The role of the Internet in teaching and research has been given too little attention in mathematics education, particularly in developing countries and underserved segments of the population of developed countries. Those with inadequate Internet connectivity lack access to the research of others and experience difficulty in achieving recognition for their own work. Exchange of ideas in their formative stage as well as the distribution of completed writing is essential for full participation in the research community. Similarly, use of the Internet to share experience and innovation in teaching and to train teachers in-service and pre-service is a cost-effective means of instituting widespread improvements, particularly with respect to increasing access for groups such as girls, adult learners, rural or disadvantaged populations, and the learning disabled. For the learners themselves, the ability to acquire information via the Internet can transform their educational experience. Although there is concern about the hegemony of developed nations in the Internet environment, the solution is inclusiveness, not isolation, as well as sharing within domestic culture. Although investment will be required, new technology and focus on community-based access will reduce the costs of providing adequate communications infrastructure.

In spite of the focus on the use of technology in mathematics education, there has been insufficient attention to the importance of the role of the Internet in teaching and research, particularly with respect to access, equity, and socio-cultural issues. In developing countries with limited resources, to the extent that Internet connections exist, they are generally confined to entrepreneurial enterprises, from local Internet cafes to outposts of multinational corporations.¹ Although the Internet first arose in a largely academic context, for the most part it is only in highly developed countries that university faculty and students, much less teachers and students in primary and secondary schools, have extensive access.

¹ This observation is based in part on the author’s extensive experience in the Middle East, including pre- and post-invasion Iraq, and to a lesser extent in Asia and Africa.
Computers are not as rare in developing countries as one might think and even the Internet has experienced rapid superficial growth, far surpassing already Bill Gates’ 1997 prediction of 500 million users by 2007. However, educational use of the Internet is very limited outside of developed countries.

Extensive surveys have been conducted of the dispersion of the Internet in developing countries, including a number using a six-part paradigm: pervasiveness, geographic dispersion, connectivity infrastructure, organizational infrastructure, sectoral absorption, and sophistication of use (Wolcott et al, 2000). Going beyond such simple metrics as numbers of hosts, the researchers measured dispersion of points of presence or toll-free access, domestic and international backbone width, collaborative arrangements and public exchanges, usage rather than just access, and whether the usage is conventional or innovative. By all measures, developing countries have a long way to go. Although they have not focused in much depth on the education sector, the general finding has been that while most universities have some Internet access, a single terminal may serve as many as a thousand students, and while secondary schools may have computers, they seldom have Internet access. As for primary schools, use of computers either for educational or administrative purposes is rare in most developing countries. However, business use, including commercial cybercafes, has expanded greatly, showing the potential for broader application of the technology.

This presents an obvious equity issue as between countries, but also means that there are inequities within the countries themselves—it is the urban, prosperous who acquire the information and skills available via the Internet. We discuss the existing situation and propose remedies.

**Research**

The obvious disadvantage to those having limited access to the Internet is that they experience difficulty in keeping up with the research of others and in making known their own contributions. Universities and research institutes in developing countries have few print journals available in mathematics or mathematics education (or any other field); whereas a typical US medical school library may subscribe to around 5000 journals, the best university medical school library in many developing countries may have no more than 20, if indeed it has any at all. Textbooks providing up-to-
date information are in similarly short supply. There are programs, supplemented by pleas for assistance from particular institutions, providing such journals, but they are not only inadequate, but misguided. Internal and outside resources currently committed to these projects should be redirected to securing on-line access through JSTOR and other services and databases. The reasons to prefer online access—in addition to the fact that the cost in the long run is likely to be less—include the fact that the electronic journals can be made simultaneously available to many users, storage is not a problem, and searching for particular topics is much easier. Moreover, increasingly journals are published directly online.

Not only do those with inadequate Internet connectivity lack access to the research of others, but also they may have difficulty making their own work known. Exchange of ideas in their formative stage as well as the distribution of completed writing is essential to full participation in the research community. In addition, notices of conferences and other opportunities for collaboration come to most researchers via the Internet. Increasing amounts of information about scientific and technological developments are now available only on the Internet. Use of the Internet can improve resource mobilization and make it possible to carry on collaborative research among distant sites.

Teaching

The usefulness of computers in teaching has been well recognized, but too little emphasis has been placed on their enhanced value if there is Internet connectivity. The amount of educational material in all fields readily available free on the Web is huge and ever growing. True, discretion is required in deciding what is worthwhile and what is not, but that there is selectivity needed is not a reason for choosing not to avail oneself of the riches waiting to be discovered.

There is justifiable fear about the hegemony of American and European culture on the Internet and complaints about the necessity of knowing English to acquire much of the information found there. However, one should consider the benefits of having a language that also enables communication among developing as well as highly developed countries throughout the world in order to share knowledge and experiences. Moreover, the Internet can be used to preserve and nurture one’s own language and culture through domestic exchanges online.
The benefits of using Internet resources in teaching are extensive and varied. There are voluminous lists of web sites providing, just as an example, up to date maps and statistics to which schools would otherwise be unlikely to have access. No longer must students hunt for stories and pictures of women or minority mathematicians nor must teachers seek in inadequate libraries for the story of the development of the concept of zero. Hieroglyphics, Mayan glyphs, Babylonian cuneiform—they are all there. The history of mathematics—and not just from a European perspective can be vividly incorporated into the teaching of mathematics via this application of technology. The audience can be widened to provide more equity in learning, but also in subject matter learned.

