Learning Science with a Child-Focused Resource: A Case Study of Kids as Global Scientists

Nancy Butler Songer
School of Education
Institute of Cognitive Science
University of Colorado at Boulder
Campus Box 249
Boulder, CO 80309-0249
(303) 492-4914
songer@spot.colorado.edu

Abstract

This project investigates student learning within an innovative model of classroom learning: student-generated and maintained nodes of "expertise" along the Internet superhighway. Using Internet access as the backbone for classroom activities in the environmental and atmospheric sciences, the Kids as Global Scientists (KGS) project[1] is contributing insights into: 1) how the technology can be used to promote middle school students' construction of knowledge, 2) the nature of distributed expertise across child-developed and focused Internet nodes, and 3) the design of K-12 appropriate Internet interfaces. In particular, the KGS project recognizes that current Internet resources are not focused with a K-12 audience in mind. Therefore, a shift in focus from adult to child-focused Internet nodes was established. In addition, the development of communities of learners which support the exchange of information between diverse and geographically distinct learners is investigated. Results indicate that becoming student experts in particular areas of science that other students value, and being responsible resources for other students' learning increases the "use value" of students' knowledge and encourages the learning of real science from first hand sources.

Introduction

Many of us hold a vision for schools in the upcoming century which includes dramatic restructuring and extensive uses of technology. Clearly, efforts need to be made to incorporate technology into core practices of schools. Often this incorporation will not allow modifications of existing practices, but extensive reworking of our present models of communication, data, curricula, and teaching and learning communities.

While the past decades have brought us many promising technological tools, the educational potential of many lay hidden in the storage closets along with the tools. Perhaps one reason for such misuse is that our understanding of the changes in student learning associated with the application of innovative technologies to classroom learning remains impoverished. Research is needed which can investigate innovative technological change associated with new models of schools and learning communities.

One example of a study which couples technological innovation with detailed studies of student learning within real classroom settings is titled, *Kids as Global Scientists: The Utilization of the Internet for Middle School Atmospheric Science* (Songer, 1992). Utilizing the Internet

[1] The research reported in this paper was supported, in part, by the National Science Foundation, Applications of Advanced Technologies #MDR 9253464. Opinions expressed are those of the author and not necessarily those of the Foundation.

telecommunications network to access real-time weather data and satellite imagery, middle school students learn to formulate their own research questions (Scardamalia & Bereiter, 1991), organize self and other-generated data, reflect and make predictions on weather outcomes in diverse parts of North America and the globe, and conduct research on topics of interest to themselves. Despite what may sound like an unrealistic, high-tech environment, this research is being conducted in authentic classroom settings; using everyday teachers who find the technology unfriendly and cumbersome, and students who, at times, find fancy screen savers more interesting than our learning activities.

Building on Constructivism

The KGS project takes as its philosophical foundation the ideas behind student construction of understandings, or constructivism. Therefore, we recognize along with Piaget that "learners build conceptual frameworks that are complex, highly organized, and strongly tied to specific subject matter" (Inhelder & Piaget, 1958). In addition, constructivist activities often explicitly recognize the importance of social dialogue in the development of understandings (see for example Vygotsky, 1978). Constructivists blend these ideas and build on them in their belief that understandings are built as a result of active manipulation of new ideas and the interaction between new information and existing knowledge. These activities often occur through dialogue or interaction with others or sophisticated tools (Resnick, 1983; Linn, 1986, others). Constructivists believe that such knowledge-building does not come easily or quickly. Therefore, a constructivist-centered curricula focuses on: depth of coverage over breadth, recognizing and working with student's prior knowledge, and attention to various student learning styles.

Up until recently, a major focus of the KGS project was the design of curricular activities and software which facilitated middle school childrens' access to scientist-oriented satellite images and weather maps. In addition, we recognized that while used extensively by many adults and professionals, the K-12 learning potential of the Internet remained unexplored. Our goals were to use our materials to promote and study student construction of understandings within this new learning environment, and to contribute insights into how students and teachers can access Internet-available materials without undue frustration and anxiety.

