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Responding to the Twin Challenges: Teachers, Teaching, and Technology

Teacher repertoires have been shaped by the crucible of experience and the culture of teaching. Policymakers need to understand that altering pedagogy requires a change in what teachers believe. Getting professionals to unlearn in order to learn, while certainly not impossible, is closer in magnitude of difficulty to performing a double bypass heart operation than to hammering a nail.

—Larry Cuban (1986)

The teaching profession is charged with the immense task of creating conditions and developing processes for building the human skills and capacities that are considered to be indispensable for economic growth, prosperity, social well-being, and individual development. It is no surprise that in any national education system teachers are considered the most important element where educational quality is concerned. Reform efforts in both developed and developing countries assume that the most direct and effective way of raising instructional quality is to introduce changes in teacher education and recruitment, to improve the knowledge and pedagogical skills of in-service teachers, and to ensure that the organizational conditions under which teachers work promote effective instruction and focus on student learning outcomes.

The shift from industrial- to knowledge-based school organization has a direct impact on teacher training and teacher deployment. More flexible arrangements are needed that, among other things, allow teachers to break away from the isolation in their classrooms. For example, team teaching to larger and flexible student groups is a worthwhile contemporary trend. The demand is for a teacher who is a knowledge worker, a designer of learning environments, with the ability to take advantage of the various areas in which knowledge is produced.

Within the context of knowledge-based, knowledge-intensive teaching, the latest revolution in the education sector has to do with the potential role

of information and communication technologies (ICTs) in introducing radical change to teaching and learning processes. ICTs include radio, television, computers, and the Internet. For some decades now, technologies have been seen, in both developing and developed countries, as tools for expanding the provision and coverage of education at a reduced cost. Although this has been true in several cases, ICTs nowadays are considered preferably as a means of offering high-quality education that is centered on student learning and geared toward relevant skills in demand in the knowledge economy. ICTs offer a means of reducing costs while expanding coverage (as in traditional distance education), but they can also increase costs without necessarily expanding coverage—an example is sophisticated online course tutoring at the tertiary level. So ICTs hold the promise of expanding access to education, but they can also be an avenue for new forms of inequity. For secondary education in particular, ICTs appear to be at the core of the twin challenges of expanding access and, at the same time, improving quality and relevance.

Secondary School Teachers: Shortages, Professional Identity, and Training Issues

Qualified secondary school teachers are becoming a precious commodity in many developed and developing countries. They tend to be the hardest segment for the teaching profession to attract, the most expensive to educate, and the most difficult to retain. The numbers of unqualified teachers tend to be much higher in secondary than in primary education in almost every developing country. And the attrition rates of secondary education teachers are the highest in the teaching profession, especially for male teachers and for those in high-demand fields such as mathematics, science, and technology (OECD 2004a).

Since, almost everywhere, preservice teacher education for secondary school tends to be consecutive (that is, teachers are educated first in a curriculum area or specialized discipline and then go on to receive some pedagogical training), the professional identity of secondary teachers is not constructed around teaching but, rather, around their discipline of specialization. But as mass secondary education spreads, more and more teachers who at the start of their careers had thought of themselves as *pretertiary* teachers are confronted with the hard fact that they are, rather, *postprimary* teachers. In contrast to the days when secondary education had elite status, student motivation can no longer be taken for granted. This fact entirely changes the conditions of day-to-day teaching for secondary school teachers. Instead of being trained to develop the new competencies required to deal with today's students, secondary teachers see their professional identity questioned and experience a loss of control over their own professional practice. And insofar as training is concerned, secondary teachers seem to

be increasingly tempted to trade off opportunities to learn to innovate in favor of survival toolkits.

Education decision makers today face the problem of attracting able graduates to the teaching profession and retaining them there. In developing countries, and especially in Africa, shortages of teachers, particularly in areas such as mathematics, science, and technology, pose a major threat to the goals of expanding education and enhancing its quality. For example, whereas in some African countries, such as Uganda, qualified teachers are unemployed (Lewin 2002), in Zambia the 1996 national education policy estimated that the numbers of teachers retiring, dying, or chronically ill would equal the entire output of teacher training colleges in the years to follow. In Lesotho it was estimated that almost half the school completion cohort would have to choose teaching in order to meet predicted demand (Lewin 2002, 229). The shortage of teachers will continue to be the main challenge for teacher policies in the near future. This will be the case worldwide, although the reasons vary—demography, labor market trends, the impact of HIV/AIDS, and so on. Comprehensive incentive policies to attract and retain high-quality teachers need to be designed taking into account the effective and dynamic integration of teacher professional development and career issues, teacher deployment policies, class size, and monitoring and evaluation practices. Such policies could commence with measures to make the teaching profession more attractive by increasing the salaries and compensation of secondary school teachers. (The case of Chile is probably the best illustration of success in this regard.) Alternatively, or in addition, measures to alleviate teacher shortages could include investments in teacher education and changes in teacher certification and recruitment policies.

Broadly speaking, solutions to teacher shortages in developing countries have taken two directions. One is to accelerate preservice teacher training, thus reducing the duration and the cost of training. In some countries, such as Guinea, training has been cut down to three months. The other solution is to institute policies that permit recruitment of unemployed graduates with no formal teacher training, graduates from teacher colleges, or secondary school graduates fresh from the classroom on a contract basis at a lower monthly salary than regular teachers receive.