Interesting and relevant applications of mathematics and statistics, tutorial help, and innovative and effective teaching techniques can be found on the Web. In many developing countries resources are not available for in-service training of widely dispersed teachers. Topics such as dealing with learning disabilities are often neglected in pre-service training as well. The ability of teachers to share their own ideas with colleagues in their own culture is another important benefit of Internet access.

**Equity**

The digital divide can be within a country as well as between countries, but this need not be. The Internet properly used has great potential for reducing this divide, for bringing the information age—and with it mathematics education—to rural areas, to girls and women, and to other underserved populations.

Distance learning applications of the Internet have great potential, especially to reach rural areas and to maximize use of scarce teaching resources. The development of adequate material can be capital intensive, but sharing from country to country as well as within a country can help. Convincing those in charge of the return on initial investment is key to establishing distance learning in terms of both hardware and teaching material.

It should also be understood that “distance” learning need not be over long distances. Particularly for part-time learners who must continue in full-time employment, the ability to get specialized training at convenient urban locations can be crucial to economic and social development.
Girls by no means have equal access to education in many developing countries. For example, in sub-Saharan Africa only six of ten girls attend primary school (compared to eight of ten boys) with the situation becoming even more disparate beyond primary school (LaFraniere, 2005). Long distances, lack of sanitary facilities, and sexual harassment problems can be overcome through distance learning. Setting up Internet access points, particularly in rural areas, can transform girls’ prospects for education; the locations can also be used for adult reading and quantitative literacy programs, especially for women with small children. Such local access centers could also be used for teacher training.

But it is not only in developing countries that inequities need to be addressed and where investment in Internet access for the schools could be instrumental in doing so. Although public primary school students in some areas in developed countries may be designing their own web sites, there are others who have no access at all to the benefits of the Internet.

**What is needed?**

Distance learning has great potential, especially to reach rural areas and to maximize use of scarce teaching resources. The development of adequate material can be capital intensive, but sharing from country to country as well as within a country can help. Convincing those in charge of education that the return on initial investment can be massive is key to establishing distance learning support of both hardware and teaching materials.

The correlation between the number of Internet hosts and the UNDP Human Development Index is high, which suggests that substantial investment will be needed to increase Internet access to the point where it can play an important role in teaching and research. Rather than focusing on individual access, the goal should be more socially beneficial community-based access.

Studies have shown that the major handicap in the broad use of the Internet is deficient telecommunications infrastructure. However, the answer is to leapfrog over, for example, the lack of landline connections. In India a nationwide cellular network was installed without an inch of copper wire, which might later be cut or stolen in any case, at a cost less than one-third of a landline installation. More generally, while there are always
problems in the introduction of innovative technology, that the population in developing countries is relatively young is a big advantage.

Instructive is the burgeoning of Internet usage in China (in spite of the restrictive government policies that hamper the openness that should be part of Internet use). Chinese universities decided some years ago to make Internet connectivity a priority, with economic reforms providing the capital for the investment needed; the primary and secondary sectors have not, however, seen similar progress. Universities in developed countries have also made Internet access an important goal, although, at least in the United States, the access is uneven, depending on the institutions’ resources. Essential to the Chinese experience was a prior decision to invest in telecommunications infrastructure and human resources.

In discussing Internet-inspired development, Shirin Madon (2000) asserts:

“The establishment of a strategic infrastructure is considered critical for developing countries where the marginal impact of improved network communications can be very high, leading to improved economic productivity, governance, education and quality of life, particularly in rural areas.”

However, skepticism regarding the potential of technology includes a fear of increasing dependency on international resources in the form of financing or technical skill. Thus an important component of technological development must be the training of the domestic workforce. In fact the Internet itself can play an important role in this preparation. For example, the Village Internet Programme of the Grameen Bank (Madon, 2000) helped to create technology-related jobs for rural poor and Cuba’s school networking project (Press, 1998) stressed grassroots participation of schools in rural areas. In the field of mathematics education, even in developed countries, rural areas or depressed urban areas may have difficulty securing access to qualified teachers and material. Educational authorities must be encouraged to see investment in informational communication as a way to help relieve inequities. Too often education budgets are a source of cuts when savings need to be made in national budgets.

Governments need to understand their role in creating and disseminating knowledge. Because of the worry of the dominance of
developed countries in the Internet environment, there is likely to be resistance to the notion of substantial investment. Therefore, “do it yourself” is an important concept for the development of information technology. To limit external dependency, human resource development for network users means concentration on training in data handling, software, monitoring, and management, not just technical matters.

Often nations are willing to commit funds for technology for commercial development purposes, but it makes no sense to invest in information superhighways while cutting down on the prerequisite, solid and adequate education for all. They must be ready to exploit the potential of the Internet for this purpose.

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