Wired, But Not Connected

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Abstract

Much money has been spent linking schools to the Internet, but are students actually connected intellectually? Do they harness the Internet for anything more than retrieving additional content? This paper introduces a new instructional model that we call *telecollaborative inquiry* in which connectivity recasts how students learn. Telecollaborative inquiry builds communities of networked classrooms that engage students in distributed, collaborative knowledge-construction. Mirroring professional and scientific communities of practice, this paradigm leverages Internet connectivity, technologies, and social networking to teach content and foundational skills like critical thinking, communications, information literacy, and teamwork. It enables synchronized investigations that produce datasets and intellectual discourse that are richer than what individual classrooms can deliver. It has the power to transform education and justify the investments in wiring schools. Telecollaborative inquiry-based curriculum was first piloted in the 1990s as the Global Lab project in 30 countries and today, an updated version of Global Lab (v.3.0) deploying Web 2.0 advances is being piloted in 150 upper-elementary classes throughout Russia with plans to scale worldwide. Based on these trials, the developers are innovating a scaffolded curricular design based on granular instructional modules called Global Learning Units (GLUs™). Each GLU converts a specific instructional topic into a bite-sized telecollaborative investigation, providing all the resources and tools needed to deliver telecollaborative inquiry. When aligned with instructional objectives, the progression of GLUs covers the scope, sequence, and content of traditional curricula, building science content and process skills more effectively than single-classroom inquiries. Tightly integrating content, data collection and analysis, and student communications into a Web-based curricular infrastructure, GLUs provide the framework and scaffolding to make telecollaborative inquiries a reality in mainstream science classrooms. They offer educators a strategy for implementing telecollaborative inquiry-based curricula that will enable students across mainstream education to construct the knowledge and skills necessary for achievement in higher education and professional endeavors.

Keywords

telecollaborative, inquiry, collaborative, science education, constructivist, project-based, networking

A New Generation of Knowledge & Skills

Billions of dollars have been spent worldwide to wire classrooms to the Internet and the common rationale is connectivity will transform education. Yet in typical classrooms today, the Internet is a digital pipeline—in effect, a digital library. Open it and content pours out in a one-way flow—to students, not from them. Certainly, this has pedagogical value, but to date, the Internet has hardly renewed how teachers teach and students learn. Classrooms remain insular and teacher/textbook-centered, and hands-on science projects are often parochial.

This model of classroom education still reflects the needs of the Industrial Revolution and analog economies when workers were expected to follow instructions rather than solve problems. Economic and social modalities have evolved, however, as the digital revolution unfolded in the late 20th century and the Internet Age reached full stride in the beginning of the 21st century.

Worldwide, business, education, and political leaders have recognized that primary and secondary education must adapt to the realities of rapidly-changing economies.

National economies are increasingly intertwined in a global grid, demanding that workers have international perspectives. Science, technology, engineering, and mathematics (STEM) are producing the innovations and technological advances that fuel economic growth and prosperity, placing a premium on STEM literacies. Moreover, how people work is changing as workplaces capitalize on the communications, productivity, and transaction processing afforded by digital technologies. Freed from geographical constraints, people increasingly collaborate in virtual groups to leverage expertise and perspectives. A comprehensive survey of corporate human resource managers revealed that after professionalism and a work ethic, collaboration was the skill most valued for new workers (Casner-Lotto & Barrington, 2006).

As a result, there are widespread calls for schools to teach not only content, but also such skills as teamwork, critical thinking, problem solving, communications, and information literacy. Moreover, schools must teach STEM-related skills like the scientific method, data evaluation and analysis, and objectivity.

To meet these needs, schools have to focus less on individual learning and more on group learning by introducing project-based inquiries into classrooms. Students should actively participate in their educations, collaborating in hands-on activities to construct knowledge while building foundational skills. Although more research is needed, evidence indicates computer-based collaborative learning can enhance higher-order thinking, student satisfaction, and improved productivity (Resta & Laferrière, 2007).

Yet collaborative inquiries within classrooms, when they occur, are face-to-face. Students do not participate in virtual teams communicating with web-based multimedia technologies, as they will in the workplace. Learning remains local rather than distributed as students use the Internet simply to access content that augments their textbooks. Data sets that students generate locally are for single points in time and location, and thus cannot be compared and analyzed with larger, protocol-bound datasets, as is done routinely in business or science.