Accelerated preservice training has greatly reduced the cost of preservice teacher education and has helped place more teachers in classrooms in a relatively short time. In some cases, however, it has negatively affected teaching quality, particularly when students' academic background is weak. Contract teacher policies can also lead to increased regional disparities, since contract teachers tend to be deployed to rural and remote areas. More empirical evidence is needed about the effects of these policies, and governments need to weigh the options carefully before putting them in practice. There are no easy shortcuts to achieving the

goal of an appropriately trained teaching force, particularly at the secondary education level.

Developed countries are also attempting to respond to shortages of secondary education teachers, in some cases with imaginative and innovative solutions. For example, in the Netherlands the Unqualified Teaching Interim Act makes it possible for professionals with a higher-education degree to choose a career in education. Interested professionals are required to go through an assessment process before they can begin teaching in a school, and they take a tailor-made two-year training program. On successful completion of the training, they earn the formal qualification to teach.

To What Extent Is Investment in Preservice Teacher Training for Secondary Education Worthwhile?

Teacher shortages are becoming severe in some countries and in some curriculum areas, particularly mathematics and science. Many educators, researchers, and policy makers are convinced that investment in preservice education is not yielding the expected results and that resources would be better utilized if redirected to other, more productive areas. The fact that in many countries preservice training has remained virtually unchanged is raising even more doubts about its effectiveness. This is particularly so where secondary school teachers are concerned, since their preservice training relies almost exclusively on specialized knowledge training at universities, with very little, if any, practical training in teaching and learning processes. To a great extent, this has meant that secondary teachers have to be responsible for their own training and professional development once they start teaching in schools. In addition, and especially in developing countries, teachers generally have to teach alone, with students the only witnesses of their professional activity. Few jobs are characterized by greater solitude and isolation. Teachers labor on their own to decide what instruction works, what standard of student work is acceptable, and what additional knowledge, skills, or insights would best serve them and their students. "It is probable that this version of private, is the modal one across most school settings and at most points of the career. Both the architectural and the social organization of schooling make it difficult to work otherwise" (Huberman 1995, 207).

There is, moreover, a profound mismatch between the radically new key competencies demanded of students in the knowledge society and the teaching skills acquired from teacher training colleges and in-service training programs (World Bank 2004a). For developing countries, designing appropriate policies for selecting and training teachers who can help students acquire the new competencies required by society and labor markets is an extraordinary challenge. The new competencies clearly require that teachers behave in classrooms in a way contrary to the training they receive.

Conservative and strongly academically oriented teacher training systems are unable to facilitate such a shift. But the inefficiency and high cost of traditional preservice teaching training do not justify abandoning such training altogether.

At least two dilemmas emerge for developing country decision makers. The first arises from the growing tension and potential conflict between the drive to raise the status of the teaching profession and the perceived need to bring teacher education back from academia and closer to schools and classrooms. Efforts are being made to upgrade the academic status of teacher education programs (which could result in greater access restrictions, thus paradoxically worsening teacher shortages). At the same time, there is a need to base and concentrate both preservice and in-service teacher training in schools and classrooms if it is to be relevant and efficient.

The second issue, which is closely related to the first, arises from the research evidence suggesting that school-based in-service training and mentoring of novice teachers is more effective and less costly than traditional preservice training (Lewin 2003). A policy move in that direction could lead to the shortening of preservice periods in teacher colleges, which would at least partially reduce university control over teacher education and access to the teaching profession and might jeopardize the academic status of teacher education programs. Such a risk might be dealt with through renewed teacher accreditation systems that sanction qualifications regardless of the duration of formal studies. Notwithstanding the caveats implicit in the trade-offs involved, a prudent and gradual shift in resource allocation from preservice to school-based training could be a change worth considering in teacher education policy in some countries.

Matching Teaching Skills with Required Key Competencies for Secondary School Graduates

A teaching skill or competency is the capacity to mobilize a variety of cognitive resources to deal with a specific type of teaching situation. Rather than relating to the teaching of a particular content or type of knowledge, teaching competencies and skills integrate and articulate cognitive resources that are relevant to a given situation. They are constructed through training and through daily practice in the classroom. Teaching competencies are common to every curriculum area and school level; they cut across subjects and disciplines, in primary, secondary, and tertiary education.

The debate about the professional, nonprofessional, or semiprofessional nature of school teaching has been going on for decades, but today the issue is more controversial and crucial than ever. In the contemporary knowledge economy, knowledge management is seen as the key to the flexibility of operations, the training and professional development of employees,

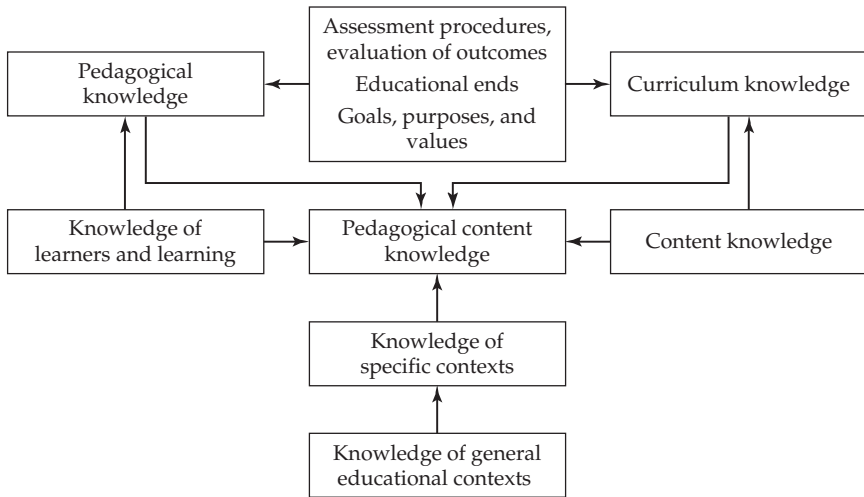
and even the overall productivity of an institution. The implicit challenge is that knowledge of teaching is for the most part tacit, difficult to articulate and systematize, and strictly practical and context based. These characteristics reinforce the traditional isolation of teachers and schools, making the transfer and full utilization of knowledge very difficult. In short, teacher education institutions, schools as organizations, and education systems in general are still very far from meeting the needs of a knowledge-management society. This is why the curriculum of teacher education, especially preservice training, remains an open, controversial, and puzzling issue, with contradictory evaluation results and research evidence.

