The World As an International Science Laboratory: Electronic Networks for Science Instruction and Problem Solving

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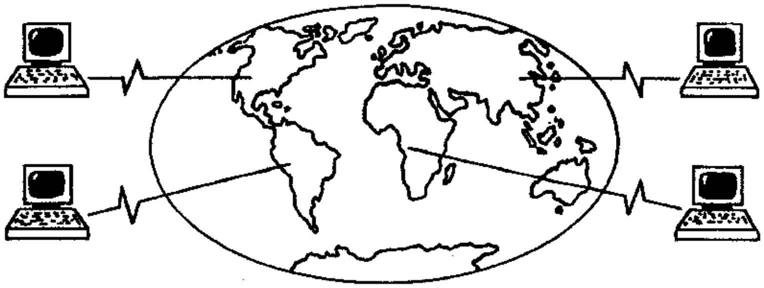

Microcomputers are having an impact on science instruction by providing high quality simulated "microworlds" for conducting similar experiments. However, concerns have been raised about the effects of learning science within simulated environments. Simulations by their very nature simplify the phenomenon, and some science teachers are concerned that students won't be able to apply the knowledge they gain in simulated experiments in non-simulated laboratory settings.

One way to offset this concern with oversimplification is to use the potential of microcomputers to serve as communication media, not just stand-alone instructional settings. A microcomputer with a modem can be connected via the telephone system to commercial computer networks. With relatively little added expense, a science classroom with a microcomputer can suddenly find itself with access to a vastly expanded set of instructional and problem solving resources beyond the walls of the school.

An obvious resource for science is the increasing number of on-line data bases that are becoming available. However, this article will focus on a very different kind of resource, which becomes available when microcomputers and telephone networks are used as a person-to-person communication medium. Such electronic networks can allow students and teachers in widely distributed geographic locations to pursue joint science projects and other problem solving activities. They can also allow students and teachers to access the knowledge of experts in the content domain being studied.

In this paper, we will describe a number of different kinds of science activities that can be conducted using an electronic message system. When people think about computers as a communication medium, they often have the image of people typing on terminals, conducting a real-time interaction by typing alternate turns of talk. This kind of interaction is often awkward, since typing is slower than talk, and also expensive to conduct over long distances, since each person pays for being connected for the duration of the interaction. Electronic message systems, in contrast, are used for "non-real-time" interaction. That is, a person types in a message to one or more other people and sends it electronically. When the other people later check their electronic mail, they will find the message waiting, which they can read and respond to. The interaction is "non-real-time" because each person does not expect an immediate (with several seconds) response to their message.

The advantage of using electronic message systems for instruction is both their convenience and their relatively low cost. Messages are written and read by students and teachers on their local microcomputers, without expensive connect time costs. The messages can be transmitted rapidly (and even automatically) at night, when the communication rates are low and the microcomputer and telephone lines are not being used for other purposes. Any of the large commercially available computer systems (The Source, CompuServe, etc.) can be used as an "electronic maildrop," a place to leave and pick up electronic messages. These systems can be accessed through computer communication networks (Telenet, Tymnet, Uninet, etc.) that have local access telephone numbers for most of the United States and much of the rest of the world.

Functional Science Activities

Once these technical details about how to interconnect microcomputers in schools with national and international networks have been worked out, then the interesting instructional issues arise. What kinds of instructional activities can be best conducted using this new instructional medium? In our work with long-distance instructional networks over the past three years, we have discovered that the selection of appropriate activities determines whether these networks are used or not. Below we will describe several activities that have evolved from our previous research, and then describe some general design principles, and finally some possible implications of such science activities.

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International Weather Reports

Our most successful instructional network activity so far has been the Computer Chronicles (Riel, 1983; Levin, Riel, Rowe, & Boruta, 1984), in which students in different schools write news stories, exchange them with other schools and publish school newspapers with a selection of their own and other students' articles. Weather reports have been very popular, both in terms of articles written and articles selected to be published. Students enjoy both reporting on their own weather and reading about very different weather elsewhere. This activity can be integrated into the science curriculum by raising the issues of WHY the weather differs in different places. The simple reporting can be turned into a joint science study, in which students in different places generate hypotheses about why weather differs, and then gather data to confirm or disconfirm them. In the process, students can uncover some of the relations between seasons, latitude, proximity to water, etc. that determine climate and weather.

Joint Science Projects

In the course of a joint weather study or other international activities, students can engage in joint science projects. For example, students might measure the boiling point of water in different locations. Students in San Diego might measure it to be 100.2 C, students in Tokyo might measure it to be 99.9 C, and then discuss experimental error. However, they should be provoked into an instructive discussion when students from Mexico City report the boiling point to be 95.2 C! After a discussion of experimental procedure, the students jointly can discover the effect of altitude on boiling point.