Additionally, collaborative approaches are not mainstream in classrooms. It is difficult for teachers trained in 20th century pedagogical strategies to merge standards-based content with building high-level process skills such as collaborative problem-solving. Individual teachers, working on their own, frequently lack the scaffolding and resources to deliver collaborative inquiries. Ironically, on their own time, children use the latest digital technologies to intellectually engage each other and are very fluent in virtual interactions, knowledge building, and networking. These are the modalities that must be brought into classrooms if schools are to offer next-generation learning environments.

Telecollaborative Inquiry

Beginning in 1991, a new learning paradigm has been in development in the form of the Global Lab project (Berenfeld, 1994, Berenfeld, 1999). Developed at TERC (www.terc.edu) with extensive support from the National Science Foundation, Global Lab was the first full-year, online middle- and high-school science course. Piloted in over 200 schools from 30 countries, the curriculum engaged students in a global community of practice in which they conducted hands-on environmental monitoring and data collection for air, soil, and water quality (Berenfeld & Bannasch, 1996).

Global Lab utilized remote hosting (a precursor of today’s cloud computing) and rudimentary social networking (a precursor of Facebook and Twitter) to pioneer a new pedagogical strategy that we call *telecollaborative inquiry* (Berenfeld, 1994). The *tele-* of telecollaborative inquiry advances the collaborative work of single classrooms with entirely new learning capabilities and outcomes. It enables learning across distances in geographically distributed groups. It also permits inquiries that are not only collaborative, but also synchronized.

Global Lab was widely acclaimed for its innovations, but at the time, few teachers were prepared to deliver telecollaborative inquiries and the networking technologies were nascent (Berenfeld et al, 2010). In 2008, with the advent of Web 2.0 technologies and growing needs to teach STEM content and process skills, the project was successfully relaunched in 150 urban and rural schools across eight time zones in The Russian Federation as a test-bed and is now being scaled and adapted for worldwide participation (www.globallab.ru/). Its developers are now preparing Global Lab 3.0 to facilitate the adoption of telecollaborative inquiry into mainstream classroom instruction.

Wired and Connected

Global Lab demonstrates that the power of telecollaborative inquiry lies in “the teachable moments” resulting from its inherent, almost Hegelian dialectic of uniformity and diversity.

Uniformity: Same-aged students use the same curriculum, tools, and procedures to gather data on their local environments. They follow the same strict protocols to make measurements and observations on the very same day. Thus, each class’s dataset is directly comparable to all others.

When Linda Maston’s eight-grade Global Lab class in San Antonio, Texas, had the opportunity to investigate the air quality in its classroom, her students seized it (Berenfeld 1993, Yazijian, 1998). Unable to leave their inner-city school to conduct investigations outdoors, her students had to use their classroom for their study site. The classroom, however, lacked windows, prompting students to question its air quality.

Using the project’s tools and instructional materials, Maston’s students measured sulfur dioxide, ozone, and carbon monoxide levels in their classroom and found them to be low. But when they measured CO_2 levels, they found levels as high as 2100 parts per million. After team of students had obtained outdoor CO_2 readings of 350 ppm and the class compared its findings with those from other Global Lab classes worldwide, students became alarmed. Belonging to an international community, they asked their peers for feedback. “*What are some of the CO2 levels that people are getting inside their various classrooms? Ours are extremely high*.” A class from Aiken, South Carolina, replied that they too had high readings, but not in spaces that opened to the outdoors.

Maston’s students decided to assess CO_2 levels throughout the school and found consistently high readings everywhere but in shops with garage doors opening to the outside. They presented their findings to the school board, which dispatched four environmental control officers to investigate. Maston reported what happened: *“They [the officers] first went into the counseling office where the counselors and teachers told them about what was going on. They were not impressed, so they were brought to our classroom. As soon as we pulled out the data and the graphs showing the patterns that we had found, they suddenly started to take notes.”*

The officers then took readings with their professional equipment. Maston continued: *“The moment of glory came when the officers got exactly the same reading as we got!”* As a result of her students’ Global Lab investigations, the school’s ventilation system was repaired.