Linkage between curriculum reforms and in-service teacher training. The implementation of curriculum reform is basically a problem of in-service teacher training. And such training is difficult because of the “stickiness” (resilience) of teachers’ preexisting know-how. Other professions have constructed highly specialized knowledge capital that permits the establishment of a considerable distance between the professional and the customer. (This is the key to the classic sociological category of professional prestige.) Professional knowledge of teaching cannot be constructed in the same manner. Being close to students, caring about them, and building learning communities that are responsive to students’ needs are part of the essence of the teaching profession. An entirely new approach to professional knowledge has to be developed (Hiebert, Gallimore, and Stigler 2002)—one that allows for the conceptualization of teacher education and teacher professional development in terms of lifelong learning.

The debate about the curriculum of teacher education programs has taken place around two fundamental and conflicting stands: (a) that the emphasis should be on subject-related knowledge (*content knowledge*) and (b) that the most pertinent knowledge for teachers is obviously *teaching- and learning-related knowledge*. Teaching- and learning-related knowledge includes professional knowledge about students themselves (in secondary education, understanding adolescence is vital) and about classroom management, pedagogy, and evaluation and the school as a learning and knowledge-producing institution. Contrary to common wisdom in education, there is strong research evidence that knowledge about teaching and learning processes is even more closely associated with student achievement than is content knowledge of the discipline (Darling-Hammond 2000).

Educational research in several related fields has pointed out the existence of a third category of knowledge that is at least as relevant for teacher education as the other two: *pedagogical content knowledge*—that is, specific and specialized knowledge about teaching and learning processes in a particular discipline (see figure 6.1). Pedagogical content knowledge is a teacher’s understanding of how to help students understand specific subject matter. It includes specialized knowledge of how particular subject-matter topics can be organized, represented, adapted to the diverse interests of learners, and presented for instruction. According to some recent

Figure 6.1 Categories Contributing to Pedagogical Content Knowledge



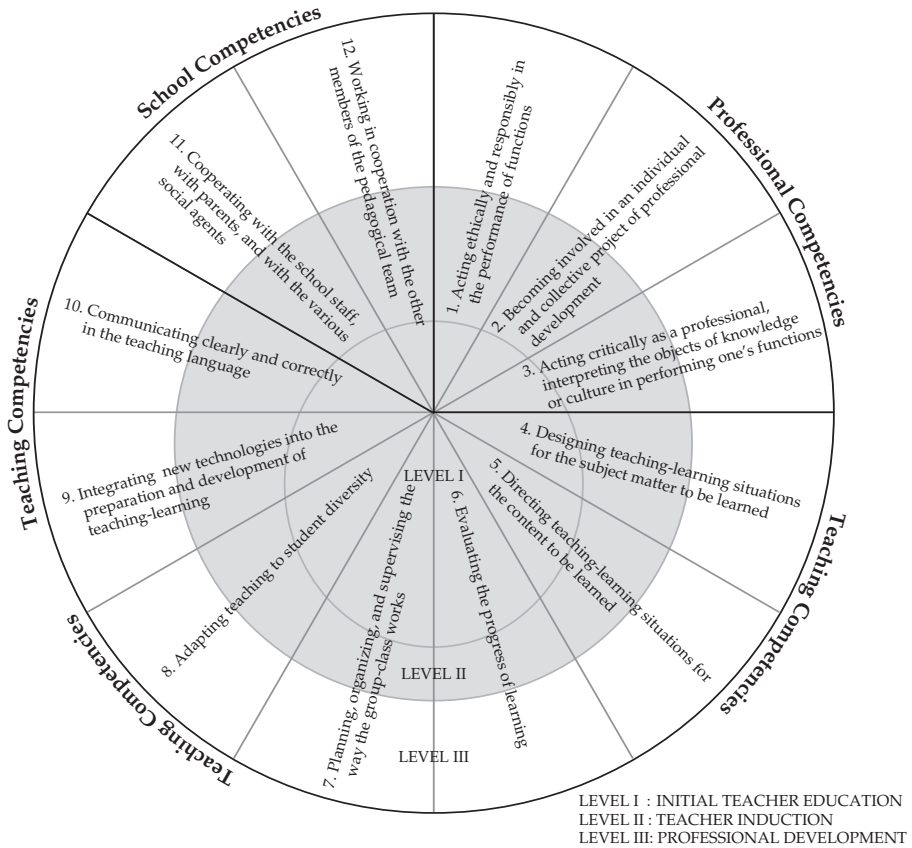
Source: Morine-Dershimer and Todd 2003.

reviews, this is the type of knowledge most clearly linked to student achievement and the one with the greatest potential vis-à-vis the professional development of teachers. Pedagogical content knowledge is not only a renewed and advanced source of a new identity for the teaching profession; it can also promote better student results and a more equitable school system. Emphasis on pedagogical content knowledge results in more productive and inclusive secondary schools.

