CHAPTER 5
The Digital Divide Within Formal School Education: Causes and Consequences

by
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Introduction

Although schools in most industrialised countries have taken strong measures to ensure equal access to ICT resources, inequalities continue to exist. To understand what measures might be effective for eliminating these remaining differences, it is necessary to partition the problem into at least three classes. In the first, here called the *missing link*, are students with specific disabilities and those in schools in remote rural or poor inner-urban areas where telecommunications are limited and expensive. For these groups, technological and economic solutions are required for access. For the second class, however, here called the *wasteland*, the very nature of ICT is the problem that needs to be corrected. This class is occupied by women and girls and by some minorities, who find computing too solitary, isolating, and mechanical. To attract females to ICT, software needs to be redesigned to appeal to a wider audience, the image of the computing world needs to be softened and made less antisocial, and

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computer games need to be made more imaginative and less violent and redundant. Similar considerations need to be made for other sub-populations who so far have shunned ICT.

The third class, the *foreign language*, is composed of students typically but not exclusively from high poverty homes and other places on the periphery of society. These students need guidance to take advantage of the new opportunities and resources that ICT provides. The digital divide for these students is not simply an equipment differential that can be overcome with further selective investments in hardware, software, and networking. Instead, the inequalities of concern derive from both within school and within home differences that influence academic aspirations and capacity for self-directed learning. Student self-learning ability is a critical factor that allows some students to profit more than other students from such open ended resources as ICT. National policies directed toward closing the digital divide for schooling must attend to all of these contributing factors to be successful.

THE NATURE OF THE DIVIDE

Several chapters in this volume have delineated characteristics of the digital divide; however, it is instructive to probe these data for a more precise description of what is unequally distributed and why we should care about it. After all, society is full of inequalities that are widely tolerated without excessive pangs of discomfort or guilt. Some countries have lots of natural resources and others do not; city dwellers usually have access to lots of movie houses and rural dwellers do not; people with high incomes or high personal wealth have access to the best health care. Furthermore, schools in more affluent areas have for decades had more computers than schools in less affluent areas, yet no national or international concern has resulted.

The digital divide is not exactly about computers *per se* but about access to the world of information and communication. At the core of the digital divide are the newer information technologies – e-mail, the World Wide Web, and file transfer protocols in particular. Not everyone restricts the digital divide to these resources, however. A recent report from the American Association of University Women, *Tech-Savvy: Educating Girls in the New Computer Age,* chose the terms "computers" and "computer technology" as proxies for the "larger 'e-culture' of information and simulation" (AAUW, 2000, p. i). A report from the Disability Statistics Center at the University of California-San Francisco mentions computer ownership and Internet use in relation to the digital divide among disabled people (Greene, 2000). In contrast, a study by the College Board in the United States, *The Virtual University and Educational Opportunity,* is primarily concerned with virtual courses taught over the World Wide Web (Gladieux and Swail, 1999).

In spite of these variations, the World Wide Web is the sine qua non of the digital divide. If it did not exist, it is unlikely that such concern would be raised over the unequal distribution of computers by gender, race/ethnicity, urbanicity, or any other factor. Computers by themselves (*i.e.*, as stand-alone devices) are powerful assistants for word processing, numerical analysis, data management, and the like; they are also useful for entertainment and for some types of instruction. They appear, according to some but not all analyses, to raise productivity in industry (see Triplett, 1998 and Gibbs, 1997 for reviews). However, no data are available on how home computers affect personal productivity. In general, keeping one's family tree on a computer, especially with the assistance of a genealogy programme, can be more efficient than keeping the same records on paper. However, recipe files on-line are a less certain advantage. Given the high percentage of jobs that now require or involve computer use, some concern should and does occur over the capacity of schools in high poverty areas to teach computer skills. It is doubtful, nevertheless, that a major digital divide would have been declared if competence with stand-alone computers were the only issue.

A similar argument could be made about the Internet without the World Wide Web. Technically, the Internet is a series of physical interconnections and information transfer protocols that allow a variety of applications, including e-mail and the World Wide Web to operate. Expressed differently, the World Wide Web and e-mail ride on the back of the Internet, just as a national mail system might ride on the back of rail and air systems that exist independently. If e-mail and a few other Internet based facilities (*e.g.*, file transfer protocol) were available, but without the World Wide Web, it is doubtful that the President of the United States and the Prime Minister of the United Kingdom would each have addressed a digital divide in major speeches, as they did in the past year. What has enabled the information revolution as well as the virtual university is the World Wide Web, and convenient access to it grows more and more essential every day. So far, full access to the World Wide Web requires a computer. Some pagers and wireless phones will display text from the Internet or WWW – stock quotes, e-mail messages, etc. – but hypertext, colour graphics, forms that can be filled and out and submitted, and animation require a colour graphics display and a relatively powerful computing engine.

