussion can help turn emergent goals into resources that can support future action (Guindon, 1990).

One of the most important innovations in our community system is that we do not specify the structure of conversations beforehand. Rather, the comments that students make enable certain actions and alternative representations. If students are debating a theory, a representation highlighting the two sides of the theory may emerge with condensed text or links pointing to supporting evidence. If students are working on a design project, different design decisions and rationales might appear with the most important factors percolating to the top of the discussion. The challenge met by this approach is to help students decompose the problem without obscuring the larger idea being developed.

The benefit for students using dynamically reconfigured discussion environments is that the representations are aligned with the processes and activities they support. By creating visualizations that reflect the process of negotiation, students are able to see which comments are credible to their peers. These productive comments should be engaged more frequently and, we expect, comments like them will appear more often.

Supporting Lifelong Learning for New Elementary Science Teachers

Elizabeth Davis

> Elementary teachers face enormous challenges in teaching science. New teachers develop facility with the rhetoric of education, but often have limited understanding of how to implement innovative teaching strategies like guiding students' scientific inquiry. New teachers also have not yet developed a collection of curriculum materials to support those innovative teaching strategies. I intend to investigate these challenges further and to develop prototype approaches to educative curriculum that educates the teachers as well as the students. I hope to increase new elementary teachers' confidence and ability in teaching science, so that elementary children have more productive experiences learning science. I plan to do this through developing a framework for educative curriculum that focuses on improving teachers' (a) understanding of teaching science for understanding as well as their (b) content knowledge in science and (c) knowledge of students' existing scientific ideas.
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> Since many elementary teachers feel more confident teaching life science than physical science, I plan to develop curriculum to teach about physical science topics through the Trojan horse of the human senses. In the context of activities focused on the sense of touch, for instance, students can explore phenomena like thermal equilibrium, insulation and conduction, and heat flow.
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> At the CILT conference, I hope to identify partners with whom to collaborate on the technology component of this work. Though elementary science activities should have a large hands-on component, technology should also play a role. Besides delivering curriculum and scaffolding reflection, technology can provide powerful tools, including simulations and models, that make students' and experts' thinking visible and promote conceptual understanding. Because this project is aimed at teacher learning, too, I also hope to identify an environment to support teacher reflection, provide opportunities for teachers to make their own thinking visible, and foster social supports to further teachers' learning.

A New Technology for Teaching Math Problem-Solving
Rob Foshay
http://www.plato.com

> PLATO(R) Education has developed a new product architecture for teaching problem-solving in moderately-structured domains. The architecture uses an innovative combination of game and intelligent coaching technologies. Original research and development work was partially funded by the Advanced Research Projects Agency.
>
> The architecture's first application is in PLATO Math Problem-Solving, a curriculum of 19 authentic math problem-solving simulations which integrate into the PLATO math curricula. The product is designed to support either solo study or collaborative learning, and includes supports for guide on the side instructor interaction. The architecture represents one of the first large-scale commercial applications of research on learning of problem-solving, and intelligent tutoring technologies.
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> Products using the architecture can be developed cost-effectively due to substantial advances in the instructional design methodology and automated authoring tool set used.

Developing An Expository Model To Assess Animated Science Visual Representations

Carlos Garcia

The study of visual information developed by students learning science, especially as it relates to animated models, is challenging because the researcher has to assess for representation of information (science content), the operations identified with the creation of an animated model (user interface), and variables that affect representational outcomes (real classroom concerns). The purpose of this presentation is to explore the usefulness of an expository model in the assessment of children's learning of science content through the use of animation software. The expository model is a criterion that includes the evaluation of spatial/temporal relations; the development of an operational unit; types of processing related to decomposition; types of processing related to the establishment of parameters; types of processing related to connections between nature and theory; and types of processing related to retrieval. These measures allow the classification of a particular representation as being tight, average or loose. The idea is to have a way of assessing animated science models while raising questions about possible reasons for particular visual outcomes. The presentation will explain in detail these categories given their role in the assessment of science content via a dynamic visual system.