Competencies relating to the work of teachers in the classroom are those that should be considered core elements in preservice teacher education. Research evidence shows the importance for beginner teachers of developing a repertoire of abilities and basic knowledge that allows them to make a good start in their professional lives (see figure 6.2).

Lifelong learning is more than just a good axiom. Fundamentally, a change is required in the way the teaching profession is viewed: a teacher must be seen as a professional, a knowledge worker who does not spend his or her entire professional life in just one education system or even in a single country. Like students, teachers must be prepared to work in changing and unpredictable environments in which knowledge is constructed from different sources and viewpoints. The ability to teach challenging content to learners with different experiences and conceptions depends on the capacity of practitioners to create powerful and diverse learning experiences that connect with what students know and how they can most effectively learn. In addition to addressing pedagogical and subject-matter knowledge and skills, secondary school teachers are expected to develop skills for communicating

Figure 6.2 Secondary School Teacher Competencies



Source: Martinet, Raymond, and Gauthier 2001.

Note: Appendix F provides a road map of teacher competencies for a knowledge-based secondary school.

with parents, dealing with dropouts, grade repetition, and poor attendance, and working in disadvantaged communities. Teacher education programs should enable teachers to teach in multiple contexts to diverse groups of children and should help them understand how to build effective school-community partnerships.

Teaching and Learning with Technology

In low-income countries the strategic use of ICT potentially provides a means of leapfrogging in educational development. The mere availability of computers and other technology, however, does not replace the core

business of teaching and learning, nor is it in itself a guarantee of gains in educational quality. Education, not connectivity, is the challenge here, but the two need not be sequential or in conflict.

There is still a long way to go before the potential of ICT in actual classroom learning processes is realized. In both developed and developing countries there is mounting skepticism about the learning outcomes of massive investments in ICT.

The challenge concerning full utilization of ICT in education closely concerns the teaching profession. ICT teachers seem to be especially hard to attract, recruit, and retain in secondary schools (OECD 2004a), and the ICT training needs of secondary school teachers with no or little knowledge of ICT in teaching and learning are enormous. Institutional innovation within educational institutions has not kept up with the pace of technological innovation in education, and this gap creates problems with the implementation and full utilization of ICT. Policies for ICT in education should be set within the framework of a precisely defined strategy for the entire education sector, entailing a new cultural framework for educational institutions. These policies should emphasize new forms of access to education and new channels for social participation. Careful review of the organizational, managerial, and financial features of educational institutions is a precondition for the successful implementation of any ICT education policy.

If anything, ICT means networking and collaboration. Institutional partnerships at all levels are the key to sustainable success. Quality control and quality assurance mechanisms become crucial. The supply of ICT education can potentially be of the highest quality but also of the poorest.

Use of ICT for Distance Education to Expand the Venues for Learning

ICTs have brought about a new approach to institutionalizing education by providing alternative venues for knowledge dissemination and learning, beyond the constraints of space, time, or physical structure. Technologies such as interactive radio broadcast, satellite and cable television, computers, and the Internet have become available for educational use (see table 6.1). These technologies have the potential to provide learners with a highly interactive, synchronous and asynchronous multimedia learning experience from geographically dispersed organizations and schools via vast national and international networks (Haddad and Draxler 2002).

Radio broadcast and interactive radio instruction (IRI). Although radio lacks the visual effects of television and computers, distance education programs via radio have many advantages: broad outreach can be attained without complex infrastructure, radio is easy to use, and the programs are less expensive to produce than television and computer-assisted programs. The first IRI program in a developing country was initiated in Nicaragua in the 1970s

Table 6.1 Distance Education for Secondary Equivalence in Africa

<i>Country</i>	<i>Subjects offered</i>	<i>Enrollment, 1999–2000</i>	<i>Technology used</i>
Botswana	All subjects	600 junior secondary	Print, radio
Burkina Faso	French, math, physics	—	Radio, television
Ethiopia	Eight subjects	8,400	Print, radio, television
Ghana	English, math, science	—	Print, radio, television
Guinea	French, math, science	300 secondary teachers	Print, radio, audio-tapes
Malawi	—	80,000	Print, audiotapes
Namibia	All subjects	18,325	Print, radio, audio-tapes
Nigeria	All subjects	—	Print
Zambia	—	11,138 (1990)	Print, radio
Zimbabwe	Academic subjects	25,000	Print

Source: World Bank 2002a.

Note: —, Not available.

to teach mathematics to students in grades 1 to 4. Since then, IRI has been used to teach a variety of subjects, including language arts, second languages, science, and environmental studies, in 20 countries, mostly in Africa and in Latin America and the Caribbean.

Experience has shown the potential of IRI for expanding secondary education. Program evaluations in Bolivia, South Africa, and Thailand have indicated that IRI programs make a substantial impact on urban-rural equity gaps and educational quality, as reflected in achievement gains by targeted students (Bosch, Rhodes, and Kariuki 2002). Studies on IRI programs in Honduras, Papua New Guinea, and South Africa have identified the potential of IRI to reduce gender equity gaps (Hartenberger and Bosch 1996). Other studies have consistently demonstrated IRI's cost-effectiveness across programs (Haddad and Draxler 2002). Although IRI requires relatively high initial fixed costs, recurrent costs are markedly lower. Initial costs include production of audio and print materials and development of management and training systems; recurrent costs include staff salaries, program dissemination, maintenance, and training of teachers and program staff. Because of the wide reach of radio broadcasts and the insignificance of the variable costs (new school and broadcast facilities, textbooks, teachers, and maintenance staff) required for additional learners, the cost per learner of IRI programs decreases proportionally with an increase in users. Thirteen of the twenty countries that launched IRI between 1974 and 1999 continue to

implement the original programs. Three countries are using different applications from those launched initially, and four have abandoned the program (World Bank 2002a).