The information revolution that was promised in the 1950s and 1960s with the widespread application of computers has arrived with the World Wide Web. With the WWW the world has shrunk dramatically and our perceptions and methods of data handling and information access have changed. Its impact on education has not yet been dramatic but there is little doubt that the Web will impact teaching and learning strongly in the near future. Those without access to or the ability to use the WWW are already disadvantaged and will become more so as time passes. Technologies are rarely reversible. Once let out of the bottle, there is little that can be done to coax them back in.

Thus the digital divide is first about the WWW, and secondarily about computers and the Internet (viewed in general). It concerns unequal capacity for accessing in a meaningful sense to the resources that the World Wide Web possesses – due either to physical access limitations or to difficulties in controlling communications mechanisms or to inability to understand what is retrieved (*e.g.*, low literacy, unfamiliar language).

WHAT DIFFERENCE DOES THE DIVIDE MAKE?

We care – or should care – about the digital divide because those who are disadvantaged vis-à-vis the WWW will potentially suffer in employment, education, and in their personal lives, as has been described in several of the papers in this same volume. Differential access to the WWW can create differences in grades received in school subjects and differences in acquisition of inquiry skills. There are subtleties, however, to be observed. Low tech skills are required to enable some high tech skills. For example, students can do better writing with a computer than with pen and paper but only if their keyboarding skills are good. A study done at Boston University, using high school students and exam questions patterned after a national writing examination, found that students who had keyboarding skills one half a standard deviation above the mean did better by computer than by hand, while the reverse was found for those with keyboarding skills one half a standard deviation or more below the mean (Russell, 1999).

The general argument to be made is that schools throughout the industrialised world are rapidly moving to incorporate technology and to subscribe to methods of teaching that allow students considerable freedom to search, to explore, and to collaborate with other students. With the skills acquired from these forms of schooling, students will be better prepared for jobs that require technology skills, information searching, and collaboration – jobs that tend to pay quite well – and to be better prepared for college where today computer skills are mandatory. If, as some studies claim, students are more motivated to attend school and to study when they have access to modern computers and the Internet, then a secondary advantage accrues to those within technology rich schools.

The Bangemann Report, which is the foundation of the European Council's action plan for participating in the global information society, includes two educational targets among the ten applications proposed for launching the European information society (Bangemann, 1994). While recognising that "the information society has the potential to improve the quality of life of Europe's citizens, the efficiency of our social and economic organisations and to enforce cohesion", the report also points out the risk of creating a digital divide (*ibid.*, p. 5). "The main risk lies in the creation of a two-tier society of haves and have-nots, in which only a part of the population has access to the new technology, is comfortable using it and can fully enjoy its benefits" (*ibid.*).

Those who sit below the salt

When salt was expensive, it was distributed unequally. The royalty and those they favoured had relatively easy access to it and the rest did not. The round table in the tales of the Knights and the Round Table was significant because when the knights ate, the salt was placed in the middle of the table, thus giving everyone equal access. When persons of unequal rank ate together, a long table was usually used and those of lowest rank placed furthest from the salt. Literally, they sat "below the salt". Comparable to those who sat below the salt are those today who have limited or no WWW access. They sit off-line, disconnected from the WWW. Some of these are unconnected by conscious choice, such as many women and girls; some because they cannott afford to be connected, such as high poverty families and people in rural areas where access is overly expensive; some because they have disabilities that interfere with either physical control of a keyboard or the perception of visual images and text; and some because they cannot interpret the texts due to low literacy or lack of understanding of the language of communication.

Each of these presents a different challenge for eliminating access differences. Some are missing links that need to be constructed, some are wastelands that need to be cultivated and landscaped, and some are foreign languages that need to be learned. Each, in turn, is explored in the following sections.

The missing link

Many people who would like to use the Internet are confronted with access problems. They are ready and willing to connect but some link in the chain that connects from transmitter to receiver is missing. This is what certain classes of disabled people face when trying to get on the WWW as well as some people in remote areas where access is either unavailable or overly expensive. These groups are quite dissimilar otherwise but share an access problem that is external to their own capacities. According to a recent report from the Disability Statistics Center at the University of California-San Francisco, around 50% of all persons in the United States own computers compared to only 24% for the disabled (Greene, 2000). Similarly, about 38% of the total US population uses the Internet compared to about 10% for the disabled.

