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WHEN EVERYONE IS A PROBE, EVERYONE IS A LEARNER

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ABSTRACT

Most students globally have mobile devices and the Global Students Laboratory (GlobalLab) project is integrating mobility into learning. First launched in 1991, GlobalLab builds a community of learners engaged in collaborative, distributed investigations. Long relying on stationary desktop computers, or students inputting their observations by hand into web-forms, GlobalLab today is pioneering the use of mobile devices as sensors to collect and stream data to the shared database where students can use visualization tools to see data on a world map, analyze the information, identify patterns and trends, and extract meaning from aggregated data. Moreover, this paradigm can enable the practice of crowd-sourced student-scientist partnerships where students stream locally-captured time- and location-stamped data for use by scientists in their endeavors, getting in return feedback, advice, and much needed motivation for learning.

KEYWORDS

Inquiry, mobile learning, probes, sensors, telecollaborative, visualizations, crowdsourcing

1. INTRODUCTION

There are 1.1 billion students in the world according to the United Nations (Primary education). It is reasonable to project that 80 percent of them have or will have mobile devices like smartphones and tablets (Portio Research).

These mobile devices have built-in sensors that either record the environment or respond to changes in the environment. These include still and video cameras, sound, ambient light, proximity and magnetic field sensors, accelerometers, and gyroscopes. Mobile devices also have built-in GPS functionality to precisely determine locations. Moreover, there is a growing trend to add additional functionality to mobile devices (Mobile Device Insight, 2011).

GlobalLab leverages the popularity and functionality of mobile devices to empower their users to be data gatherers and submitters and deploy data analytics in their learning. In GlobalLab, everyone is a probe, able to collect data about the world around them and submit their findings for sharing, analysis, and discovery. Users can create data streams that are time and location stamped and submit them directly to the GlobalLab server in real-time. There, the data are shared and visualized for data processing and analysis. Data streams are displayed on global maps and can be graphed, charted, and compared by range, latitude, and longitude. Data gathering and visualization becomes a collaborative global endeavor. Teachers can implement data collected in real time by the geographically distributed community into their daily instructions.

2. BODY OF PAPER

GlobalLab, which has been piloted in nearly 30 countries, offers a new learning paradigm called telecollaborative inquiry (Berenfeld, 1994). GlobalLab harnesses social networking, cloud computing, and new technologies to engage learners in distributed, hands-on investigations that uniquely build content mastery and foundational skills (Yazijian, 1998). The current GlobalLab reflects its past and future scope and it leverages twenty years of evolving computer technologies and pedagogical strategies that, when integrated, afford entirely new ways of inquiry learning.

Inquiry focuses students on constructing their own knowledge through investigative projects. In GlobalLab, learning is “telecollaborative” because Internet connectivity changes the nature of inquiries, multiplying the power of individual inquiries (Berenfeld, 1994). Telecollaborative inquiry enables students to leverage their community’s findings to make the data more meaningful and learning deeper, more immediate, and more efficient (Means, 1998). Students conduct one experiment or collect one set of measurements, but in return they then have everyone’s data to study. In addition, immersing students in a distributed community of learners better deploys the social aspect of learning: students feel needed and valued as they begin to appreciate the importance of their data to the entire community (Berenfeld, 1999a).

Telecollaborative inquiry also teaches the processes of science. When a teacher tells students to make measurements in a specific location following a strict protocol, students can conclude that these instructions are arbitrary and irrelevant. But when they understand that many other classes are making the same measurements and they will then compare their findings, the need for rigorous protocols and common standards becomes almost intuitive. Students also can begin to grasp that the essence of science is collaborative knowledge construction. Telecollaborative communities of inquiry, for example, provide a critical audience and rationale for peer review (Berenfeld, 1999b).

2.1 Launching Telecollaborative Inquiry

First launched in 1991, the GlobalLab project was an eight-year effort supported by several grants from the US National Science Foundation that explored the use of the Internet for engaging students in authentic, collaborative scientific investigations. The project culminated in the first yearlong, middle-school, interdisciplinary science curriculum that implemented online collaborations for student inquiries. The curriculum used the Internet, affordable tools, and scaffolding to link teachers, students, and scientists into an international community united by common goals, curriculum, and technologies and engaged in real-world, open-ended investigations. Nearly six hundred schools in almost 30 countries on five continents participated in the project (Berenfeld, 1994; Berenfeld & Bannasch, 1996).

GlobalLab was one of the first classroom communities of practice to deploy a curricular structure and community-building techniques. Students communicated with their peers worldwide, engaged in building their own community, and learned both science skills and content. Rather than individual classes trying to understand natural phenomena using a single set of locally collected data, GlobalLab classes examined datasets from the entire community, accelerating and deepening students’ understanding of key science concepts. This model of telecollaborative inquiry delivered on the promise of Internet connectivity to enhance education and justify the enormous costs of wiring classrooms for computers (Berenfeld, 1999b).