“The CO2 study was (the students’) pride and joy. They were just so pleased and proud of themselves that they had managed to do what nobody else had been able to accomplish in 17 years. To have their data taken seriously by adults in general, and the district in particular, was just awesome for them. They are so used to failure that it's hard to convince them sometimes that they are doing good work.”

Maston’s students performed real-world scientific research with their Global Lab peers and their findings made a difference in their lives.

Dissimilarities: When a Global Lab class compares its data to those of all other classes, a global snapshot emerges, stimulating curiosity and opportunities for teachable moments. The simple question of why different locations have different soil temperatures can drive a variety of inquiries. Students can visualize their data and incorporate additional community-wide metadata such as latitude, elevation, mean air temperature, and geographical coordinates to discover potential causes for the discrepancies. They might find a correlation between soil temperature and latitude, for example, and try to determine causality, revealing such factors as the angle of the sun. Or they may wonder about an outlier along a certain latitude range and discover that a nearby mountain range at that location affects climate, which impacts soil temperature.

Any individual class can make the same measurements, but what separates Global Lab from standard curricula is its students place their findings into regional and global contexts. Students across the Global Lab community have differing cultures, perspectives, and experiences. Similarly, their local environments all differ geographically, geologically, climatically, biologically, and historically. These differences are reflected in the project's datasets. These dissimilarities create a dynamic learning environment that produces the motivation and research questions for inquiries.

When engaged in telecollaborative inquiries, students learn that when partnering with peers around the world, they must work responsibly not just for good grades but also for each other. After finding errors in the data submitted by other Global Lab classes, students at a Moscow high school sent the following message to the community: "*It is natural for every scientist to make mistakes. But the low accuracy of the data may lead to wrong conclusions. In science, this problem is one of the most important. In our scientific community, we have to overcome it too…We invite everyone who has any idea on improving the accuracy of our work to communicate with us*." Few other teaching approaches so encourage students to demand accountability of themselves.

A single classroom collecting data will have difficulties in revealing trends and patterns. Measuring soil temperature at different depths, for example, will not offer much meaning for students. Students can measure soil temperatures over the school year, but when graphed, this data will indicate only that temperatures generally conform to local temperature changes. By itself, a single dataset is not necessarily thought provoking and offers limited scientific and pedagogical value.

With telecollaborative inquiries, students learn about causalities and correlations as they explore the patterns and trends in their data. The traditional "compare and contrast" mode of analysis offers new meaning and relevance: Why are my data different from theirs? Is this finding a discovery or an anomaly or mistake? How do we know that our data can be compared to everyone else's? Did we use the same procedures? Was my thermometer at the same height above the ground as theirs? At the same distance from our schools building? Was it in shade? Why does all of this matter? Students engage in real science in a ways that are nearly impossible with individual classroom inquiries. Again, this power lies in uniformity and dissimilarities (Berenfeld, 1994).

Designing Telecollaborative Curriculum

The keys to building effective telecollaborative inquiry curricula are:

- engaging students in a community of peers;
- providing community-shared goals and the scaffolding to meet them;
- and ensuring students are invested in the outcomes.

Global Lab seeks to meet these objectives by structuring the school year into three progressive stages.

The first, *Meeting Your Global Lab Community*, is dedicated to community building. At the start of the Global Lab year, each class introduces itself, its school, its community, and its region with multimedia presentations they create using tools on the project's web site. Presentations can include text, audio, image, and video data, and students are encouraged to personalize them with their interests and other information. They can deploy a tool developed for the project called Annotator to annotate their images with text. When other classes place the cursor over an individual student in a class photo, for example, that student's name and messaging automatically appears. Once submitted, all presentations are easily accessible by all other classes.

Each class also submits basic metadata about its location, such as its geographical coordinates, elevation, and mean air temperature, into a database designed for easy data extractions, comparisons, and visualizations. Using the database's sophisticated search engine, students can access data within ranges, enabling them to identify all Global Lab classes within ten degrees of a latitude or with certain levels of precipitation. They can compare their data to project-wide averages, to groups of schools, or to individual classes. In addition to this data mining, they can visualize numerical data using graphs, histograms, scatter plots, and pie charts.

When a class's information is uploaded, it automatically appears as a star at the appropriate location on a map of Russia (soon to be expanded to a world map when the project recruits schools internationally), showing the distribution and scope of Global Lab classes. Placing the cursor over any star automatically displays that class's metadata. Consequently, students soon understand that they have joined a community of peers.