Schools in the industrialised countries have made considerable progress in the past several decades in making learning more accessible to students with disabilities. Wheel chair ramps, large print books, and the like have made learning easier both in school and out of school for disabled students. Computer technology has offered an even larger potential for assistance, especially for students with motor and communication disabilities. In some schools as well as in many hospitals and other types of health care centres, computer-based assistive devices abound. For those with degenerative nerve diseases, for example, input devices that react to eye movements or even tongue placement are available (Strauss, 1998). However, the dissemination of these devices has not caught up to the demand for them. In addition, some assistive devices are expensive and require special software that limits students who use them to a single machine or to a small number of such machines. Like all other resources, they tend to be more easily available in affluent schools than in less affluent ones.

Not all types of disabilities, however, can be overcome easily with existing assistive devices. For the sight impaired, text-to-speech systems as well as video screen readers are available but their quality still lags for complex Web pages. Speech recognition, a technology that appears to be improving rapidly now, offers considerable advantages for computer input for this group. Nevertheless, it still is expensive and performs quite poorly with continuous speech.

The payoff of the WWW (as well as other Internet based facilities) for the disabled is potentially enormous – relief from social isolation through collaborative learning with e-mail, chat rooms, forums, and the like; access to library resources and other information; on-line instruction; and net-based tutors and mentors – all without having to leave home or school.

A second group of persons affected by the missing link are those in schools in rural areas where convenient access to the Internet is often lacking. For these students satellite and microwave transmission as well as rate reductions such as the E-Rate in the United States are the most practical solutions. Effective access to affordable telecommunications may help schools in remote locations overcome a further inequality resulting from their small enrolments. A small high school may not be able to hire instructors or attract sufficient students for many types of courses that larger high schools offer; *e.g.*, foreign languages, advanced placement, or highly technical subjects. Technology offers a workable solution to this problem through Web-based virtual courses, some of which are already available in a number of countries. Unlike correspondence courses and radio- and video-based instruction, virtual courses on the Web can allow student collaboration, synchronous and asynchronous communications, convenient downloading of instructional resources, and even remote manipulation of laboratory instruments.

A third group affected by the missing link are those from poverty neighbourhoods and those whose schooling is in institutions that draw predominantly from the underclass in a society, which usually means the poor, immigrants, and under-privileged minorities. In the United States, 80 per cent of the first-year students at private universities used e-mail during 1998 while at public, historically Black colleges, only 41 per cent did (Gladieux and Swail, 1999). At the elementary and secondary levels similar inequalities also exist. In 1998, 57 per cent of the instructional rooms within public and private schools with less than 6 per cent minority students enrolled were connected to the Internet, yet only 37 per cent of the instructional rooms in schools with 50% or more minority students were.

A more recent report from the National Center on Education Statistics, a division of the U.S. Department of Education, shows that in the spring of 1999, 52% of the teachers in low poverty schools (defined as having fewer than 11% of the students eligible for free or reduced-price school lunch) used computers and the Internet "a lot" to create instructional materials while only 32% of the teachers in high poverty schools (71% or more of the students eligible for free or reduced-price school lunch) did so. Similar differences also occurred for using computers and the Internet for administrative record keeping and for communicating with colleagues (NCES, 2000). These differences probably result from differences in technical equipment and support, training in the use of ICT, and the school culture related to ICT.

It should be observed, nevertheless, that the inequalities in most countries within schools are far smaller than those found outside of schools, that is, within communities and homes. Furthermore, in most of the industrialised countries, a high percentage of the classrooms in all schools will soon be technology supplied. This will not eliminate inequalities based upon other factors such as teacher preparedness for integrating ICT into instruction, but it will reduce the size of the gap between schools in low income areas and those in high ones.

Nevertheless, school children in poorer urban neighbourhoods have two potential access problems. One is in the school itself, where, as cited above, technology access is rarely equal to that of the schools in more affluent areas. But another barrier is found in the community and home support system for academic ICT use. In the more affluent areas there are more computers and Internet connections available outside of school for supporting homework, and more technical expertise for correcting problems that might occur. To overcome these problems in the United Kingdom, the ministers of E-Commerce and of Technology have jointly suggested wiring Internet connections in schools, churches, and bars in poor urban areas as an approach to exposing people in deprived neighbourhoods to the Internet (Pastore, 2000). In the United States, President Clinton has proposed a $100 million programme to create 1 000 Community Technology Centers in low-income urban and rural neighbourhoods (Clinton, 2000).