Barry Goldman

The Lawrence Livermore National Laboratory Science & Technology Education Program facilitates internships which support the long-term manpower and core-competency needs of the national security-related programs within LLNL and DOE Defense Programs. Students, teachers, and faculty are placed within research areas that cover a spectrum of topics from: * High Performance Computing (Accelerated Strategic Computing Initiative), * Actinide Chemistry (Seaborg Institute), * Military Academic Research Associates (MARA) and the ROTC, and * Lasers, optics, and crystal growth (National Ignition Facility). Although most of these programs are for upper level undergraduates, students in community colleges may qualify as they complete their sophomore year and should learn of these opportunities as they schedule their upper level undergraduate years.

Enhancing and Representing Free Choice in Informal Science Learning Environments

Robert Lebeau

Science museums and centers are popular resources for teachers and students. Often, however, school group visits to such institutions are isolated and self-contained experiences in which many learning opportunities are unrealized. This presentation discusses a research project in which we sought to influence participants' goal-setting as part of visits to a science center. We did so by designing a new science center map that students receive prior to a visit, and by encouraging particular pre-visit and post-visit planning and reflection in conjunction with map use. We now intend to enhance and integrate these reflective and representational processes through the use of learning technologies.

In the pilot study, we compared self-reports of attitudes and behaviors among students who were given just the map, and those who were given the map plus suggested activities for setting selective goals for a visit. Students in the "map + activity" group demonstrated a trend toward a greater readiness to seek help from center staff when encountering difficulties in understanding. All students indicated shifts in their attitudes toward science learning. Students appeared to find the format of the map, as a consistent part of both pre- and post-visit planning, to be a good foundation for drawing together their experiences and planning for subsequent activity.

The project as a whole centered on concrete representations of the free choices learners make, or intend to make, in informal learning environments. These representations can serve self-instructional goals, teacher documentation of student learning and interests, and as a measure of the nature and quality of learner engagement with science center resources. As such, they provide structural support for the self-direction, social mediation, and free choice characteristic of informal learning. We are eager to further explore with CILT participants how the use of learning technologies can enhance these processes in this context.

The Progress Portfolio: Tools to promote reflective inquiry with visually-oriented investigation environments

Ben Loh
http://www.ls.sesp.nwu.edu/sible/

Computer-based learning environments provide unprecedented opportunities for scientific inquiry using large databases and sophisticated simulation and analytical tools. But these complex environments also create new challenges for students, who often become performance-oriented, lost in the activities of doing inquiry. This problem is compounded by the addition of computer technologies that encourage browsing. Rather than blindly forging ahead in their investigations, students need to be reflective inquirers, to periodically step back to document and monitor their progress, review their understanding and conclusions, and communicate their understanding to others.

We have designed software, called the Progress Portfolio, to help students reflect on the inquiry process as they construct artifacts that represent the progress of their investigations. It provides tools to document these otherwise invisible processes: capturing states of work, documenting thoughts, observations, direction and purpose with annotation tools, organizing work through data management tools, and communicating the products of investigation through presentation tools. These inscriptions of the work process provide tangible artifacts for learning about the process of inquiry through self-reflection and social discourse. Additionally, teachers can customize the Progress Portfolio with structured workspaces and prompts to support their own ideas about what is important for inquiry.

In collaboration with CILT partners, we are interested in further pursuit of an important research agenda: a better understanding of the kinds of inquiry projects and learning environments for which the Progress Portfolio is ideally suited. With design features that include the easy capture, organization, and annotation of images from the Internet or data visualization programs, we believe that the Progress Portfolio is well suited for projects typical of visualization and modeling curricula. By collaborating with developers of such curricula and tools, we can continue to learn how best to support reflective inquiry.

Visualization Tools for Inquiry-Based Classrooms

Harold McWilliams
http://www.terc.edu , http://www.wri.org/enved/datascap.html

VisualizationTools for Inquiry-Based Classrooms Since 1994, TERC has been involved with GIS and other visualization technologies. Research indicates that four factors condition the implementation of these technologies in K-12 education: appropriate hardware and software, accessible and appropriate data, curriculum integration, and teacher professional development. TERC has been involved with the creation of two recent visualization products, Visual Earth (from TERC) and DataScape (from World Resources Institute and ESRI). Visual Earth is a multimedia application designed around the Map Objects LT library of GIS functionality. DataScape is based on ArcView 3.0/3.1. This demo/presentation will present the technical and interface design innovations of these two products, compare the two approaches taken, discuss the technical and philosophical differences reflected in the products, and outline a research strategy to study the actual use of such visualization products in K-12 classrooms.