The Global Lab curriculum also endows the community with purpose. The project breaks with traditional curriculum, which nearly always specifies what students study, by enabling students themselves to decide what they will spend the school year examining. This is their study site, an important Global Lab innovation that has been adopted by other projects (Berenfeld, 2010). The study site is a piece of land near the school whose environmental characteristics students will investigate over the curriculum. The project guides students in the selection, such as ensuring that they can access it within a class period, but the choice still belongs to them. The study site may simply be on school grounds but by enabling students to choose an object of study beyond their classrooms, the project invests them with a sense of relevance and ownership in their learning.

The second phase, *Building Investigative Skills*, provides the scaffolding to perform true science inquiries. Students first make qualitative observations and careful surveys of their study sites, and progress to quantitative measurements. Using the same protocols, tools, standards, and schedules, and with instructional guidance, they precisely gather data on the characteristics of their site's soil, air, and water in five content modules around primary Earth science topics—Understanding Weather & Climate, Forms in Nature, Atoms & Molecules at Work, The Sky Above, and How Does a Seed Know? Moreover, they research the site's history and uses as well as its scientific characteristics to make learning interdisciplinary.

As data is collected, Global Lab classes submit the information to the community database for comparison and analysis. Students gain the ability to place their local environments into regional and then global contexts, and are encouraged to raise questions and discuss their findings on project forums (this discourse is used for student assessments).

To prime students for telecollaborative inquiry, Global Lab promotes intra-classroom collaborations. Students work in small teams when they start investigating their study sites. Supported by the curriculum, teachers present the job descriptions for the various teams, permitting students to join groups of their choice. Students assume specific roles, which rotate over the school year. The teams, which include biologists, zoologists, cartographers, geologists, meteorologists, historians, and artists, take responsibility for certain tasks and data collections. The curriculum provides each team with its own scaffolding in students' Global Lab Journals. Teacher materials include suggestions for small group management, role rotations, and conflict resolution. Thus, students work together both face-to-face and virtually to build inter-personal skills, teamwork, and trust.

What makes Global Lab an authentic networked student science laboratory is not just shared curriculum, resources, procedures, and goals, but also synchronicity. Students make measurements concurrently, sometimes at the same time of day relative to time zones. This simultaneity makes data truly comparable as well as builds a sense of community. Synchronicity is exemplified by two highlights of the Global Lab year—the Fall and Spring Snapshots, which occur on the winter solstice and spring equinox. Patterned after the International Geophysical Year of 1957, the Snapshots are skill-building activities in which all schools make identical measurements of their study sites at the same hour on the same day. Students prepare for the Snapshots for a month with skill-building activities and once they have submitted their data, spend a month analyzing the various datasets.

With the community functional and students having acquired collaboration and basic investigative skills, classes enter the final stage of Global Lab—*Extended Investigations*. Drawing from their observations and measurements made during *Building Investigative Skills,* each class engages in open-ended telecollaborative investigations in a field of its choosing. The curriculum supports such topics as air and water quality, tracking pesticides, nitrate studies, butterfly migrations, lichens and other bioindicator plants, and UV and stratospheric ozone. Students submit ideas for investigations, frame their research questions, develop research plans, and search for collaborators. Anecdotal evidence indicates that learning to work in and with groups spurs students' willingness to telecollaborate (Means, 1998). Classes identify collaborators via forums or by searching the database for potential partners with appropriate environmental conditions. Throughout their inquiries, students are asked to peer review each other's work for accuracy and rigor.

This stage reduces the scaffolding as the project transforms from curriculum-directed to student-directed and curriculum supported. From selecting the study site onwards, students are given increasing latitude to make their own choices, building their stake in the project's outcomes. Like entrepreneurs in their own learning, they take initiatives and assume responsibility for their work. They perform basic science and learn of the need for cooperation, feeling valued as they grasp the importance of their data to the community. They discover that making measurements using standards and strict protocols is not arbitrary but essential for gathering meaningful data. They learn to separate facts from speculation, make sense of data, and understand the value of metadata. Thanks to the affordances of telecollaborative inquiry, they experience science as collaborative knowledge construction, a perspective seldom conveyed by textbooks and traditional instruction.