Structuring joint science projects around factors that vary naturally from location to location can provide powerful environments for learning science. There are many factors that vary from place to place: magnetic field, temperature, soil and air composition, Coriolis force, astronomical observations. Students in different locations can gather data, and then engage in joint discussion to work toward a synthesis of the different data, writing up a joint science report. There are even ways in which these joint instructional activities can merge into real science problem solving.

A Study of Everyday Weather Predictors

People in different places around the world have different ways to predict what the weather will be like. This information is crucial for such everyday decisions as what to wear and what activities to do, including activities such as farming, fishing, hunting, building, or shopping. The everyday predictors vary from observations of cloud patterns, patterns of temperature, humidity or pressure changes, and wind direction and strength. A distributed science project could collect these everyday predictors in different places around the world, observe the weather that is thus predicted, and then analyze the accuracy and reliability of the predictors, studying the reasons for success or failure. One interesting issue would be the potential "transfer" of predictors from one area to another: could a predictor that works in one place be used, either directly or modified, in other places?

A distributed science project like this would be difficult for a student or teacher to coordinate. However, a scientist studying this issue might be happy to coordinate such activity, because in exchange for help in setting up the data collection and reporting procedures and participation in the discussion, the meteorologist would be able to collect much more widely distributed data (both in space and in time) than otherwise possible. In the scientist's own research project, he or she has limited resources for data collection, and has to focus on the few sites likely to be most informative. This kind of distributed science instructional activity is not so constrained, since the participation of students is justified on instructional grounds. Any research payoff is a bonus. So, distributed science projects may have real research value, because it allows scientists to collect "long-shot" data: data from sites that experts can predict with relatively high confidence. Most of the time, then, the data will merely confirm these expectations, and then only serve its instructional purpose for the students involved. However, once in a while, the expectations will be violated, and thus the data will be very valuable for the on-going research project.

This "weather predictor" example points to ways that students can participate in activities that are both instructional and real science problem solving. Experts could guide the research at a distance, coordinating the joint inquiry at a relatively low cost (in money and in time). The value for students is that they are participating in a dynamically supportive environment for learning problem solving, planning, analysis, and communication in science. They are participating in real "functional" environments, which every once in a while will produce important contributions to real world problem solving.

Water Cycle Science Project

Let us examine another possible distributed science project to see how these science instruction activities integrate with real science problem solving. A topic in many earth science classes is the water cycle, the process by which water cycles from the oceans to the atmosphere, to the ground, and finally back to the ocean. Man's use of water is dependent on the operation of this cycle, whether the water comes from lakes or rivers, from wells or cisterns. A shortage of water is a real problem in many areas of the world. Students could conduct a distributed project on the water cycle, focusing on water shortage and methods for dealing with the problem. In each site, students could collect data on the sources of water, conservation and recycling techniques. The "transfer" possibility exists in this domain as well—students can consider whether techniques that work well in one site can be used (either directly or suitably modified) in other sites.

It is possible that science students participating in such instructional networks could "discover" solutions to real problems that were overlooked by experts. Approaches to the same problem that work in another site have an initial plausibility.

Students in a site will be aware of the many local constraints, both physical and social, that a solution has to satisfy, more so than most outside experts on the problem. So local students will be able to reject solutions with a surface applicability that violate local constraints, will be able to modify solutions that work elsewhere to be more appropriate for local conditions, and will be able to explain the solution in terms understandable in that locality. Even if students fail to develop a solution, they gain a deep understanding of the domain, including the problem solving processes involved. The cases where they come up with real solutions to real problems is an added bonus.

International Science Fairs and International Science Teleconferences

An important aspect of these international science networks is the way in which they create functional learning environments for reporting data and writing up project reports. Usually science data is only being collected as a laboratory exercise to be written up for the instructor to read. Within the networks described here, writing systematic and unambiguous reports of data takes on additional value since students elsewhere will be reading these reports and trying to use the data as part of the joint project. A message from another student saying that they don't understand the data report may have more impact on a student than a low grade from their teacher.

Joint science projects can be reported to other students and teachers at electronic science fairs, with the presentation, discussion and evaluation of projects taking place using the electronic message system. This kind of joint interaction can evolve into international science teleconferences, as the science activities evolve into real problem solving activities.

Summary

This has been a short sketch of the kinds of activities that can be organized to use the new electronic media for science instruction. Each new medium has its own properties. Some existing activities can be transferred over, but usually an activity has to be modified substantially to take full advantage of the strengths of the medium and to avoid the shortcomings. Based on our research on the use of electronic networks for instruction, we have described here some directions that teachers can pursue in this new medium. ☐

References

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