Educational television. Television has been used in secondary education since the late 1960s, with mixed results. The most important advantage of educational television is that complex or abstract concepts can be illustrated through visual effects. Notable disadvantages include high production costs associated with relatively sophisticated production facilities, equipment, and technical skills, and inflexibility in updating programs once they have been developed.

Programs implemented in Côte d'Ivoire and El Salvador with the support of international agencies did not succeed. The program in Côte d'Ivoire came to an end soon after external financing was discontinued, the victim of high per-student costs, teachers' resistance to centralized institutions, and weak local capacity resulting from overreliance on foreign or expatriate technical assistance. By contrast, two educational television programs in Latin America and one in Asia—Mexico's Telesecundaria, Brazil's Telecurso, and the National Open School of India—have succeeded in providing secondary education to students who would not otherwise have had the opportunity. The success of television-based educational programs in these three countries, despite the high initial fixed-cost investments, is attributed to their large populations of potential secondary school students, which permit economies of scale.

Telesecundaria was developed in 1968 by Mexico without external financing. Its main objective was to solve the problem of access in rural areas. (The urban delivery version became financially unviable because of low demand.) Telesecundaria targeted students in the 200,000 rural communities with populations of less than 2,500. In 1998, 15 percent of Mexico's junior secondary students were educated through the program (World Bank 2002a).

Brazil's Telecurso was developed in the late 1970s by the Roberto Marinho Foundation and was supported by the country's largest commercial network, Rede Globo. Its purpose was to provide young working adults with the opportunity to acquire primary or secondary equivalency certificates. To respond to the new demands of the labor market, a new program, Telecurso 2000, was developed in the early 1990s by the Roberto Marinho Foundation, the Globo media company, and industrialists. Telecurso 2000 is a condensed version of a basic secondary education curriculum, with an optional curriculum on basic mechanical skills. The guiding principles of its design are job-oriented education, development of basic skills, citizenship education, and contextualization (Haddad and Draxler 2002).

The National Open School of India was established in 1989 as an autonomous institution under the Ministry of Human Resources Development to support India's National Policy on Education. The school

mainly caters to the educational needs of out-of-school children and of socially and economically disadvantaged students in general. Although it started with academic courses at the secondary level (including the senior secondary level), it currently offers courses in vocational and other life-skill areas. It has also extended its range from elementary to preuniversity programs. Over 400,000 children from physically, socially, economically, and geographically disadvantaged groups have enrolled in the school.

Computers and the Internet. The major investments made over the past two decades have brought modern ICTs into nearly all secondary schools in the most advanced OECD countries (OECD 2004b).¹ In some middle-income countries too, computers and the Internet have been introduced in a large number of secondary schools; for example, in Chile the student-computer ratio is 33 to 1 (Hepp et al. 2004). Computers and the Internet are used for educational purposes in three basic ways: (a) as teaching tools (simulations, courseware, online learning communities, professional development of teachers); (b) as content delivery tools (online libraries, journals, and books); and (c) as management tools (Education Management Information System, or EMIS, assessment, record keeping). Examples of how computers and the Internet have been used to expand access to secondary education include community telecenters, for the most part in developing countries, and virtual high schools, mainly in developed countries.

Community telecenters in poor rural areas provide computers and Internet access to the public. They are diverse in structure, clientele, services provided, financing, and availability of hardware and software. Some serve as nonformal education centers providing basic literacy courses and training to school dropouts and adults. For instance, LearnLink telecenters in Ghana offer supplementary educational programs beyond those available in public and private institutions. In the three years 1998–2001 the program provided more than 14,000 individuals—students, teachers, businesspeople, and even national telecommunications staff—with useful ICT skills (USAID and AED 2003).

Virtual schools offer courses to students over the Internet. Since 1997 many new virtual schools have been established in Australia, Canada (British Columbia and Alberta), Europe, and the United States. Virtual schools vary significantly in their curricula and in how they are structured and funded. Some have individual courses that students may take to receive credit from their school districts toward a regular diploma. Others offer a complete program and diploma. In the United States about 300,000 students, mainly high school students, were enrolled in virtual schools during the 2002/3 academic year. It is estimated that more than 520,000 students were enrolled in 2004/5 (Revenaugh 2004). More than half of the U.S. states offer some form of virtual education. In addition, 67 virtual charter schools in 17 states served 21,000 students in 2003/4 (see box 6.1).

