Research Report for GeSCI Meta-Review of ICT in Education

Phase One

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Meta-review of ICT in Education Research

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ICT Infrastructure, Connectivity and Accessibility

Overview

In this section, we examine issues that focus on questions of infrastructure. By "infrastructure" we mean more than computer network capacity. We present literature related to the newer tools under the contemporary discussion of ICT: mobile phones, hand-held digital assistants, ubiquitous laptop computer distribution, Web 2.0 utilities and "thin client" technologies. Of particular concern are conditions in developing countries and the connectivity implications of meeting educational needs with the ICT. Some of the topics addressed in this section overlap with discussions undertaken from different perspectives in other sections.

In a recent BBC broadcast of the program, *Digital Planet*, Gareth Mitchell (2009) discussed impending initiatives to upgrade Internet access for several African countries. These projects promise to speed-up access and lower costs of connecting to high-speed Internet backbones. For the moment such projects, such as Nigeria's MainOne Cable Company and the Eastern Africa Submarine Cable System (EASSy), will only reach selected countries and leave unsolved the challenge of last-mile links to individual homes and schools. Nevertheless, the infrastructural climate in Africa promises to change dramatically during the coming year. Educators will need to ready themselves for this shift in network infrastructure.

Challenges and constraints impacting progress

Among the steepest challenges confronting the development of access to a well-connected infrastructure appears to be a lack of effective leadership and planning, not only at the local educational level but also in the higher reaches of policy-making. Based on a study of ICT implementation in 20 European secondary schools, Mueller et al. (2007) reveal gaps in efforts to plan effectively for long-term educational transformation. They suggest that educational leadership should recognize more clearly the full range of components that support sustainable change. These include a better recognition of educational research, theory, and philosophy. Recognizing the need for change, Kozma (2008) has outlined a policy framework for social, economic and educational ICT reform in development at national levels.

Concerned about unmet ICT needs, especially in developing countries, Aczel and Hardy (2008) offer a framework for analyzing technological gaps. In addition to the obvious costs of hardware and software, they offer four categories of investment need:

- instructional design capacity,
- tutorial capacity,
- production capacity, and
- community building capacity

Rumble et al. (2007) report on the organization and structure of open schooling efforts in India and Namibia. In these, as in many countries, investments in ICT infrastructure suffer from the relatively low status accorded by government, educators and the general public to computer networked modes of teaching and learning.

Evolving approaches in the field

Much of the literature on this theme addresses the inequitable distribution of ICT resources within and across nations. This issue is commonly labeled the "digital divide." Educators sometimes think of the digital divide as a particular phenomenon of the developing world, but it also exists within the national boundaries of developed countries. In the US state of Florida, for example, Hohlfield et al. (2008) has presented a theoretical model defining "digital divide" across a variety of dimensions. Hohlfield's model reveals clear resource distinctions between high and low SES schools according to the dimensions of high-quality instruction, software access and levels of technical support for ICT implementation.

An American-based project, One Laptop per Child (OLPC), attempts to address this problem. In the Democratic Republic of Congo (DRC) Banza (2006) affirms that OLPC's $100 (US) laptop may, on the surface, seem to offer a viable resolution of the resource scarcity confronted by African schools. To citizens of affluent countries, $100 for a laptop computer may seem cheap, but in the DRC this sum represents more than one month's teacher salary. Additionally, this amount fails to account for the cost of ancillary resources such as materials, curriculum and professional development required for effective implementation. (Moreover, the $100 price tag has already escalated to more than $200.) Momanyi et al. (2006) describes the network computing lag experienced in developing countries in comparison to the developed world. As African educators increasingly declare their intention to invest in ICT, nationally-coordinated initiatives to plan, set policy and develop collective purchasing strategies are urged.

Writing respectively in global and American contexts, Ameil (2006) and Davis et al., (2007) caution against thinking about the "digital divide" in simple terms of computers and software. They

have suggested that educational leaders need to consider the full scope of resources necessary for effective ICT integration. Judge et al. (2006) undertook a massive survey of more than 8000 US public schools at the early grade levels (K-3). Ironically, this research revealed that high-poverty schools tend to possess better computer-to-student ratios than low-poverty schools. These data, however, simply count computers; they say little or nothing about the condition of those computers or the uses to which they are put. However, children in relatively affluent schools have superior access to technology in their homes. (An interesting subtext of this study suggests that early-grade reading achievement is negatively associated with frequent use of reading software.)

Various strategies have been employed in different countries as incentives for schools to become well-connected to data networks. Although the Internet is acknowledged as an important source of learning, Ryle et al. (2008) report from Indonesia that cultural values and existing infrastructural constraints can inhibit the implementation of Internet connectivity. Young Indonesians are slow to abandon cultural norms in order to embrace digital tools for networked learning. According to Park et al. (2007), the US federal government has instituted a nationwide program of telecommunications discounts called the "e-rate." Although this program has improved network access across public schools, it has been criticized for its inflexibility and for its failure to account for the myriad ICT costs beyond network access. The e-rate initiative should be better synchronized with other funding sources.