Structurally and metaphorically, GlobalLab was organized as an international, networked, science laboratory with every participating class having its own presence. All interactions between schools were computer-based, and each school was a fully functional node on the network. The community was supported by a virtual library where project data and background resources were kept, a project-wide electronic bulletin board for announcements, and online discussion groups for students and teachers. Student forums allowed classes to post their findings, ideas for further investigations, and research plans. In their own online discussions groups, teachers reflected upon their practices and shared tips and advice (Berenfeld, 1999b).

Learning in GlobalLab is an almost Hegelian dialectic of similarities and dissimilarities (Berenfeld, 1994) that exemplifies the pedagogical value of distributed, telecollaborative inquiry. GlobalLab emphasized uniformity; students used the same tools and strict protocols at the same time to collect data on their study sites. This uniformity enabled them to study their local environments in precisely the same way, thus allowing for comparisons and analyses. Yet, while sharing common methodologies, the GlobalLab community was geographically, ecologically, and culturally diverse, and represented many unique social and historical perspectives. When students, therefore, placed their findings into regional, national, and global contexts, they inevitably discovered that their data differed from each other (Yazijian, 1998).

When students explored the causes of these differences, the interplay of uniformity and diversity yielded a dynamic and stimulating learning environment. Students learned about statistical variations, the reproducibility of data, and metadata. They experienced how science operates, which, by its nature, is collaborative. And as they sought to account for the differences in their data, they learned to separate facts from inferences, and how some phenomena must be reproduced by distributed peers.

2.2 Similarities & Dissimilarities

The duality of similarities and differences in data offered learning opportunities that sometimes impacted students' lives. A GlobalLab class in San Antonio that was part of a research cluster studying CO_2 levels, for example, determined that its classroom had relatively high levels of CO_2. Its students assumed that the CO_2 had caused observed classroom respiratory illnesses, but the science advisor assigned by the Project to the cluster helped students understand that a correlation does not necessarily mean causality. Through a productive online discourse students hypothesised that the real cause of the increase in respiratory illnesses they surveyed in the classes with high CO_2 levels was inadequate ventilation in the classroom.

Pressured by the students, the school's administrators called in environmental professionals to take their own CO_2 measurements. Indeed, their findings correlated to the data that the students obtained using the project's tools and protocols. For these GlobalLab students, it was, in the words of their teacher, "a moment of glory" (Berenfeld, 1993). In a reflection of how science is generally taught in secondary schools, the same teacher, in a personal communication, noted that her students assumed science was just memorizing content from textbooks and they eagerly engaged in GlobalLab activities to avoid doing what they had perceived as "*real science*" (Linda Maston, personal communication).

When performed by a single classroom, hands-on science inquiries deliver limited experiences. But when performed simultaneously by a hundred networked schools, they provide a rich set of data that can be the source of many interesting discoveries and conclusions. GlobalLab demonstrated that distributed, synchronized investigations in virtual communities offer more powerful learning opportunities than small or individual inquiries.

GlobalLab's innovations were effective and widely praised by teachers and the education community. Based on surveys, classroom observations, and teacher and student interviews, GlobalLab enabled student inquiry. Students demonstrated increased abilities to design, execute, and interpret experiments. Network-based peer review was particularly effective. Learners enhanced their abilities to evaluate experimental design and benefit from criticism. They better appreciated science and ethics, and became more aware of their accountability to their peers. Significantly, they also acquired science process skills like the abilities to articulate research problems, create procedures, and analyze data. Teachers also reported that the project motivated at-risk students and other typically under-served groups. In all participating classes, students' attitude towards science improved and their curiosity of world problems related to science appeared to increase (Primary education; Means, 1998).

Thanks to these accomplishments, GlobalLab was featured in *Science* (Holden, 1993), *Wired* (Leslie, 1993), and *Fortune* (Corcoran, 1993) magazines, and National Public Radio. The White House's National Information Infrastructure 1994 Agenda for Action report cited GlobalLab as an exemplar of online K–12 education in America (The National Information Infrastructure, 1994).

2.3 Unleashing the Power of Students' Creativity

GlobalLab today (www.globallab.org) has evolved into an integrated, web-based learning platform that supports collaborative investigations, crowdsourcing, and authoring of investigation-driven learning modules.

Its technologies include:

- virtual research environments
- data enrichment technologies
- data exchanges, aggregation, and visualization
- data collection directly from probes via the Internet
- a sophisticated, cloud-based authoring system that allows users to create investigations and surveys.