One of our major developments was our efforts to address data access problems through the design of a Hypercard front-end interface called "InternetTrek". This tool allowed students and teachers to literally "trek" all over the world via the click of Hypercard buttons which access relevant Internet resources. While our early activities were met with great enthusiasm from teachers, parents, and students, our personal reflections revealed a strong dissatisfaction with the types of interactions students were having with the Internet resources.

Learning with a Child-Focused Internet

Many reasons exist why K-12 populations are just beginning to explore the Internet. Present telecommunications interfaces are awkward and confusing and are not appropriate for K-12 audiences. But most importantly, a large majority of K-12 Internet-available activities do not permit two-way, interactive communication. This encourages a relatively passive model of student interaction which is based on the assumption that **others** are contributing important knowledge which our students should know about and use.

The project therefore addressed this problem through a shift in the resource focus from adult to child-centered. During the current research cycle, our primary goal was to study student learning associated with a model of the Internet as a child-focused resource for all learners, especially those who might not normally have access to the technology or view themselves as classroom leaders. Through activities which supported student investigation of their own research questions and the development of student expertise, we hoped to empower middle school students to make the Internet an interactive resource which has nodes of information developed, maintained, and focused for themselves.

In order to develop the model, our research group established five domestic and one international KGS Internet Classroom Hubs in which primarily sixth grade students chose an area of atmospheric science expertise, researched their topic, and developed resource materials for other students in diverse locations. Our Hubs were located in widely distributed locations and included rural and inner-city settings and several populations with extensive ethnic diversity. In particular, Internet Hubs included: sixth grade classrooms in Boulder[2] and a nearby Mountainous Area of, Colorado; a fifth grade Navajo reservation school near the Four Corners area of Arizona; and sixth grade classrooms in New York City; Tallahassee, Florida; and Melbourne, Australia.

Supporting Student Experts: Research and Exchange

The four week instructional cycle went as follows: During the first two weeks, groups of 2-4 students in each Hub performed research to become experts in a particular aspect of their local weather. For example, student groups became experts in either local Winds, Severe Weather, Environmental Weather, Precipitation, or Clouds & Humidity. Questions students investigated included: *How does your local geography affect environmental conditions? Why is it so windy in the Four Corners area of Arizona in the Spring?, and Why don't we have tornadoes?* Research materials collected by students included written reports or letters, graphs or charts of daily weather observations, videotapes and other materials which the students found informative for others. Data collection included searching over Internet resources, personal dialogue with local scientists, book research, and other information.

The most popular way to collect data was through electronic dialogue with local meteorologists who were matched to each Hub as volunteer student mentors. An example of such a dialogue is illustrated below.

message 2
To: Cyclones [group of 3 Boulder 6th graders]
From: Larry [a local graduate student in meteorology]
Now I have a question for you. Why does warm air always end up on top?

message 3
To: Larry
From: Cyclones
Hi, Larry. We think we have the answer to your question, which is: why does warm air always end up on top: because warm air rises. We are the Cyclones. Our names are Alan, Maria and Laura.

message 4
To: Cyclones
From: Larry
Hi Cyclones,
You're right warm air rises. Now take that one step further, why does warm air rise? I'll give you a few hints: it only rises relative to cooler air, and it rises for the same reason things float in water.
Bye, Larry

The scientists were not encouraged to give the students answers directly, but to provide support through the presentation of information which was to help the kids think about the situation and come to their own answers.

At the completion of the research phase, each student team sent a brief description of their sub-specialty and an e-mail address to the KGS researchers to be organized into the software which was distributed to all participating groups.

During the last two weeks, students shared and exchanged their expertise with other students. First, students were required to develop a series of questions to ask

[2] Pseudonyms are used for all field site schools, students and teachers.

student teams in the same specialty in other locations. For example, the Colorado area student experts in Clouds and Humidity and Severe Weather sent these questions to peer experts in New York City and Florida:

Dear Clouds with an Attitude
We are the Humidifiers from Boulder, Colorado. Our question is, did you notice any strange clouds before the big snowstorm? (The Storm of the Century which hit the East Coast during mid March, 1993). Please write back.

Hello! We're the Severe Weather Dudes. We're from Mountain Elementary and in charge of investigating Severe Weather. Our last big storm was about two weeks ago. We got about one foot of snow.