In Singapore, the Infocomm Development Authority has committed $25 million to a programme to bring affordable and accessible computers and Internet connections to 30 000 low income households, along with technology training. The object is to allow lower-income families access to the same computing resources that students from more affluent homes have through their own equipment and service provider subscriptions. Free broadband access to the Internet will also be offered to community centres and clubs (Nisperos, 2000). Teachers in Singapore have noticed that students with access to the Internet outside of school are able to download images and other types of information that allow them to earn higher grades. In addition, these pupils are acquiring more advanced inquiry skills.

The wasteland

Many women and girls view the world of computing as a wasteland, according to a recent report from the American Association of University Women (AAUW, 2000). A co-chair of the Commission that drafted the report concluded that "Girls are critical of the computer culture, not computer phobic" (AAUW, 2000, p. 1). Women, who make up over 50% of the US college enrolment, receive about 9% of the engineering-related bachelors degrees, less than 28% of the computer science bachelor degrees, and represent only 17% of those who take the computer science advanced placement test. Among information technology professionals, women are about 20% of the total.

The Commission found that programming classes were perceived by girls to be tedious and dull, computer games "boring, redundant, and violent, and computer career options uninspiring" (*ibid.*, p. 1f). To remedy this situation, the Commission recommended a number of steps for schools and communities, including changing the public face of computing so that women will not perceive it as solitary and antisocial; transforming software so that it appeals to a wider range of people and does not reinforce the "computer nerd" stereotype; preparing tech-savvy teachers who can teach how to use computers as productivity tools; and providing opportunities for girls to express their technological imaginations.

A wasteland also separates college training in the information technology field in the United States and two large minority groups there: African-Americans and Hispanics. For example, only about two per cent of all undergraduate computer science degrees were awarded in 1998 to these two groups, respectively, and only 10 of those receiving Ph.D.'s that same year were African-Americans and only 6 were Hispanics, out of a total of about 950 degrees received (Becht *et al.,* 1999). (At the undergraduate level, African-Americans represent 10.5% of the total US citizen enrolment and Hispanics, 8.1%.)

Whether this problem is a function of a wasteland that potentially could be made more inviting or belongs more in the foreign language category is difficult to determine. The majority of those students who major in computer sciences at the university level were probably identified as advanced in mathematics before the end of elementary school. The probability of such talent being recognised and fostered in schools drawing from high poverty areas, where a high percentage of African-Americans and Hispanics live, is not as high as for the same ability level in schools drawing from more affluent areas. If the problem begins at this level (or earlier), changes to hardware and software will have little impact on reducing it.

The foreign language

Simply wiring schools or neighbourhood organisations to the Internet does not guarantee that effective use of ICT will occur. For many, computers and the

Internet represent, metaphorically and actually, a foreign language that they do not speak or understand. Janet Schofield and her colleagues have documented many of the non-technical barriers to using the Internet effectively in schools, including mismatches in schedules, goals, and norms (Schofield and Davidson, 1998). These problems result from a failure to understand the Internet and the conditions under which it is most effectively used for learning. More importantly, many students lack experience not only in technically-based skills but also in information handling and in effective independent learning. For these students a range of skills need to be taught, including self-monitoring and time management, before computers and the Internet become intelligible.

Unlike television and radio, the Internet requires active, autonomous engagement to realise its full benefits. Stored information is available, as well as connections to dynamic information sources, including real-time data (*e.g.*, weather satellite transmissions) and advisors, tutors, mentors, and the like. But all of these require active search, communication, and information management skills, as well as constant monitoring to extract from the overwhelming bulk of texts, diagrams, tables, photographs, and the like what is needed for a given task or assignment. Those students who have good self-monitoring skills and are highly motivated to learn usually do better in independent learning than those who do not (Heckhausen and Dweck, 1998; Schunk and Zimmerman, 1994).