In Latin America, where illiteracy continues to plague indigent, primarily indigenous populations, m-learning is under examination as an important strategy to improve literacy (Kim et al., 2008). Kim perceives literacy as the foundation for long-term personal prosperity, health, safety, career success and continuing education. In the United States, efforts have also been made to improve network access and ubiquitous laptop computing to populations living in very remote Alaskan regions (McHale, 2007; Subramony, 2007). Some children reside so far from population centers that they cannot physically attend school. Thus, they depend crucially on resources that can be made available in their homes and communities. Based on an ethnographic study, Subramony concluded that the success of such investments depends as much on successful pedagogical integration as it does on the distribution of educational resources via computer networks.

Several strategies reveal themselves in the literature to improve access to the learning benefits of ICT: one-to-one ubiquitous laptop computing initiatives, a migration from fixed computers to

mobile devices, increased reliance on digital resources accessible "in the cloud" (Web 2.0), and a re-dedication to traditional technologies such as broadcast radio. Let us examine these strategies case by case.

A qualitative study of three demographically diverse elementary school systems in California examined the outcomes of a one-on-one laptop initiative (Grimes and Warschauer 2008). The results were mixed. The strongest student achievement gains appeared to be in writing, but in the initial stages of the project there appeared to be performance losses in mathematics and English. Livingston (2007) has outlined a variety of creative strategies for financing the substantial costs of a one-to-one laptop program.

Hoffman (2007) and McHale (2006) describe the establishment of two American school district-wide wireless network projects that support multiple laptops, one in Ohio and the other in Maryland. Notwithstanding increased security concerns, wirelessly-connected laptops substantially elevated access to networked ICT resources. The wireless network in Maryland provides service to portable laptop carts that are provided on-demand to classrooms. This approach comes close to offering the advantage of a one-to-one laptop ratio without requiring the purchase of a unique computer for each student. Looking ahead, an evolution of wireless networking capacity toward service of mobile devices, in addition to computers, is anticipated. In an effort to control spiraling ICT costs, one urban New England school district has migrated from the conventional distribution of computer access to a "terminal server - thin client" approach, according to St. Jean (2008). It is too early to determine the efficacy of this new strategy.

Ubiquitous laptop initiatives have been attempted in broader jurisdictions than local school districts. As previously described, the OLPC project attempts to infuse laptop computers across entire countries in the developing world. In Canada, the Eastern Townships regional school board of Québec has recently scaffolded its ubiquitous one-laptop-per-child project, originally launched in 2003, into a formal trans-national cooperative agreement with Uruguayan schools (Canuel, 2009).

The work of Grimes and Warschauer has already been mentioned. Warschauer (2006) additionally reports on statewide initiatives undertaken in California and Maine. He has cautioned that ubiquitous laptop computer investments do not, and should not be expected to, achieve such objectives as improved test scores, reformed schools or equitable achievement among student populations. However, these programs have been shown to advance engaged learning, to promote acquisition of 21st Century skills, and to broaden access to educational resources.

Planning for ubiquitous laptop infusion needs to work from a baseline of educational goals and to be clear about how success will be measured. Additional narrative on the implications of one-to-one laptop computer initiatives appears in the section of this report entitled "Integration of ICTs into Teaching and Learning."

Several observers have suggested that resource-poor regions of the world should retain their commitments to analog technologies such as radio and broadcast television (Kinuthia, 2008). Infrastructure and know-how already exists for these technologies, and they can be augmented by other strategies to promote engaged learning and student interaction. Kinuthia (2008) regards the digital divide as a "knowledge divide" which traditional technologies are well-positioned to address. Calandra et al. (2008) advocates investment in low-bandwidth digital audio technology where high-speed Internet access is unavailable. Berman (2008) recommends similar strategies for South Asia. James (2008) believes that ICT resource and investment models appropriate for the developed world do not apply in developing countries because these models have not been designed with equitable distribution in mind.

Researchers might legitimately ask if ubiquitous laptop computing any longer represents a viable future for ICT investment. With the burgeoning distribution of mobile devices connected to cellular telephone networks, laptops may represent a disappearing phenomenon. Swan (2007) has outlined the unique affordances of mobile devices, especially resulting from the fact that they are carried by virtually all young people, anywhere, and at any time around-the-clock. The failure of educators to acknowledge this reality will exacerbate the growing "disconnect" between schools and their constituencies. Recognizing the display limitations of mobile devices, Huang et al. (2008) describe innovative models to support synchronous learner access to educational content using these tools.

