The Knowledge Ladder: Using ICT and Education Reform to Advance Economic and Social Development Goals

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Challenges and Opportunities for Education Policymakers

Society expects a lot from its education system. Schools are expected to train the work force of the future, prepare a citizenry for active participation in the democratic process, preserve and enrich the cultural environment, develop the full potential of each student, provide opportunity for individual advancement, produce some level of social integration and equity across the population, and create a society that can address some of the most pressing problems of our time, such as persistent poverty, HIV/AIDS, food security, energy shortage, global warming, and environmental degradation. Around the world, education policymakers are faced with the challenge of devising programs and initiatives that respond to these multiple demands and always to do so within highly constrained budgets. But perhaps the most significant challenge for policymakers is to weave together education policies and programs that foster sustained economic growth which over an extended period of time produces the economic and human resources needed to address these multiple goals.

In the face of these challenges, the introduction of information and communications technologies (ICT) into schools has come to be seen as a unique opportunity. The potential is that ICT can provide access to remote colleagues and experts, provide simulations and media-rich learning environments, and provide data collection and management tools that support teacher training, improve student learning, and increase the efficiency of the education system. As the power and capability of computers has gone up, as they have interconnected in a world-wide web of information and resources, as they have become linked to other devices, and—most importantly—as their costs have come down, policymakers have come to see the integration of ICT into the education system as a viable, and even dramatic, way of responding to the multiple demands that are placed on them.

Of course, the introduction of ICT into schools generates its own challenges: How many computers do you buy? Do you really need one for every student? Will one for each classroom or a dozen for each school be sufficient? Do they all need to be networked? What bandwidth is necessary? What kind of training do teachers need to take advantage of these resources? How should they use them in the classroom? These

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and many other questions quickly push aside any notion that technology is a ready-made answer to the needs of policymakers.

This paper is designed to help policymakers think through the ICT opportunity. It positions the ICT within a broader context of global trends and challenges and it provides policymakers with a conceptual framework—the *knowledge ladder*—that they can use to analyze and plan systemic education change that advances economic and social development goals.

Looking at Global Trends

Over the past several decades, a converging set of global trends have created enormous challenges but also significant economic and social opportunities. Trade agreements, international financial structures, and the reduced costs of communication have increased the flow of capital, goods, services, knowledge—and jobs—between countries. Between 1995 and 2005, the U.S. lost 3 million manufacturing jobs while there are now well over 100 million workers employed in Chinese manufacturing firms.

The pervasiveness of information and communication technologies—from cell phones, to low-cost video cameras, personal digital assistants, and laptops wirelessly connected to the internet—has impacted the way people work, play, and live, even in developing countries. In Norway, 87% of the adult population uses computers at least weekly, 73% used them daily and 84% of them use the Internet for online buying or banking (Statistics Norway, n.d.). But even in rural Philippines farmers, fishermen, and small and medium enterprises can use cell phones and the internet to access market prices and trade products (Batchelor, et al., 2003).

New knowledge and the use of new technologies have resulted in the creation of new products, services, and jobs, some of which were unimaginable only a few decades ago. People all over the world use eBay, Google, and Yahoo every day. None of these companies existed 15 years ago yet they now have a combined market value of more than $200 billion.

Restructuring of the global economy. At the core of these global trends has been a fundamental restructuring of the global economy that has had a profound effect on all nations, although affecting each differently. The shifting of manufacturing and assembly facilities to emerging nations has resulted in tremendous dislocation in industrialized countries. The movement of these jobs to China, Thailand, Malaysia, and Indonesia has pulled hundreds of millions of people out of abject poverty, although recent and dramatic increases in the cost of grains and fuel threatens to push them back down. At the same time, development in these countries has created significant problems related to economic inequality, urbanization, pollution, and environmental degradation.

In developed economies, manufacturing facilities have closed and assembly jobs have been lost but whole new industries have been launched and new types of jobs have been created. Over the past four decades, the global economy has been shifting from a manufacturing economy to a service economy. In every one of the world's 25 largest economies, services either account for more than 50% of the GNP or they are the largest sector in the economy (Apte, Kamarkar, & Nath, in press). Within the service sector, the largest growth in the recent decade has come from *information* services, such as financial services, broadcast services, education, rather than *material* services, such as transportation, construction, and retailing. Indeed, between information services and

information products (such as computers, books, televisions, software), most developed countries now have what economists call an *information economy*.