The Granularity of Daily Instruction

Telecollaborative inquiry is a new instructional paradigm for science classrooms. To facilitate its adoption by teachers, the current Global Lab, version 3.0, is pioneering an innovation that aligns the curriculum to the realities of daily instruction. Curriculum and content are delivered in granular units called Global Learning Units (GLUs™), each providing one to two class periods of investigations. All GLUs use a nine-stage structure that scaffolds and guides students through their work with a standardized web interface that branches off through the use of tabs and icons.

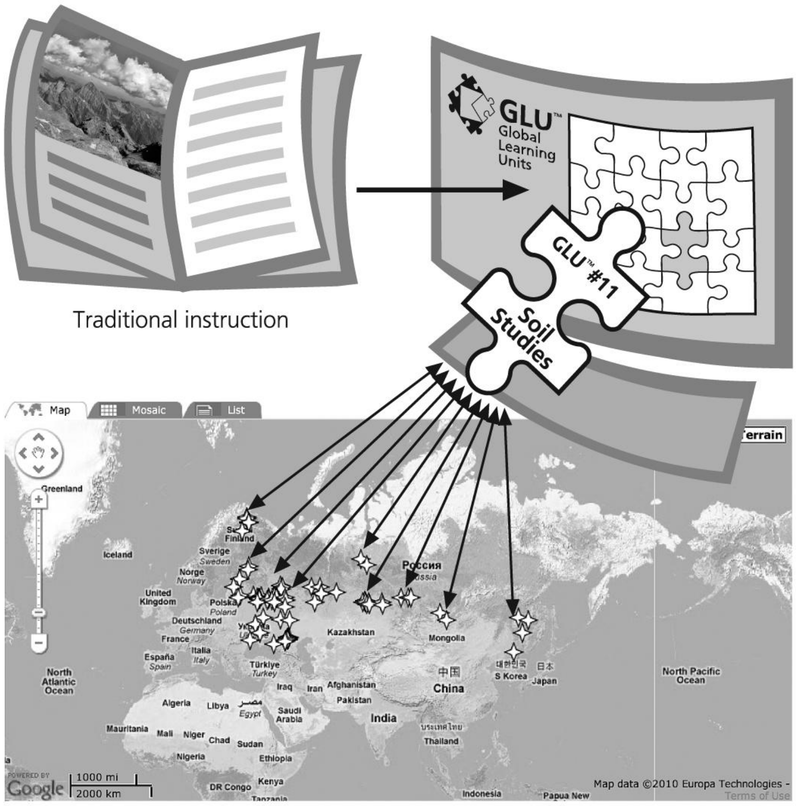

Figure 1. Global Lab converts conventional instruction into GLUs. When aligned with instructional objectives, GLUs cover the scope, sequence, and content of traditional curricula, building science content and process skills more effectively than single-classroom inquiries. The map shows schools in The Russian Federation that synchronously perform GLUs in telecollaborative investigations.

The common web interface furnishes the curriculum, collaborative tools, and resources for all GLU activities. In addition to providing a daily structure for teachers, GLUs offer an alternative strategy to either digital or hard-copy textbooks for delivering content. Each GLU includes the content, background, and vocabulary that students need to learn, thereby tightly aligning content with instruction. As a result, a GLU is a self-contained educational ecosystem that teachers can integrate into daily practice.

All GLUs feature common components. The first, “Introduction,” introduces students to the GLU’s topic and activities. The second, “Glossary,” provides the vocabulary and concepts that the GLU addresses. Students can add to it as needed. “Resources” allows students to access all relevant content with a click. Content, therefore, is a seamlessly merged with the curriculum and quickly available, not ensconced in a textbook or web site. The “Work with data” component guides students in data observations, collections, and analysis. “Our gallery” is where students post video, photos, artwork, metadata, and anything else about themselves and their work for other classes to access, enriching and personalizing investigations.