Motlik and Scott (2008) suggest that future African and Asian ICT development should concentrate resource development on mobile technologies rather than Web-based strategies. The wireless infrastructure for mobile telecommunication is already in place or under development. Compared to Internet-connected computers, the popular distribution of mobile devices is relatively familiar, easy-to-use and widespread in developing regions. These attributes are deemed important for adoption in any culture (Norris, 2007). Norris et al. (2008) advance the further case that schools and teachers need to adopt mobile 21st-century tools for 21st-century learners. As matters now stand, schools are not exposing students to these tools, thus widening the technology gap between home and school.

Ramaswami (2008) reports success from North Carolina where state-level leadership is supporting its public schools with resources and strategies to teach mathematics and science with mobile phones and other handheld devices. Patten et al. (2006) have analyzed the pedagogical underpinnings -- real and theorized -- for hand-held ICT tools. They argue that the unique affordances of hand-held devices should not simply be applied to replicating more efficiently the practices of earlier technologies. Rather, they advocate the creation of innovative scenarios peculiar to the capacities of these newer tools.

Soule (2008) makes a similar case for Web 2.0 teaching and learning innovations. Although young people (the so-called millennial generation) are regular, facile users of wireless mobile technologies, they have not abandoned the use of networked computers. Social networking (e.g. Facebook, MySpace) blends in with mobile text messaging and file-sharing to provide a complete picture of useful network application. Building on the research of Albert Bandura, Girasoli and Hannafin (2007) urge the use of asynchronous CMC tools to promote student self-efficacy and hence academic performance.

What do students think of m-learning? Corvus et al. (2008) note the advancing incursion of mobile phone technology across the various learner educational levels, especially at universities and colleges. More than 300 students from the Near East University in Turkey were surveyed for their perspectives. Student opinion tended to be positive, partly because mobile technologies are already embedded in their day-to-day lives. Neither gender nor national origin was related to the opinions expressed.

Whether or not investments in infrastructure and access actually produce beneficial results remains open to debate. Mouza (2008) presents results from a mixed-mode study examining outcomes of a laptop-intensive investment in poor, urban American schools. Mouza claims that children in the experimental classrooms demonstrated improved engagement and motivation compared with their control group counterparts.

In Chile, however, a summative account of the nationwide ICT infrastructure initiative, labeled "Enlaces," offered mixed results. Despite acknowledged gains in information access and distribution of resources, there is no hard evidence of improved student learning. According to Shen et al. (2008) potential benefits from infrastructure investments in Chinese schools have been curtailed because of a national tendency to discourage active student engagement in favor direct instruction techniques. In this case, teaching style appears to matter more than the ICT tools used to implement it.

“Hot” topics in this field

The literature emerging from this search pinpoints a variety of pressing contemporary issues related to the themes of connectivity and accessibility. Among the most prominent issues are:

1. Addressing the digital divide, domestically and globally,
2. Assessing one-to-one computer distribution, in and outside the developed world,
3. Assessing the potential of m-learning devices for teaching and learning,
4. Assessing the potential of Web 2.0 tools to promote cost-effective teaching and learning,
5. Creating analytical models to assess the benefits of costs invested:
    a. efficacy of ubiquitous laptop investment in the light of emerging 3G mobile devices,
    b. total cost of program development,
    c. justifying ITC investment for building infrastructure and assuring access,
6. Assessing the balance between wired and wireless network development,
7. Addressing questions of effective leadership in assuring access to ICT resources.

Research gaps suggesting further investigation

The literature reported above seems to indicate the need for continuing attention on questions of ICT policy and educational leadership, providing clearer models to link known principles of effective leadership to the particular needs of connectivity and access. Strategies are needed that will enable educators to respond nimbly to technological changes in the larger world. Educators tend to become trapped in the technologies with which they have become familiar. Oftentimes, by the time they become familiar with new developments, events in the broader world have passed them by. This phenomenon occurs at an increasingly rapid pace. If educators continue to make 20th-century decisions in a 21st-century setting, scarce resources will be wasted and educational opportunities lost.

Paralleling these issues is a need to create stable models for evaluating the scholarly outcomes of expenditures made, for linking new investments to the realities of existing culture and infrastructure, and for assessing the benefits of these investments. Through its aim of distributing low-cost laptop computers to schools in developing countries the OLPC project, for example, appears to address a pressing need. However, important ancillary questions about this project need closer scrutiny. What curriculum supports a classroom infusion of computers? How are teachers equipped with the pedagogical skills to capitalize on the sudden availability of laptops? Where is the infrastructure to support the networking of these computers? How is the infusion of laptops maintained and sustained over time? How should implementing teachers be trained and

who should do the training? With the advent of 3G mobile technologies, should developing countries be concentrating their investments in laptop computing in the first place?

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