Box 6.1 Types of Virtual School in the United States, with Examples

- *State-sanctioned, state-level.* Sanctioned by the state government to act as the state's own virtual school. *Example:* the Florida Virtual School, which is state funded as an independent entity and offers a full online curriculum but not a diploma.
- *College and university based.* Virtual introductory college-level courses have been made available to upper-division high school students through dual or concurrent enrollment. *Example:* the University of Nebraska–Lincoln Independent Study High School, which has developed, under a federal grant, CLASS online diploma program courses that are marketed through the for-profit CLASS.com.
- *Consortium and regionally based.* Virtual school consortia can be national, multistate, state-level, or regional. Many regional education agencies have added virtual K–12 courses to their service menus for schools. Most consortia act as brokers for external provider opportunities or share courses among members. *Example:* the nonprofit VHS Inc. (formerly Concord VHS) in Massachusetts, which is seeking sustainability through its broad network of participating schools.
- *Local education agency based.* A large number of local public schools and school districts have created virtual schools, mainly to serve their own supplemental or alternative educational needs and to reach out to homeschool populations. They usually employ their own regular, certified K–12 teachers, either within the regular course of instruction or on the side. *Example:* the HISD Virtual School in Houston, which offers middle school curricula for enrolled and homeschool students, as well as advanced placement courses to supplement its high school offerings.
- *Virtual charter schools.* State-chartered entities—including public school districts, nonprofit organizations, and for-profit organizations—operate public charter schools that are exempt from some rules and regulations. Charter school legislation has a major impact on how these schools operate. *Example:* the Basehor-Linwood Virtual Charter School in Kansas, which focuses on providing state-funded public education opportunities for K–12 homeschoolers across the state. It delivers self-developed courses in a full diploma program, using a certified district teacher for each elementary grade level and secondary content area.
- *Private virtual schools.* Like local public schools, many private schools have developed virtual school programs, mainly designed to provide supplemental courses and instructional materials for homeschoolers. A limited number offer state-approved or regionally accredited high

(Continued)

Box 6.1 Continued

school diplomas. *Example:* the Christa McAuliffe Academy in Washington State, where student cohorts meet weekly with their mentor in an online virtual classroom meeting and students follow online mastery-based learning curricula facilitated by academy mentors and developed by external providers.

- *For-profit providers of curricula, content, tools, and infrastructure.* Many for-profit companies have played an important role in the development of virtual schools. *Example:* companies such as Apex Learning and Class.com have supplied starter courses for many new virtual school efforts. Blackboard and eCollege have provided delivery platforms that are used by many virtual schools. Many companies are broadening their original focus and are making available expanded curricula or comprehensive services to meet the needs of this growing market. Web development software companies such as Macromedia have provided the tools used by virtual schools to self-develop courses.

Source: T. Clark 2001.

The greatest benefit of virtual schools lies in the increased opportunities for students in small rural districts. Often, these districts cannot offer a full range of courses such as advanced placement (specialized preuniversity) courses and enrichment courses. This explains the prevalence of virtual schools in some of the less-populated areas of Australia, Canada, and the United States. Another noteworthy benefit of virtual schools is that they provide learning opportunities for individuals who cannot attend school because, for example, they have severe medical problems or are incarcerated. It also helps parents who decide to homeschool their children.

Three main factors need to be taken into account when considering the virtual school as an alternative venue for secondary education:

1. *Technology requirements.* The more closely a course resembles a real classroom with frequent simultaneous interactions, the more bandwidth is required. Equity concerns arise immediately: the higher the technology infrastructure requirements, the lower the number of students who will be able to participate, especially those who are economically disadvantaged. This issue needs to be carefully thought out during the design stage so that alternative technologies can be used to avoid heavy reliance on the Internet and on Web sites. For instance, CD-ROMs can be used to disseminate high-volume course materials and resources, and dedicated

listservs, newsgroups, and discussion boards can be used for asynchronous discussion and conferencing.

2. *Teachers and instructors.* Because the online teaching environment is quite different from the traditional classroom, different skills and pedagogy are required. It is important that teachers and instructors receive appropriate training on pedagogy, course design, and the use of technology.
3. *Students.* Not all students are prepared for online learning. Some may lack motivation, some may have a learning style unsuitable for online learning, and some may not be proficient in using the technologies. Lessons learned from existing virtual schools can be drawn on: readiness assessments of students, provision of support mechanisms, and good online technical support are all useful.

Integrated approach with multimedia. All the programs mentioned so far utilize mainly one type of technology, whether radio, television, or computers. But programs may also use a blend of technologies, each serving a specific purpose. National General Upper Secondary Distance Education in Finland is an example of this integrated approach.

The program was developed in 1997 by the National Board of Education (NBE) and the Finnish Broadcasting Company together with 12 educational institutions as pilot institutions. Encouraging results from the pilot schools led to the extension of the project to all of Finland's provinces. By February 2003 nearly 90 upper secondary institutions with approximately 3,200 students were participating. The objectives of the project are to improve educational equity by expanding access to general upper secondary education, to increase citizens' ability to use ICTs, and to meet the challenges of lifelong learning by offering students an open and flexible educational track.

All students in the Finnish program are enrolled at a participating educational institution and draw up their personal study plans in consultation with the institution's principal and the subject counselors. Students use textbooks and other written materials, distance learning programs on radio and television, audiocassettes, e-mail, and Web-based and other online learning materials. The success factors for this integrated approach are the nationwide scale and the NBE's partnerships with the business sector, which includes publishers, hardware suppliers, network operators, and the national public service broadcasting company.

Use of Computers and the Internet to Improve the Quality and Relevance of Education

Computer literacy is becoming a baseline requirement for many jobs, and demand for highly skilled ICT workers has increased where new technologies have been introduced (World Bank 2003a). To measure the quality

of ICT skills of students and employers, educational institutions and government agencies in over 100 countries have adopted international competency standards such as the International Computer Driving License (ICDL) and the European Computer Driving License (ECDL). Some countries are setting up their own ICT literacy standards for secondary students; Chile, for instance, is establishing national accreditation for ICT skills in secondary schools based on the ICDL (Hepp et al. 2004).