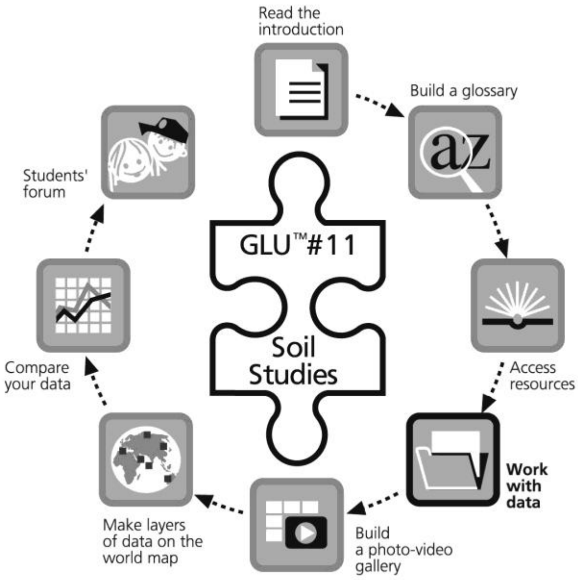

Figure 2. Every GLU is a standalone learning unit containing all necessary resources and capabilities to teach an instructional topic as telecollaborative inquiry. Each box in the figure represents one component of a GLU.

By clicking the "On the map" icon, students access a map of the project's community to view the findings of other schools. In "Compare data," they compare their findings with other classes using the Global Lab database and search engine. Students are encouraged to reflect on both the entire scope of data as well as data subsets, and to pursue further inquiries. They can examine metadata to identify a class or classes with which to collaborate. "Students' forum" enables students to discuss their findings and explore why their data may be similar or dissimilar. Teachers obtain support from their peers by using the "Teachers' forum" to exchange ideas and tips.

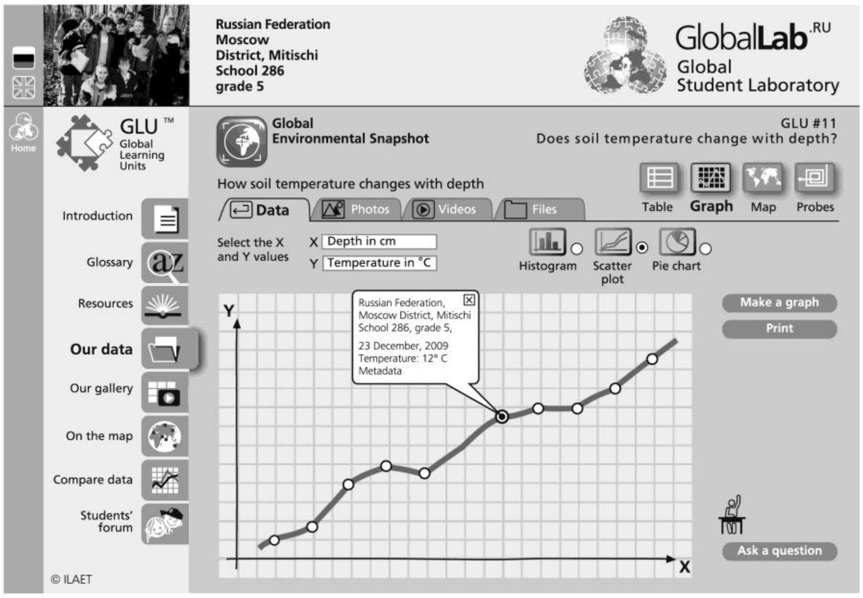

Figure 3. This is a GLU's data-processing component. This example is an investigation into soil properties where students analyze how soil temperatures change with depth.

GLUs offer an effective strategy for converting traditional curriculum into telecollaborative curriculum. Global Lab weaves together content, curriculum, tools, and resources into a carefully sequenced structure to build knowledge and skills within a synchronized community. GLUs obviate the need for textbooks, regardless if they are print or digital. They are a user-friendly framework for providing everything that teachers need to guide students through true collaborative investigations and build their content mastery and skills.

Fulfilling the Promise of Connectivity

Telecollaborative inquiry can potentially justify the tremendous investments in wiring classrooms. Students may have digital access to each other via the Internet, but they are not connected intellectually—at least not in the classroom. Outside of school, children are digital natives who routinely use cutting-edge technologies to communicate and exchange information. When in classrooms, students are like nodes in a power grid that has been short-circuited; they generate ideas and interests, but have nowhere to go with them.

Global Lab realizes the power of connectivity by engaging students in intellectual pursuits that are bi-directional and fully interactive. With a telecollaborative inquiry project, the Internet does more than provide content and resources—it becomes the means for learning, fulfilling the promise of the wired classroom. Global Lab harnesses the latest communication technologies to not only render learning more meaningful, to not only make the Internet a richer source of information, but also to enhance teaching and learning.