How many tornadoes have you had in the last year? Where were you when Hurricane Andrew struck? If you were in it, what was it like? Where do hurricanes usually strike in Florida? Do they strike in your area?

Secondly, student experts in all sites simultaneously served as experts for other students' questions and inquiries. As a result of this exchange, each student group collected a range of materials from a variety of Hubs which enhanced their understanding of their own topic and local conditions.

Investigating Real Science with Distributed Expertise

Our work investigating student learning is based on previous work, by this author and others, in the cognitive and learning sciences, and telecommunications in education. Linn & Songer (1991a, 1991b) recognize the significance of science inquiry which builds on topics of importance to individuals and makes explicit connections between scientific ideas and natural world phenomena. Tinker (1991) has found tremendous success with his KidsNetwork which encourages students to do "real science" through the world-wide exchange of scientific information on a timely and interesting topic such as Acid Rain. Unlike traditional exercises which perhaps follow an outdated textbook and are read only by the teacher, all of the KGS activities were explicitly designed to build on real-time, important topics in science which are made relevant to students through their personal research and questioning of geographically distinct peers.

Brown and colleagues (Brown, A.; Ash, D.; Rutherford, M.; Nakagawa, K.; Gordon, A.; Campione, J.C.; in press) have shown that "distributed expertise" is a powerful method of empowering knowledge development in classrooms of varied learners. In Brown's classrooms, seventh grade students are encouraged to choose "majors", such as one particular endangered species or camouflage mechanism. Other children choose a major related to classroom features, such as the Superpaint software or use of the mouse. By empowering every child to be an expert in some area that others need, all children, even those who do not normally see themselves as classroom leaders, are seen as experts with important knowledge to share. We see our students as not only classroom resources, but global (Internet) resources on their topic area. We believe that this will prove to be an important empowering and learning process for the students involved, and we are currently investigating the extent to which empowerment is occurring.

Methods

During this past research cycle, we extensively observed two classrooms of students instructed by the same teacher. One classroom, the experimental classroom, performed research as described above, using and exchanging information via telecommunications networks. A second classroom, our control, also performed research and exchange--but the research utilized traditional resources, such as The World Book Encyclopedia available in their local library, or phone inquiries to local television stations and insurance agents. In the control classroom, information exchange was between students in the same classroom only. Data collection on students in both classrooms included: pre and post written assessments, videotaping of all classroom activities, and detailed pre and post interviews of eight control and eight experimental students. In addition, three of the participating teachers from different Internet Hubs were chosen for detailed analysis of teacher learning. These teachers kept journals and participated in written assessments and interviews (see Tonso and Songer, in press this volume).

Results

Preliminary results indicate a distinct difference in the value of knowledge developed for the two groups. While the experimental students were becoming experts in order to be accountable resources for peers in distinct locations, the control group were becoming experts largely to achieve a desirable grade from the teacher. Therefore, we believe a lower level of internal motivation to learn existed for the control students. Lave and Wenger, in their book, *Situated Learning*, (1991) discuss a similar distinction in their comparison of learning under two quite different situations. They discuss knowledge that is developed within a community of practice, where knowledge has a "use value"--it is learned to be explicitly applied and used in context. In contrast, knowledge that is developed within more traditional learning situations, such as schools, tends to obtain value primarily for "exchange" purposes--it is of value not to be applied and used in context, but to be exchanged for an external reward such as a grade. We believe that through the responsibility of being experts for other students, our KGS students found a higher "use value" of their knowledge than present in our more traditional learning situation. A similar finding in telecommunications and education is that found by Margaret Reil in her work with the AT&T Learning Networks. She found that when students wrote telecommunications material to be sent to a specific audience as opposed to writing just for schoolwork purposes, the quality of their writing increased (Reil, 1985). Our data analysis continues to investigate the extent to which knowledge value differences occur.

Additional research results indicate differences between control and experimental students in the type of knowledge understandings that develop. Preliminary results indicate that the majority of information gathered by control students consisted largely of weather information which was not specific to a particular time or location, such as general information on how clouds form obtained from encyclopedic sources. In contrast, experimental students' information focused on recent or real-time occurrences, such as the development of The Storm of the Century, and the sharing of students' and meteorologists' personal experiences with others in locations where the storm only made newspaper headlines, but was not personally experienced. The following example illustrates this point.