A CIA approach to conceptual change in science education

Alireza Rezaei

Three groups were studied in this project. The first group comprising 48 students was the control group (CG group) which received one month conventional physics instruction. The second group comprising 39 students is called the radical constructivist group (RC group) which received a 3-hour individualized computer assisted instruction based on radical constructivist approach. The third group comprising 56 students is called the Inventive group (IN group) which received a 3-hour individualized computer assisted instruction based on the Inventive Model explained (Rezaei, Katz, 1998). Two Physics tests were used in this study: the knowledge test, and the conceptual test (Fore Concept Inventory, FCI, Hestenes, 1998). The same tests were used for the post-tests.

The results showed that group 1 (the control group) scored significantly higher on both the knowledge pretest and the conceptual pretest. However, group 3 (the Inventive Model group) scored significantly higher than the other groups on the conceptual posttest. Group 1 scored significantly higher than other groups on the Knowledge posttest. Regarding the time efficacy, the Inventive Model was 5 times more effective than the conventional approach.

The effectiveness of each teaching method on individual items was also considered in this study. In summary the results showed that the Inventive Model had positive effects on almost all items of the conceptual test. However, the radical constructivist approach has different effects on different items. It was also observed that the Radical constructivist approach and the conventional instruction had negative effects on some conceptual items.

Finally the analysis of students' log files showed that most of students had visited most of their assigned pages and had answered most of their assigned questions. However, their first answers to most questions, were mainly incorrect. The results also showed that students spent more time on answering short time questions than the multiple choice ones and that Hint and Help buttons were rarely used by students.

Challenge 2000 Multimedia Project

Michael Simkins
http://pblmm.k12.ca.us

Begun in 1995, the Challenge 2000 Multimedia Project is an innovative program that harnesses the power of multimedia to engage students in challenging learning activities. Students complete projects that draw on real-world information and research methods- and design them as sophisticated multimedia presentations. Students learn course work and technology skills in a way that also fosters valuable workplace competencies such as teamwork, communication, planning and problem solving. Students display their work at Project-sponsored multimedia fairs.

The Multimedia Project is both a curriculum development and professional development project. The Project provides tools for teachers to transform conventional course work into project-based, technology-rich curriculum. Teachers work together to develop instructional designs that include:

- challenging, multidisciplinary curriculum
- sustained student effort
- student decision making
- collaboration
- real-world connections
- measures of student accomplishment
- multimedia applications

Teachers build on what they do well, learn new practices and develop exemplary educational experiences for all students. Multimedia Project teachers establish a peer learning community in which they gradually take on responsibility for planning and conducting their own professional development. Veteran teachers share their skills with less experienced colleagues. The Project provides support in the form of on-site mentors, training workshops, mini-grants for equipment and supplies, more time for planning, and on-line resources and networking opportunities.

Results

An initial portrait and assessment of the Challenge 2000 Multimedia Project is found in Transforming Teaching and Learning with Multimedia Technology, a report prepared by staff at SRI International. The report highlights positive changes in classroom practices as well as describing the challenges the project faces in moving forward. The Multimedia Project is a program of Challenge 2000, a broad school reform effort sponsored by Joint Venture: Silicon Valley Network, in collaboration with San Mateo County Office of Education. The Multimedia Project is one of the U.S. Department of Education Technology Innovation Challenge Grants.

BGuILE: Teachers, students and materials interacting to construct biological knowledge

Iris Tabak
http://www.ls.sesp.nwu.edu/bguile

BGuILE learning environments bring scientific inquiry into middle school science and high school biology classrooms. The environments consist of computer-based scenarios and associated classroom activities in which students conduct authentic scientific investigations. Students explain phenomena such as animal behavior and evolution - why lion hunts succeed or fail, how some finches are able to survive while their population is decimated, or how strains of Tuberculosis are resistant to antibiotics.