The association of educational ICT with constructivist approaches to learning, although often overplayed, derives from the potential that ICT has for implementing active and collaborative learning. Simulations, case-based teaching, cross-national discussion and debate, and the like are all facilitated by the Internet in particular. For these approaches to work productively, however, teachers must shift from lecturing and micro-managing activity and discussion to guiding learning through more and more independent student engagements with other students and with extra-classroom resources (Jonassen *et al.,* 1999). The ideal instructional mixture for K-12 schooling will vary according to student age and maturity level but will always involve a combination of direct instruction, guided and independent practice, group interaction, and individual reflection, search, and creation. Some teachers already teach this way and can, through acquisition of technology skills, integrate ICT easily into their teaching. Others need to acquire both new teaching styles and the requisite technology skills.

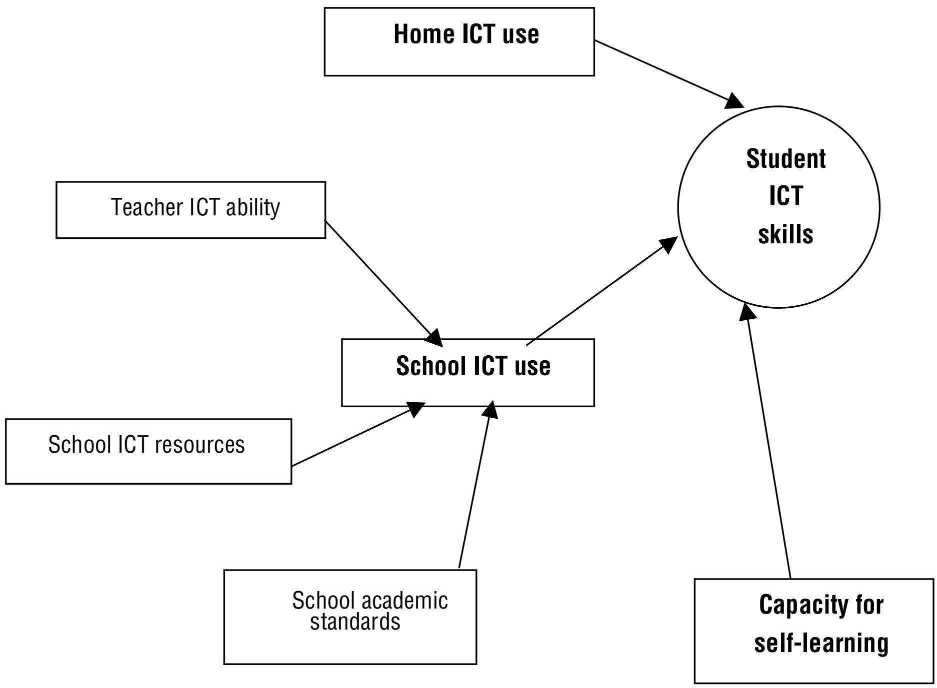
A less tractable problem is presented by those with low literacy and inadequate language skills for the languages of wider communication used within a country. Much of the value of the WWW rests in text and technical diagrams that are at or above high school reading level. Students who enter secondary school still reading at a far lower level will gain little meaning from most of what they encounter on the WWW. Similarly, those who do not command the language of the WWW materials will also have limited access to content. Although smart text-to-speech systems could serve the low literacy audience along with the blind, the low literacy group often has difficulties with listening comprehension due to vocabulary deficits. For those who do not comprehend the language of wider communication, translation systems are a possible relief. However, systems are currently in development primarily for the major world languages – Spanish, German, French, English, Russian – and so far lack the reliability required for educational applications. Some school systems are placing a stronger emphasis than ever before on second language learning, particularly English, to ensure that students will be able to use the WWW profitably.

To understand what national policies might work to close the digital divide for those affected by the foreign language problem, we must first develop a working model of how ICT impacts student abilities. One such model is shown in the figure below, using the development of ICT skills as the dependent variable. This model assumes that three factors feed directly into this ability: school ICT use, home ICT use, and student capacity for self-learning. In turn, school ICT use is controlled by teacher ICT ability, school ICT resources, and school academic standards. Home ICT use is not further analysed, but might be viewed as a function of resources, technology assistance, and attitudes toward learning.

Student capacity for self-learning is important for ICT skill acquisition because of the nature of computing as a solitary activity, particularly for middle and secondary grade levels, as well as the high demand for problem solving caused by the current state of the technologies: system crashes, incompatibilities across file formats, inaccurate or opaque instruction manuals, and so on. Hativa (1988), for example, has found that differences in self-study ability are a major contribution to the widening of the performance gap that occurs when computer-assisted instruction is used for mathematics. Students who can monitor their own learning, recognise when they are not understanding a concept, seek help, and communicate their learning needs to others tend to learn more from a self-paced system than those who are weak in these abilities.