Towards the end of the exchange phase of the research cycle, an individual in the experimental classroom downloaded a weather map showing basic weather information for that day in Australia. The individual noticed an unfamiliar "wavy line" weather symbol in the Melbourne area, and referred to their weather symbol chart to discover that the symbol represented "smoke in the air". While this research group was wondering why, perhaps, the symbol for smoke was present, a student in the environmental weather group downloaded the following message from the peer experts in the Melbourne area:

Hi Envios
We live in a farming area. The farmers burn the stubble from their wheat crops to prepare the pasture for ploughing and planting. That makes smoke and that causes air pollution. They do it in Autumn which is now. Today, the air is full of smoke. But the rest of the time it is clean.
From the Ozone Layers outside Melbourne, Australia

Clearly, investigating weather phenomena through first-hand, real-time sources such as other students changes what is possible for science learning in classrooms. Data analysis continues to further investigate student learning differences.

Contribution and Implications of this Work

This project defines itself as a case study of research devoted to the study of individual student learning amidst an innovative, yet authentic classroom-based learning community. In its focused investigation of student learning with a child-focused technological tool, this work investigates the potential of increasing students' use value of knowledge through information exchange between students world-wide. This work builds on previous work by this author and others, and will contribute to work in many important areas of education including: the cognitive and learning sciences, the design and implementation of learning environments for diverse learners; science education reform; and the application of network technology to education.

Acknowledgments

The author would like to thank Karen Tonso, Zhihua Long and Laurie Silfven for their dialogues on research topics and their tremendous contributions in the implementation of the research. I also thank Tina Mueh for her excellent teaching and insight, and the students for their willing and enthusiastic participation.

References

Brown, A.; Ash, D.; Rutherford, M.; Nakagawa, K.; Gordon, A.; Campione, J.C.; (in press) Distributed Expertise in the Classroom, in Salomon, G. (Ed.), Distributed Cognitions, New York: Cambridge University Press.

Inhelder, B. & Piaget, J. (1958) The growth of logical thinking from childhood to adolescence. New York: Basic.

Lave, J. & Wenger, E. (1991) Situated learning, legitimate peripheral participation. New York: Cambridge University Press.

Linn, M. C. (1986) Establishing a Research Base for Science Education: Challenges, Trends and Recommendations. Berkeley: CA: Lawrence Hall of Science and the Graduate School of Education.

Linn, M.C., & Songer, N.B. (1991a) Cognitive and conceptual change in adolescence. American Journal of Education 99:4 , 379-417.

Linn, M.C., & Songer, N.B. (1991b) Teaching thermodynamics to middle school students: What are appropriate cognitive demands? Journal of Research in Science Teaching 28:10, 885-918.

Reil, M. (1985) The Computer Chronicles Newswire: A functional learning environment for acquiring literacy skills, Journal of Educational Computing Research 1(13), 3 17-337.

Resnick, L. (1983) Towards a Cognitive Theory of Instruction, In Paris, S.; Olson, G., and Stevenson, H., eds. Learning and Motivation in the Classroom, Hillsdale: Erlbaum.

Scardamalia, M. and Bereiter, C. (1991) Higher Levels of Agency for Children in Knowledge Building: A Challenge for the design of new knowledge media, The Journal of the Learning Sciences 1(1), 37-68.

Songer, N.B. (1992) Kids as Global Scientists: The utilization of the Internet for middle school atmospheric science, National Science Foundation Applications of Advanced Technologies # MDR 9253464.

Tonso, K. L. & Songer, N.B. (in press) Teaching Science with a Child-Focused Internet Resource: What do teachers need to know, where do they learn it, and how does it change their teaching? Proceedings of the Fifteenth Annual Meeting of the Cognitive Science Society.

Tinker, R. (1991) Thinking about science, Technical Education Research Centers Publication, Cambridge, MA.

Vygotsky, L. (1987) Mind in Society: The development of higher psychological processes. Cambridge, MA.: Harvard University Press.