The learning environment supports students' progression through a cycle of investigation. Students choose variables on which to focus, construct comparisons, interpret and synthesize results. They construct, evaluate and revise explanations, and respond to critiques from classmates. Students explore a myriad of data: qualitative behavioral data through video and text, quantitative morphological data through graphs, and simulated results of in-vitro experiments. Teachers in the BGuILE classroom augment and reinforce the supports in the computer environments. Teachers encourage students to consider alternative hypotheses, debate investigation strategies, and challenge interpretations.

One focus of our research concerns how to provide support for student-directed investigations. We combine general inquiry support with biology-specific support. General analysis support encourages students to construct comparisons and annotate data with interpretations. Specific support helps students look for biological patterns, such as individual variation and relating structure to function, as well as organize data into biological evidence categories. General support for explanation construction encourages students to tie evidence to each claim. Specific support helps students articulate explanations that are consistent with canonical biological explanations.

A second research theme examines how teachers enact inquiry projects. We examine how teachers create a climate conducive to scientific inquiry, how they frame and structure tasks to communicate expectations and values, and how they provide ongoing support as students conduct their investigations. Design research focuses on creating technological supports for these effective teaching practices.

eeZone TEXAS: Exploring Interdisciplinary Environmental Issues via the Internet

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eeZone TEXAS is a 6-12 grade Internet-based learning program that uses interdisciplinary environmental education issues to teach students problem solving skills and systems thinking. eeZone was developed for the Texas Education Agency as part of a 1998 Technology Integration in Education grant awarded to a cooperative group of rural school districts and Bricolage Interactive. eeZone Texas currently hosts landfill, litter and graffiti projects. Each of these eeZone projects engages students collaboratively in authentic real-world investigations of environmental issues relevant to the local community. The eeZone website provides students and teachers with the learning tools necessary to explore the relationships among social and scientific systems inherent in complex environmental issues. The eeZone Landfill project facilitates students' collaborative investigation of solid wastes streams at their school and within a "planned community" proposal in order to calculate solid waste management needs and propose a plan for siting a landfill. Using a GIS map viewer, students also explore a set digital topographic maps to determine potential ground water contamination concerns. The eeZone Graffiti Project challenges students to understand different points of views and health hazards associated with graffiti. Using interactive databases, students are able to quickly identify relationships between toxic chemical exposure rates and lifelong health impacts. Finally the eeZone Litter project help students gather data on litter behaviors around their school campus in order to propose and evaluate various litter control policies. Using CAD based software, students create a digital map of their campus and enter data into an on-line database with the aide of drag-and-drop icons that record the location and amount of litter. At the completion of all eeZone projects, students use their authentic research to make real recommendations for changes in their local community and to actively impact their local environment. The eeZone projects are currently being used by over 2,000 students and are expected to involve another 60,000 students by the year 2000.

Demonstrations

ChemViz: Quantum Chemistry Visualization Tools

Lisa Bievenue
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ChemViz is a set of scientific visualization tools and curriculum materials designed to make computational chemistry accessible to high school, and college, teachers and students. Waltz, one of the ChemViz tools, is a web-based interface to DiSCO, a computational chemistry tool that calculates electron densities and molecular orbitals. Students use Waltz as a web-based computational laboratory for designing experiments that can answer their questions concerning such abstract concepts as electrons, atoms, molecules, and chemical bonding. By using Waltz to generate images of the electron densities for various combinations of atoms, students are able to understand in concrete terms the differences between equal and unequal sharing of electrons, bonding and antibonding orbitals, strong and weak bonds, and the energy differences of atoms at appropriate and inappropriate bond distances and angles. A second tool of ChemViz is a web-based interface to the Cambridge Structural Database of crystallographic structures. Students can search for a named molecular structure such as aspirin, ethanol or caffeine, or they can search for a chemical formula. In either case a 3-dimensional interactive representation of the structure is shown to them via the Chime plugin or the RasMol application.

