Woolf, B., Hart, D., Rees, P., Reid, J., Stillings, N., Bruno, M., Murray, D., Peterfreund, A. "Expanding A General Platform for Inquiry Learning." International Conference on Computer Support for Collaborative Learning, Workshop on Learning Environments for Inquiry Skills, Boulder Colorado, January 2002.

Expanding A General Platform for Inquiry Learning

CSCL '02 Workshop:
Learning Environments for Inquiry Skills
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Representative URLs.
Home Page: http://ccbit.cs.umass.edu/ckc/index.html
Geology Inquiry: http://ccbit.cs.umass.edu/ccbit/
Other Multimedia Modules: http://mielsvr2.ecs.umass.edu/tutors/mainmenu.html

We are expanding a successful computer model for inquiry learning into three disciplines –geology, biology and civil engineering – in several different types of post secondary institutions (a community college, small liberal arts college and medium and large universities) in Massachusetts and Rhode Island and using teaching styles of both large lectures and small case-based classes. The software design uses intelligent tutors and a discovery approach to guide students' inquiry in problem-cases illustrated with multimedia and text[1].

Inquiry Learning is Difficult. Inquiry learning is labor intensive in any class, but especially so in large classrooms. Students who work in teams and ask their own questions place heavy demands on the faculty. Technology has been used to introduce problem-solving and concept manipulation, e.g. Class-talk and lecture-less workshop classes, but these are often are directed at in-lecture solution of computer-based problems. Commercial multimedia software often pushes science education further from inquiry-oriented instruction and discipline-specific CDs often serve as an encyclopedic review.

Software Goals. We have developed and will expand inquiry-based software that involves students in reasoning, addresses their misunderstandings and focuses on inquiry or critical thinking skills. The goals of the expanded software are:1) Ensure that *students remain* active. Students write observations and must justify the need for additional data to support conjectures, e.g. medical tests in the biology course or flow, depth, and grain data in geology. Students are supported to read source material, ask good questions, gather evidence, critique a hypothesis and judiciously find support for their hypotheses; 2) Help students gain *enhanced conceptual understanding*. Processes, such as medical diagnosis or geological phenomenon, have always been difficult to convey via text or traditional lecture, yet conceptual understanding is the key to understanding such processes; 3) *Encourage autonomous learning.* Students will use their intuitions to connect existing ideas to new ideas. Software will provide less support as students take responsibility for their own learning, questioning, reflection and investigation; 4) Improve students' *inquiry-based strategies.* Students should recognize when to ask for input and learn how to find a solution to an impasse. Learners benefit when the inquiry cycle and their thinking are made visible; 5) Provide *social support for learning.* Making observations should exist within a social context, i.e., students should work together, across computers or several on one computer to suggest new observations or propose new ideas.

Existing Software. The existing inquiry-based software gently moves students through five phases of inquiry, see Table 1. The basic framework, presents a situation and guides a student to 1) carefully, critically and thoroughly observe a situation or case; 2) synthesize observations into a coherent set of interpretations and predictions; 3) ask for data and tests to confirm the hypothesis and 4) learn to assess and trust the validity of the hypotheses independent of a mentor's input. The successful model of inquiry teaching includes a

Phase	**Student Activity**	**Software Tool**
I	Qualitative observations	Observation pad, notebook
II	Identify significant features	Records location of student's observation
III	Suggest hypotheses, ask for data	Description, explanation pages
IV	Experiment and collect data	Prediction space, actual data trace
V	Complete final report	Records processing space

Table 1. Five Inquiry phases supported by software

[1] This work is supported by the Department of Education, Fund for the Improvement of Post Secondary Education, Comprehensive Program, #P116B010483.

generalized software platform that enables faculty to position graphics and data for inquiry learning. The modules support students to thoroughly and carefully observe natural phenomena, synthesize these observations into testable hypotheses, envision the fruitful questions that arise and become their own best critics, eventually knowing when to trust their own interpretations.

The basic inquiry framework has been successfully evaluated and disseminated in three institutions in Massachusetts and Rhode Island. It was developed as part of an NSF award[2] that enabled us to characterized scientific inquiry interactions between students and instructors in the classroom. In several studies, using faculty interviews and structured classroom observations, we found that inquiry-oriented instructors devoted significantly more time to activities designed for the acquisition of inquiry skills, in comparison with more traditional instruction, and that these practices lead to greater changes in students' inquiry skills and epistemologies than more traditional practices.

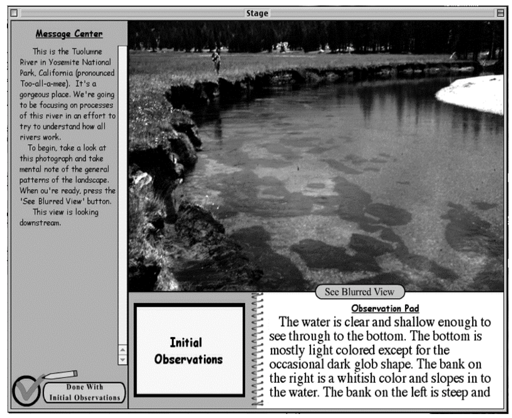

Figure 1: View of a bend in the Tuolumne River, Yosemite National Park with dialog box beneath for students to enter detailed observations.