Users can generate tables for collecting qualitative data and streaming data from probes. They can visualize all data in charts and tables as well as geographically on maps.

The GlobalLab platform's intuitive authoring system provides pedagogical scaffolding for students willing to propose their own projects and invite collaborators from the international community. The platform has been developed based on a novel paradigm that encompasses cloud-based data processing, project-based learning, crowdsourcing, ICT instrumentation, IT solutions, as well as modern pedagogical approaches. It allows for challenging, unique, and engaging research projects that, in turn, open the door to more comprehensive endeavors. At the same time, GlobalLab projects help users to choose their future vocations and prepare them for successful career opportunities. All GlobalLab projects comply with national educational standards. Students, for example, can directly upload data from a wide range of inexpensive, commercially-available digital probes, streamlining data collection and enabling real-time graphing and visualizations of phenomena. Such a capability further reinforces the project's portal and web-based tools as an entire ecosystem for learning and teaching.

One of the developers' primary objectives was to structure GlobalLab's platform so teachers could use it in the core of their daily instruction. The pedagogy of telecollaborative inquiry conflicts with the structure of science classrooms, which tend to be insular, textbook-centered, and demand definitive answers in accordance with course scheduling. Typical science classrooms function with daily granularity; each class is predictable with its activities and outcomes, a characteristic that true collaborative investigations often fail to produce. As a result, inquiry projects too often remain as ancillary instruction to mainstream science classes, used after school or with motivated students.

To bring collaborative inquiry into the heart of classroom instructions, GlobalLab adapted its model of open-ended investigations to the realities of classroom practices. The project offered a new framework that functioned at the granularity of daily instruction, addressing teachers' needs to present designated content areas and build specific science process skills. Key to this effort was the delivery of the digitized content that integrates collaborative data acquisition, sharing and analysis. There have been widespread efforts to adopt digital textbooks to avoid the costs of print textbooks and ensure students always work with up-to-date information. GlobalLab now enhances the effort by adding real world inquiries as a series of sequential investigations called projects. Each project provides necessary content and instruction to ensure just-in-time availability of learning resources necessary for collaborative investigations.

2.4 From Stationary to Mobile Learning

More significantly, GlobalLab is leveraging the routine availability of mobile devices among students. It is developing a series of probes that run on smartphones, tablets, and laptops, enabling users, for example to monitor sound levels with microphones of their handheld devices (see Figure 1); and others in development will measure light intensity, the strength of the magnetic field, wind speed, distance, acceleration, temperature, barometric pressure, and humidity. The latter three can transform a mobile device into a handheld weather station.

Figure 1. Sound levels measured with the use of mobile probes together with a photograph made on location, are streamed to GlobalLab data base. Geo-stamped and color–coded the data are represented on a regional map.

Enabling mobile devices to serve as sensors is hardly unique to GlobalLab, however. What is unique is the aggregation and real time visualization of collaboratively gathered datasets, making data visualization a critical component of collaborative, inquiry-based science learning (Berenfeld & Barstow, 1996). There are only limited learning opportunities when a single class measures local noise levels. Single datasets offer limited possibilities without baselines and comparisons becoming often just a lot of numbers.

GlobalLab, on the other hand, enables users to stream locally captured data in real-time directly from their mobile devices to the GlobalLab database where data from many classes are aggregated A class collects one set of data and receives hundreds in return. Moreover, all data are time- and geo-stamped, enabling each dataset to be placed on a world map by both location and time (see Figure 1). Learners then can use the database's tools to visualize the data in charts and graphs, enabling to discern patterns, trends, and meaning.

2.5 Crowdsourcing for Authentic Science

This tight integration of mobility to learning also offers opportunities for citizen/scientist partnerships. When data is automatically submitted to databases with time and location stamps, scientific crowdsourcing can become a reality. Scientists no longer have to worry if data were collected improperly or if a user submitted incorrect coordinates. Moreover, a mobile device's most important sensor—its camera—provides a measure of groundtruthing.

For example, the GlobalLab paradigm can enable a ground-level UV monitoring network in which users collect and submit UV data with their mobile devices. Scientists now use computer models that account for solar radiation and cloud cover as seen by satellites. Citizen-scientists can submit UV data along with light intensity readings to account for cloud cover. Moreover, they can forward images of the cloud cover to confirm the data's veracity.

GlobalLab will continue to pioneer the use of mobility to foster true inquiry-based learning both in and out of the classroom. It will allow teachers to integrate student-generated data into the very fabric of classroom work and allow scientists to integrate citizen-generated data into scientific endeavors. When everyone is a probe, everyone will be a lifelong learner.

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