With these tools, chemistry teachers who currently use handwaving to teach invisible submicroscopic concepts will instead use computational and visualization tools to represent three-dimensional processes. An evaluation report documented that ChemViz was successful in changing the teaching of quantum chemistry (Moran, et. al., 1995).

Teachers learned to move away from a role as purveyor of knowledge to a more facilitative role. Students and teachers learned how to use a supercomputing application to ask questions, develop and test hypotheses, and document results with images and animations of atomic structures.

Moran, J., Pearson, P.D., Bievenue, L.A., Chang, C.S., Nelson, S. D., and Pasero, S.L. (1995). Visualizations in Teaching Chemistry. Final Evaluation Report for the NSF Funded ChemViz Project. National Center for Supercomputing Applications, Champaign, IL.

Using Function Probe for Trigonometric Applications

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We are beginning a project investigating the development of trigonometric thinking. The project will have a number of parts including a careful examination of trigonmetric thinking as it is used in graphic arts, semiconductor work and sound machines. In addition, we plan to examine critically the understanding of trigonometric reasoning in students in advanced courses. Finally, after undertaking these initial studies of reasoning currently in successful students and in experts who use the ideas explicitly and implicitly, we plan to build a connecting and enhancing series of computer tools and interactive diagrams to bridge the divide and to work with teachers in our implementation site to embed these within existing state curriculum frameworks. In our demo, we will show a simple and inital application of our software Function Probe to web-based data for sunrise, midday and sunset and illustrate how the visualization tools of the grapher and the table capacity can lead to more effective understanding of transformations of trigonometric functions.

Stagecast Creator – Desktop Simulation

Allen Cypher
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Stagecast Creator is a new desktop simulation program that enables anyone -- kids, teachers, publishers and software authors -- to easily create interactive games and simulations. It is ideal for project-based learning, and for creating math and science visualizations. The teacher's edition of Stagecast Creator includes a Teacher's Guide that presents 20 different lessons for using Creator in the classroom. There are lessons for grades K through 12, covering topics from math and science to language arts and music. Any world built in Creator can be placed on a web page for others to view and use, making Creator the easiest way to build fully interactive demonstrations for the web. Based on Apple's Cocoa technology, Creator is a cross-platform Java application that runs on Windows PC and Macintosh PowerPC computers. At the CILT workshop, I would like to present a demo of Creator, show math and science visualizations that have been built in Creator, and demonstrate how to create your own worlds.

Visual Programming with Function Machines

Wallace Feurzeig

Function Machines is a visual programming language expressly designed for mathematics and computer science education. The Function Machines language employs two-dimensional visual representations-graphical icons-in contrast with the linear textual expressions used for representing program structures in traditional (one-dimensional) languages. In Function Machines the transmission of data and the passage of control are graphically animated in a fashion readily accessible to students.

Function Machines is based on a "function as machine" metaphor. Mathematical functions are viewed as machines that communicate with other machines through data flow and control flow connections. The system provides as primitive constructs, machines corresponding to the standard mathematical, graphics, list processing, logic, and I/O operations found in one-dimensional languages. These machines are used as building blocks to construct more complex machines in a modular and extensible fashion. The visual representation of machines and the animation of the passage of data and control makes the semantics of functional operation and iterative and recursive computation transparent. The operation of recursion is shown visually by displaying a separate window for each instantiation of the program as it is created, and erasing it when it terminates.

In the Function Machines environment, a machine runs whenever its inputs are available. Since this can occur simultaneously for several machines, the system naturally supports parallel operation. Thus, the system opens new opportunities for introducing the study of parallel algorithms to beginning students. Function Machines has been piloted in elementary and secondary classrooms. A recent implementation by BBN Technologies in collaboration with the Education Development Center extends the previous version by incorporating additional functionality, a richly enhanced graphical user interface, and a ten-fold increase in computational speed. A demonstration of teachers' and students' work will illustrate the system's special capabilities and educational benefits.

Student Visualization Tools Explore Time and Space

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Two software products developed by TERC empower students to interactively explore real-world data organized by time and geographic position.