The basic inquiry framework has been implemented in geology and presents field trips in which students type in observations of photographs of natural phenomenon, make hypotheses and use data to confirm or refute their hypotheses. It is based on an expedition approach using 35mm slides or field trips in introductory classes at Hampshire College. The student moves through the phases in Table 1: ***I.*** The student is asked to compile as complete a list of observational facts as possible, couching them in language that is rich in detail (observation pad, bottom of Figure 1). ***II.*** As the student types in observations, each one is linked with markers to spots on the zoomed in photograph. The module automatically recalls comments made by the student for use in the final report, Phase V. ***III.*** The student makes a hypothesis, types in causes for the observed phenomenon and predicts data that will either support or refute the hypotheses. ***IV.*** The student manipulates a slider bar graph to indicate his/her hypothesized data points, Figure 2. Before doing each field measurement, the student predicts the graphical representation of the variable as though he or she were standing in the river at each measurement location with, for example, a flow meter or a depth probe. ***V.*** An organized sequential review of all observations, hypotheses, data and explanations made by the student is presented. The student can re-order the text for better organization of their final report, edit individual observations or hypotheses, and synthesize all their work, which is then either printed out or sent electronically to the teacher for evaluation.

The intelligent software. The intelligent inquiry modules will guide students towards additional observations, questions or experiments as needed. For example, in the biology course, the module

[2] NSF KDI REC 9729363 Inquiry Based Science Education: Cognitive Measures and System Support.. This research program on inquiry-oriented instruction based at Hampshire College included comparative investigation of ongoing, sustainable educational settings that involve varying degrees of inquiry-oriented reform. It also focused on developing software to support inquiry support into linguistics, geology and forest ecology tutors used by students to support hypothesis generation, experimental data collection and analysis and model building.

will determine whether a student has asked enough questions and proposed sufficient hypotheses to *merit* seeing additional data. In other words, the student must probe the problem for him or herself. The nature of the module's feedback is the very essence of where inquiry environments will gain their power. Typical simulations or discovery modules allow students to change parameters yet do not support reasoning about the data and refining hypotheses. The intelligent inquiry modules, on the other hand, will find out what the student does not comprehend and direct him or her to another inquiry phase or activity. The modules will provide intelligent feedback based on an analysis of individual student's history of observations, data gathering, experiments made and any deficiencies or lack of complete exploration. They will tailor remarks directly to individual learning needs. The tutor will guide the student towards an observation, or experiment, or discovery. For example, in the human anatomy course, the tutor will determine whether a student has asked enough questions and proposed sufficient hypotheses to *merit* seeing additional medical data. In other words, the student must probe the problem for himself.

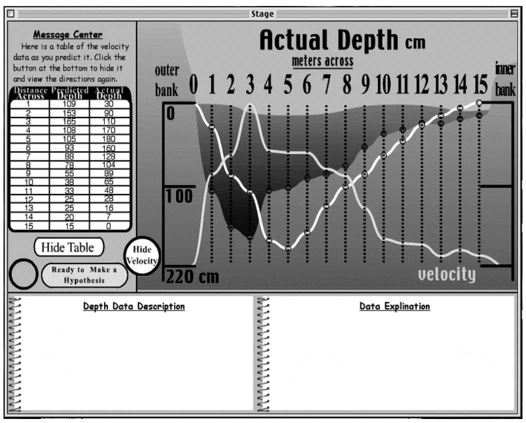

Figure 2: The student manipulates bar graph sliders to enter hypothesized data.

The intelligent inquiry platform should affect the content and pacing of first year courses. Certainly, students will progress at different rates through the material and individual students will spend more time on the importance and application of concepts as opposed to just learning facts and procedures.

Evaluation Goals. We will evaluate whether technology can provide the efficiency needed to make inquiry-oriented instruction widely available. Student performance across institutions and learning styles will be measured, based on rigorous evaluation methodologies, including student/faculty outcomes. We will provide empirical evidence for the portability of inquiry-oriented instruction for the traditional college-level classroom and compare student performance across disciplines (biology, geology, engineering) institutions, locales (Rhode Island and Massachusetts)

Dissemination. A strong dissemination effort from members of the seven partnering institutions will spread the results of the project to faculty across the relevant sciences, see Table 2.

Discipline	Activity	Original Teaching Style	Institution
Civil Engineering	Water Quality Hydrology	Traditional lecture-based classes	University of Massachusetts
Human Biology	Medical-diagnosis	Small case-based classes	Hampshire College (Merle Bruno)
Geology 1	Toulomne River Field Trip	Large traditional lecture-based classes	University of Massachusetts
	Toulomne River Field Trip	Small problem Based classes	Greenfield Community College
Geology 2	Evolution of New England	Small inquiry-based classes	Hampshire College
Geology 3	Glaciers and Ice Fields	Medium-sized traditional lecture-based classes	University of Rhode Island

Geology 4	Neotechtonics	Medium sized traditional lecture-based classes	Skidmore College

Table 2. Dissemination of Inquiry Modules