School ICT use is the area where national policies can have their most direct impact. However, much more than hardware, software, and networking is required. Besides assuring that all schools have modern equipment and technological support, policy must also be directed at teacher training and at school standards. Model teacher training projects for ICT skills can be found in a number of countries, including Ireland, the Netherlands, Singapore, and the United Kingdom. A proposed Mexican effort is of special interest because it is part of a larger strategy to use ICT to promote school reform and involves a large element of participation by teachers in planning, courseware development, and instructional support. The UK project has been built around laptops and Internet service accounts provided at reduced costs to teachers who receive ICT training (BECTA, 1998).

The development of student ICT skills – A causal mapping



In contrast to the assumptions of even 10 years ago about the role of ICT in schooling, the modern view is that the teacher's ability to integrate ICT into the curriculum is critical to the successful use of ICT by students. This is a radical change from the past where computer-assisted instruction (CAI) and integrated learning systems (ILS) were viewed as answers within themselves and little need was seen to prepare teachers in ICT skills. The further step needed to make courseware effective for all students is for publishers to focus on providing resources for teachers to integrate in their lessons rather than full on-line courses that attempt to duplicate what teachers do. The resources that are most needed are those that centre on topics that are difficult to teach – the water cycle and electrical conductivity in science, place value in basic arithmetic operations, comprehension of conditional phrases in reading, and so on. If there is a true added value to full colour animation, real-time data, hypertext, diagnostic networks, and the like, then it will show up best in those areas where teachers typically have the most difficulties rather than in areas where teaching is less challenging.

The role of school academic standards in student ICT skill acquisition has been largely ignored, yet looms as large as equipment differences in the skill acquisition equation. Schools that have high standards encourage their students to do more sophisticated learning with ICT than schools with lower standards. In the lower standards settings, students might use word processors and spread sheets for mundane tasks, and occasionally search the World Wide Web for information, using simple searches and a single search engine. In schools with higher standards, students use spreadsheets to simulate different planting options in agriculture or policy options in government, build their own Web pages, and manage forums. When they search the WWW, they use complex searches and a variety of different search engines.

Policies for improving home computing for school-age students can be modelled on a number of successful projects world-wide. The Singapore home computing effort is one such project as is the Buddy project in the United States that supplies equipment, training and support services for parents of school-age children. Some factors related to home computing are more difficult to equalise. For example, in many countries wealthy neighbourhoods are upgraded with modern, high speed Internet lines while low income neighbourhoods are left with inferior communication equipment, if any at all. National policies to eliminate these disparities will be more difficult to formulate because the private sector is often involved.

The College Board report cited earlier has other recommendations for avoiding a wider digital divide in virtual campuses and in other technology-based academic programmes. For designers, they suggested placing access at the core of system design, keeping the promise of technology in perspective by balancing traditional and technology-based delivery, and learning from the distance-learning pioneers. For the communications industry, they suggest more social responsibility, reflected in consideration of how to stimulate broad access when developing products and services (Gladieux and Swail, 1999).

SUMMARY

The digital divide in formal schooling is not simply an equipment differential that can be overcome with further selective investments in hardware, software, and networking. Instead it derives from both within school and within home differences that extend to learning standards as well as support. Student self-learning ability, and in particular, student ability for independent learning, is an additional factor. National policies that attempt to close the digital divide for schooling must attend to all of these contributing factors to be successful.

Not discussed here are differences across even the highly industrialised countries in computer ownership and in use of the Internet, factors that impact schooling and learning. For example, while almost 37 per cent of the Swedish population has used the Internet this past year (1999), only about 26 per cent of the Danish population has and only about 10 per cent of the Italian. Within the European Union these differences may, in time, become important, especially as students become more mobile and courses and programmes more global.

Efforts to eliminate digital differences need to continue along all fronts: assistive devices, including speech recognition for the disabled, low cost communications for schools in remote areas, redesign of both hardware and software for women and girls, and more training for teachers, more technical assistance for parents, and more academic supports for students from high poverty and language minority backgrounds. The digital divide in formal schooling is not a single problem that can be fixed with a programme of massive school aid and technological supports. Instead it is, in part, a function of a lack of specific types of resources and in part of chronic differences that will not yield to any single remediation. These latter problems are a continuing reminder of the basic inequalities of most modern societies. ICT, if appropriately deployed, could contribute in more than a small way to alleviating these problems; employed differently may only exacerbate them.