The impact of ICT on business. In parallel with changes in the larger economy, industries and firms have also changed their organizational structures and business practices. Several studies of industries and firms (Gera & Gu, 2004; Pilat, 2004; Black & Lynch, 2003) have documented significant organizational and behavioral shifts, such as organizational flattening, decentralized decision making, the use of task teams, cross-organizational networking, just-in-time inventory, and flexible work arrangements. Often these changes in organizational structures and practices have been enabled by the application of ICT in business for communication, information sharing, design of new products, and simulation of business processes. While early studies of ICT use showed little productivity gain from the investment in technology (Pilat, 2004; Black & Lynch, 2003), more recent studies have found significant productivity gains when ICT investments are accompanied by new business practices and new organizational structures. In other words, it is only when ICT is accompanied by a cluster of inter-related and mutually-reinforcing changes in the system that significant impact occurs—the mere introduction of ICT to the usual business practices can actually result in decreased productivity as workers struggle fit the new technologies into otherwise finely-tuned practices.

The impact of ICT on society. ICT is impacting not just the economy but society more generally; access to ICT is spreading widely across the world and affecting how people live their lives. According to World Bank 2005 figures, of the world's 20 largest economies, in only one country (India) does less than 89% of the population has immediate access to television. In only 4 countries are there fewer than 50 cell phone subscribers per 100 people. In 11 of these 20 countries, there are more than 50 computers per 100 people, and in 9 of them more than 50 of 100 people are internet users. In the U.S., according to the Pew Internet and American Life Project, half of all Americans report having broadband access at home; 58% of the general public turns to the internet to find answers to common problems about health, taxes, job training, government services (Fallows, 2008); 66% of U.S. internet users have purchased at least one product online (Horrigan, 2008), 48% of them have been to a video sharing site (Rainie, 2008), and 64% of online teens, principally girls, have participated in at least one form of digital content creation (Lenhart, Madden, Macgill, & Smith, 2007). Most developed countries have now become a *knowledge society* where large numbers of people are engaged in the construction and sharing of ideas and creative works.

The penetration of computers into U.S. society is a sharp contrast with the condition in sub-Saharan Africa where, according to World Bank figures, only 14% of the households have televisions, there are only two computer users per 100 people, and the entire eastern half of the continent is not yet connected to the world's fiber optic grid. The situation is particularly bleak in rural areas where villages often do not have access to electricity, passable roads, and safe water, let alone telecommunications. But even in Africa, national leaders from Senegal to Kenya and Rwanda to South Africa see the prospect that ICT can support economic and social progress, from the development of call center hubs in major cities to improved health services to remote villages.

Challenges and opportunities for education policymakers. These converging trends put tremendous stress on education and other social systems responsible for preparing

society for the future and moderating the adverse impact of social and economic change. In response, education policymakers must adjust their school systems to meet new demands. Wise decisions can lay the foundations for economic prosperity and social advancement.

Climbing the Development Ladder

Economic growth and development. When people in developing countries lack enough food to eat, it may not be apparent how contributing to economic growth can help the poor. Growth is not sufficient for poverty reduction; there are many cases where growth was used to enrich the few. But poverty cannot end without it for it is economic growth that generates the resources that are needed to end poverty—not just health services, education, safe water, and electricity, but jobs and the income that improves living conditions. The Commission on Global Development (2008) points out that sustained growth is the surest way to reduce poverty. Without it, the sheer lack of material resources will dominate everything else.

The Commission identifies 13 countries that have taken advantage of global trends to create sustained growth—an average increase of 7% in GDP or more for 25 years or longer. This is the kind of economic development that can make it possible to achieve other important objectives, such as poverty reduction, enhanced social services, and improved standard of living. In each of these 13 cases government policy played an important role to support and sustain growth. While each of these countries crafted their own policies and strategies, there were important commonalities worth noting. Specifically, in each case, governments created mechanisms for accumulating local savings and foreign investment, opened markets, and provided structures for market development. Governments also made significant public investments in infrastructure, health, and education.

Indeed, the development of human capital was one of the principal means by which government policy was used to support economic development in these high growth countries. But if education policy is to contribute to overall economic and social goals, it must be conceived and implemented within the broader development context.

The development ladder. Jeffrey Sachs (2008), economist at Columbia University and Director of the United Nations Millennium Project, has developed a conceptual scheme—an *economic development ladder*—to describe the progressive stages of economic growth and to give policymakers a tool they can use to think broadly about economic policy. The ladder is developmental in that at each stage the use of physical, technological, and human resources generates additional resources that are reinvested to improve physical, technological, and human capital that, in turn, generate yet more resources, in a virtuous cycle of progress.