More specific skills are also being taught at secondary schools around the world. A network company, Cisco, distributes to schools through the Internet the Cisco Networking Academy curricula, allowing students to be certified as Network Associates and Network Professionals. The program, launched in 1997, has evolved from a high school network support curriculum to a worldwide educational program. Over 450,000 students have enrolled in more than 10,000 Cisco Networking Academies located in high schools, technical schools, colleges, universities, and community-based organizations in over 160 countries (see <http://www.cisco.com/en/US/learning/netacad/index.html>).

Potential and Promise

Studies and evaluations of the effect that the use of computers and the Internet in the classroom has on student learning have yielded mixed results. Some studies show no clear or substantial evidence of improved academic achievement or cite negative evidence (Angrist and Lavy 2002; Cuban 2001; Wood, Underwood, and Avis 1999). Other studies have shown that the use of computers and the Internet can help build effective learning environments and improve student learning (Earle 2002; Honey 2001; Mehlinger 1996; Van Dusen and Worthen 1995). More recent surveys (OECD 2004b) indicate that actual levels of computer and Internet use in secondary schools are much lower than expected, even in developed countries that have made huge investments in ICT in secondary schools. These results obviously raise questions about the significance of impact evaluation studies in the field. There is a need for more rigorous studies and evaluations in different school contexts and different teaching and learning environments. Some of the recognized contributions of technologies to building effective learning environments are summarized here using the categories identified by Bransford, Brown, and Cocking (2000): learner-centered, knowledge-centered, assessment-centered, and community-centered environments.

Learner-centered environment. Some computer and Internet programs provide individualized instruction and present content beyond what has traditionally been available to a classroom teacher through textbooks. The programs motivate students through collaborative learning activities and by building a network of learners. They put students in the driver's seat, providing them with structure and giving them responsibility for their own learning.

Computer simulation programs can be used to teach core topics and to provide science students with theoretical or simplified models of real-world phenomena. (An example is the GenScope Project for genetics in precollege biology.) Such programs allow learners to investigate scientific and mathematical concepts through direct manipulation and experimentation. These scientific video- and computer-based simulations and visualization tools have been shown to lead to increased understanding of core scientific concepts (Honey 2001).

Knowledge-centered environment. Computers and the Internet make curricula more exciting by bringing real-world problems into the classroom. For example, through the Global Learning and Observations to Benefit the Environment (GLOBE) project, over a million students from more than 12,000 schools around the world have taken part in gathering data about their local environments using protocols specified by principal investigators. Students submit their data to a GLOBE data archive through the Internet, which both scientists and the students use to conduct their analyses. Visualization tools such as maps, graphs, and digital photos on the GLOBE Web site enable students to see their own data and to make comparisons with data collected in other locations. These knowledge-centered environments, which provide access to a vast array of information, including digital libraries and real-world data for analysis, as well as connections and interactions with meteorologists, geologists, astronomers, computer scientists, and other practitioners, make students enthusiastic about their work while producing impressive intellectual achievements (Means et al. 2000).

Assessment-centered environment. Computers and the Internet can help create a self-assessment-centered environment that gives students and teachers more opportunities to receive feedback, reflect, refine their understanding, and build new knowledge. For instance, networked technologies for communication such as the Computer-Supported International Learning Environments (CSILE) developed at the Ontario Institute for Studies in Education provide opportunities for students to collaborate on learning activities by working through a communal database that has text and graphic capabilities. Within the networked multimedia environment, students create “nodes” that contain an idea or piece of information about the topic they are studying. The nodes are available for other students to comment on, leading to dialogue and knowledge accumulation (Bransford, Brown, and Cocking 2000).

Community-centered environment. The Internet is especially effective in enabling teachers and students to build local and global communities that include teachers, administrators, students, parents, practicing scientists, and other interested people. For example, Internet-based international collaborative learning programs such as the International Education and Resource Network (iEARN) and the World Links program (see box 6.2) offer an online platform through which students work with peers in their

Box 6.2 World Links: A Global Learning Community

The World Links program was launched in 1997 by the World Bank Institute (WBI) as an effort to pilot-test the impact of information and communication technologies on teaching and learning in developing countries. The program is now an independent nongovernmental organization. As of 2004, World Links was operating in more than 35 countries, reaching over 400,000 teachers and students. The program introduces students and teachers to the vast educational resources available on the Internet, the possibilities for information sharing and networking among learners and educators, and the potential for the creation of new knowledge and learning resources in electronic format. Much of the World Links pedagogy for professional development programs for teachers centers on the use of technology for international collaborative project-based learning. Teachers develop curriculum-based projects ranging from a study of local flora and fauna to an examination of myths having to do with the traditional role of women in society. Each project involves interaction with one or more classrooms outside the teacher's city or country.

An important finding from the implementation of the program is that although individual teachers were enthusiastic about engaging in innovative pedagogy in the classroom, there were no incentives for doing so. The collaborative project work was not a formal part of the curriculum and was not measured by any examinations. Many of the projects, therefore, were developed and implemented as extracurricular activities outside normal school hours. The lesson is that if teachers and students are to gain from the use of ICTs in the classroom, a broader commitment must be made at the policy level to ensure full integration of technology into education systems through, for example, appropriate curricular integration and associated professional development for teachers.