VideoScape is a data acquisition and analysis tool which combines MBL probe measurements with synchronized video. A picture is worth a thousand words; students explore sets of data observations which are presented as graphs that are actively linked to video. As they browse through the graph data, the video displays the frame which corresponds to each data point. As they play the video, or drag the playback position to interesting moments, the corresponding data point is highlighted on the graph. The context of time-dependent measurements is immediately conveyed. Abstract data representations are suddenly rooted in reality. The computer is used to extend the students' senses while maintaining a compelling visual connection to the data. Accurate probe data and flexible video playback speeds empower students to enter time realms usually unavailable to human apprehension, like time lapse observations of light and clouds in the sky, or the transient events of kids jumping under the influence of gravity. Students can also collect their own VideoScape data using MBL probes and a video capture device.

Visual Earth is a professional-strength Geographic Information System application tailored for use by students, which supports guided discovery and open-ended investigation. Visual Earth's student-friendly GIS interface concentrates on the essential GIS tools students need to investigate intriguing questions using layers of global and local data. The Visual Earth user interface includes a guided discovery mechanism for presenting multimedia material which supports the students' inquiry process. As students master the process of using real data to investigate a problem and deduce solutions, they can move on to open-ended research questions which draw upon a variety of available data overlays.

UNOmaha's Office of Internet Studies Features CASDE

Bob Pawloski
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Over the past five years, the University of Nebraska at Omaha's Office of Internet Studies has been involved in assessing Internet applications as utilized in K-12 classrooms. Gathering data with web-enabled databases, this research office of UNOmaha's College of Education evaluates widespread integration in Nebraska as well as two USDOE Technology Integration Challenge Grants. Furthermore, curriculum development and resources have been advanced in the form of a Space Shuttle Simulation Laboratory and also by forming a consortium with NASA's Jet Propulsion Laboratory (JPL) and the University of Nebraska at Lincoln's Center for the Advancement of Land Management Technology (CALMIT). The Consortium for the Application of Space Data to Education (CASDE) has produced a cross-platform sampler CD with lesson plan starters or Building Blocks, and DataSlate. DataSlate is a Java application authored by NASA's Jet Propulsion laboratory. It allows users to view data sets at several resolutions, and to simultaneously compare different types of space imagery covering the same geographical area. Applications with other types of imagery are being explored. Measurement and annotation tools have been included in the current release, with extensive input solicited from practicing K-12 educators. CASDE's third partner, CALMIT, has developed an extensive and very educator-friendly web site titled Virtual Nebraska (http://www.casde.unl.edu/vn.html). The CASDE project has a strong evaluation and metrics process in place, and is carefully monitoring the effectiveness of CASDE based activities with students and teachers. Results from several quantitative pilot studies, as well as a variety of evolving qualitative information (such as interviews and testimonials), is very encouraging. The full evaluation portfolio for the CASDE project is available at http://ois.unomaha.edu/casde/ .

Strawberry Creek: Supporting student understanding of water quality through causal modeling

Sherry Seethaler
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Strawberry Creek is a web-based curriculum designed to teach high school physics, chemistry and biology students about water quality. Developed as a partnership project involving researchers, high school teachers, and scientists, the curriculum is based on a set of pedagogical principles that are the result of fifteen years research. One of these principles is to help students make visible their thinking about particular scientific concepts.

Toward this end, Strawberry Creek employs a (http://cilt.berkeley.edu/creek/modeling) causal modeling tool which allows students to make and explain relationships between different factors (e.g. chemicals and organisms) in the creek. The particular nature of these relationships is represented through color, shape, and textual explanations. Students use the modeling tool to make initial predictions about the factors that contribute to water quality. As students explore online evidence about these factors, they iteratively refine their model. In addition to providing students with an external representation of water quality relationships, the tool also makes student thinking visible to the research team by logging changes to student models over time.

The study we report on explores changes in students' understanding of the role of phosphates and nitrates in the eutrophication of a body of water: where they are used, how they enter a water system, and their consequences on algae, bacteria, and other organisms in the stream. By helping to make student thinking visible, the modeling tool serves as an instructional scaffold for student learning. By tracking change to student models over time, the tool, combined with pre/post measures, serves an important assessment function that helps us to develop a deeper understanding of student learning about water quality as we iteratively redesign the curriculum.