Global Lab uses much more than standard broadband Internet access. It leverages today's networking advances that are ideal for telecollaborative inquiry. One example, of course, is social networking. Even in its first version and well before the term "social networking" reached popular culture, Global Lab encouraged spirited and thoughtful communications between students who were continents apart. The project never wanted students to just exchange numerical data with each other; it wanted them to share interests, ideas, questions—the rich intellectual discourse that drives collaborations and learning. Future versions of Global Lab may utilize more advanced communications such as live video, web conferencing, and networked telephony to make investigations even more vivid, dynamic, and interactive.

The strong social dimensions of telecollaborative projects, however, contrasts with common classroom practices. Teachers need a structured workplan each week and interactions among students must be controlled and often minimized. Most importantly, teachers focus on individual work and achievement (Resnick, 1987). Despite the project's pedagogical power, many teachers struggled to implement the first Global Lab as daily instruction and, instead, used it after school or to augment traditional curriculum (Means, 1998).

GLUs are a response for delivering many-to-many communications within a structure designed for classrooms. They present content and traditional curriculum in an integrated digital ecosystem that is built on the granularity of individual class periods. They offer a framework with which to adapt curriculum for telecollaborative inquiries, complete with teacher supports.

Another technological innovation that is prime for telecollaborative inquiries is cloud computing, a networking paradigm that companies around the globe are increasingly adopting. The original Global Lab was possible only because it could offer a remotely-hosted infrastructure available to all designated users, which, while not cloud computing, was its precursor. This infrastructure, however, is modest compared to the Web 2.0 technologies of today's Global Lab. Moving forward, the project will leverage cloud computing to deliver shared resources and communications—from content, curriculum, and applications to teacher training and student assessments—to thousands of schools.

Global Lab is a test-bed for telecollaborative inquiry. Its materials are being translated into English to again enable worldwide participation, and it will be refined, scaled, and evaluated. The project will continue to explore how social networking can help transform education, how cloud computing offers schools new capabilities and economies, and how conventional curriculum can become more effective pedagogy. Global Lab is a working laboratory for how educators can bring true science into classrooms to prepare children with the knowledge and skills needed for tomorrow's world.

References

Casner-Lotto, J. and Barrington, S. (2006). Are they really ready to work? Employers' perspectives on the basic knowledge and applied. Skills of new entrants to the 21st. Century U.S. Workforce. 2009 (May 17).

Berenfeld, B. (1994). Technology and the new model of science education: The Global Lab Experience. *Machine-Mediated Learning*, vol. 4. 203-227.

B. Berenfeld, B. & Bannasch, S. (1996). Global Lab: From Classroom Labs to Real-World Research Labs. *Microcomputer-Based Labs: Educational Research and Standards*. R. Tinker, Ed. Berlin: Springer Verlag. 247-257.

Berenfeld, B. (1999) The internet In our classrooms: teaching tomorrow's skills for tomorrow's world. *Human Development Network. Secondary Education Series. Science and Environment Education. Views from Developing Countries*. Washington, DC: World Bank. 215-235.

Resta, P. and Laferrière, T. (2007) Technology in support of collaborative learning. Educational Psychology Review, 19, 65-83.

Berenfeld, B., Lovyagin, S.N., Yazijian, H., Kovalevskaya, E., Mazhurina, K., Vekhter, B. (2010) *Global Lab: Harnessing Social Networking and Cloud Computing for K-12 Science Learning.* Proceedings of the Society for Information Technology & Teacher Education.

Berenfeld, B. (2010) *Leveraging Technology for a New Science Learning Paradigm*. Proceedings of the MIT Learning International Networks Consortium.

Berenfeld, B. (1993) "A moment of glory in San Antonio: A Global Lab story." *Hands-On,* 16(2), TERC, Cambridge, Massachusetts.

Yazijian, H. (1998) "The World's Biggest Science Class," *UNESCO Sources*, Volume 98, February 1998.

Means, B. (1998) Models and prospects for bridging technologically supported education reform to scale. *American Educational Research Association Annual Meeting*. San Diego, CA.

Resnick, L. B. (1987) *Learning in school and out.* Educational Researcher, 13(9), 13-54.