Sources: World Bank staff; World Links program data, 2004.

own countries and around the world on collaborative learning projects. Such projects can expose students to the personal stories, expertise, resources, and authentic feedback necessary for in-depth analysis of other cultures and can give them opportunities for interaction and collaboration they would not otherwise have had (Spector 1999).

Controlled studies of cross-classroom collaboration have shown an increase in students' writing skills and motivation to read, write, investigate, and explore science and social science topics (Riel 1996). Teachers have also benefited from electronic communication, which enables them to form

new working relationships with educators throughout the world and to learn from one another.

Challenges and Risks

As noted above, despite all the evidence about the positive impact of the use of computers and the Internet on student learning, some studies show no significant effects or even negative effects. Certain limitations in these studies need to be taken into account when comparing findings on the effects of computer-based instruction. The first limitation is the wide variety of computer-based instructional arrangements contemplated in the studies, as well as the multiplicity of subject areas involved and the grade level of students.² The second is the wide variation in the duration of the implementation of the instruction. The third is the inherent technical difficulty of measuring the skills these studies attempt to assess, such as motivation, student attitudes, self-directed learning, and teamwork (Sinko and Lehtinen 1999).

Several reasons have been given for limited and even negative effects on student learning: (a) the transition to computer-based instruction is disruptive; (b) real change and lasting results take time to appear, and the evaluation does not always cover the necessary duration; (c) computer-based programs were not implemented appropriately or as intended (too short implementation periods, failure to integrate the programs into the curriculum, inadequate teacher knowledge about the program, and so on); and (d) computer-based instruction may have consumed school resources or displaced educational activities that would have been in place otherwise (Angrist and Lavy 2002; Honey 2001; Van Dusen and Worthen 1995).

An extreme example comes from a study of two high schools in California's Silicon Valley, where new technologies were made lavishly available to teachers and students and where there was indisputably great encouragement to use computers in classroom instruction. Yet according to the study, the use of computers and the Internet in classrooms yielded no clear and significant effects on student learning achievement (Cuban 2001). Moreover, there were some unexpected findings: fewer than 5 percent of high school students had intense "tech-heavy" experience in school, and only a tiny percentage of teachers used the new technologies to accelerate student-centered and project-based teaching practices.

Conclusion: Options for Change

The mere availability of computers and the Internet in the classroom provides no guarantee that the quality and relevance of education and student learning will improve. Changes in teaching and learning or in school organization and management are difficult to bring about because a school is a complex system—socially, culturally, and politically. In order for change to

take place, a comprehensive reform in the overall school context is needed (Cuban 2001). Some recommendations for policy makers and practitioners seeking to optimize the potential and the impact of the use of computers and the Internet in classrooms are summarized below (Cuban 2001; Earle 2002; Hepp et al. 2004; Honey 2001).

Program design and planning

- Understand teachers' expertise and perspectives on classroom work and engage teachers fully in deliberations about the design, deployment, and implementation of technology plans.
- Involve principals, parents, and the community in designing the program, using democratic processes, and provide them with access to ICT resources.
- Start small, with a pilot, and build on experience (step-by-step project development).
- Incorporate lessons learned from other programs.
- Focus on sustained and intensive teacher training and professional development as the central focus of the project.
- Include evaluations—preferably by an external body—in the original program design evaluations to increase program transparency; make certain that school leaders and teachers are informed about the impacts of the programs.

Organization

- ICT should be an integrated part of the existing education system, not a stand-alone project; it should be a vehicle for change and should be anchored in solid educational objectives. Accordingly, plan for fundamental changes in how secondary schools are organized, time is allocated, and teachers are prepared.
- Reduce the structural constraints that limit teacher choices in secondary schools and implement a more relaxed schedule with large chunks of uninterrupted time for joint planning, crossing of departmental boundaries, and sustained attention to different forms of learning.

Technical dimension

- Hardware manufacturers, software firms, and telecommunication companies need to develop software and equipment specifically designed for teachers and students.
- These suppliers must improve product reliability to limit the defects in their wares, increase technical support to teachers, and test software on consumers before marketing it to district and state administrators.

- The infrastructure for technical support and professional development needs to be redesigned and made responsive to the organizational incentives and workplace constraints that teachers face.

Whether the use of ICT is aimed at expanding access or at improving the quality and relevance of secondary education, the program needs to be cost-effective and financially sustainable. It is important that the forecasts of fixed and variable costs and the financing options be well thought out during the planning stage. Low- and middle-income countries face serious challenges with respect to the availability of supporting infrastructure, connectivity, and appropriate hardware and software. Countries may want to explore, in light of their particular educational needs and infrastructure availability, the new technologies available: solar energy, wireless solutions, digital satellite radio, and so on. The key decision should focus on the educational objective for which ICT is to be used, and this decision should lead to the right choice of technologies and modalities of use (Haddad and Draxler 2002).

Notes

1. By 2000 over 90 percent of students in 14 OECD countries surveyed—Belgium (Flanders), Denmark, Finland, France, Hungary, Ireland, Italy, the Republic of Korea, Mexico, Norway, Portugal, Spain, Sweden, and Switzerland—attended upper secondary schools where standard computer applications such as word processing, spreadsheets, and graphics programs were available. By 2001 the Internet was accessible in practically all schools in all these countries, with the exception of Mexico, a middle-income country.

2. Among the computer-based programs used in the studies were computer-assisted instruction (CAI), computer-enriched instruction (CEI), computer simulation in instruction (CSI), drill, computer tutorials, and microcomputer-based laboratories (MBLs).