Sachs starts his development analysis with the *subsistence economy* characterized by countries with low agricultural productivity, poor coverage of public services and infrastructure, and small amounts of exports, all concentrated in a narrow range of commodities (produce, cotton, etc.). In such an economy, living standards are near subsistence or below and most small-holder farm production goes for immediate use rather than to the market. There is little exchange of money and little margin for saving or taxes. Consequently, there is little capital available for private investment or for public financing of the infrastructure needed to foster economic development—what Sachs calls

the "poverty trap". Tragically, this is the condition of many Sub-Saharan African countries. The challenge for policymakers in such countries is to acquire the resources from other sources, perhaps oil earnings, foreign aid, or tourism, to create the conditions under which broad-based economic development can take hold. Basic infrastructure is laid—roads, power grid, ports, primary schools and health system—that sets the stage for further development.

From a subsistence to a commercial economy. Beyond the subsistence stage is the next stage of development that Sachs calls the *commercial economy*. In this stage, both rural and urban households are part of the monetary economy and both save and invest as they can. Such investments support the development of an economy that goes beyond a few primary commodities. Basic manufacturing capacity is established that draws on low-skill, low-wage labor that takes simple, local inputs such as raw fiber and produces low-value products, such a woven fabric or assembled clothing. More people enter the workforce, save, and pay taxes. Capital accumulation is still the challenge in the phase, attracting the large amounts of foreign direct investment that is needed to build a modern manufacturing base that will move up the value chain and provide for a higher standard of living.

From a commercial to emerging economy. The use of the above strategy many years ago brought Singapore and other Southeast Asian countries into the next development stage that Sachs calls *emerging market economy*. This stage is characterized by the nearly complete coverage of basic infrastructure (roads, power, telecoms, and ports), basic education, basic health services, safe drinking water, and sanitation. The economy becomes an exporter of both manufactured goods and, perhaps, some construction and information-based services. Capital accumulation continues to play a role in growth but increasingly, productivity becomes the source of sustained growth. This is where the knowledge ladder comes into play. As foreign investment grows it brings not only capital but also know-how, technology, and linkages to global production and distribution systems. The products produced and services provided become more sophisticated and move up the value chain.

According to Sachs, as the economy progresses through the emerging stage, it is no longer simply importing technologies from abroad but is also improving them and beginning to export technology-based manufactures and services of its own. Products, services, technologies, and knowledge brought with foreign investment begin to work their way into the broader economic base of the country to spawn a more-indigenous economic growth.

From an emerging to an information economy. The final step in Sachs' development ladder is the transition to full-fledged science-based innovative activities, what he calls a *technology-based economy* and what in this paper is referred to as an information economy and knowledge society. This stage is characterized by widespread tertiary education, extensive public financing of scientific studies, extensive private-sector-led research and development, and a sophisticated information-based society. The

economy continues to import technologies from abroad, but now foreign exchange is also earned by exporting knowledge and technological advances.

Countries may not fall neatly into one of these developmental steps or the other. In fact, different regions or groups within countries may be at different stages in this developmental continuum. India is a particularly significant example of this situation where the economy has successfully generated high-end, knowledge-intensive jobs but it has failed to create a broad-based, labor-intensive industrial economy (Das, 2006). Nonetheless, the development ladder provides policymakers with a conceptual tool that they can use to think about economic development and related policies.

Education and Development: The Knowledge Ladder

But what relevance does the development ladder have for education policy makers? How can education leaders connect their policies and programs to the development of sustained economic growth and widespread prosperity? An important feature of Sachs' model is that as economies develop, their growth moves from a dependence on the accumulation of physical capital to one that increasingly depends on the development of human capital—development of the skills, knowledge, creativity, and innovation of its people. This has important implications for educational policy.

Economists point out that there are two sources of economic growth. Economic output can occur with an increase in input factors: more equipment is purchased and more workers enter the labor force—what economists call *capital accumulation*. This is what is now happening in China and other Asian countries and it has been an important mechanism by which hundreds of millions of people have moved out of poverty. Capital accumulation is the key to initial economic development. However, growth based on capital accumulation is subject to diminishing returns; additional increases in input result in smaller and smaller increases in output.

Beyond capital accumulation, growth can occur with an increase in the economic output per person, that is, an increase in *productivity*. Increased productivity is the key to raising the standard of living and to sustained growth. Economic theory describes three factors that can lead to increased productivity: One is *capital deepening*, the use of equipment and technology that is more productive than earlier versions. A second is *higher quality labor*, a more knowledgeable workforce that is more productive, that can solve problems, and can add value to products and services. A third is the creation, distribution, and use of *new knowledge*, knowledge that is the source of new products and services, of cultural enrichment, and of yet more new ideas.

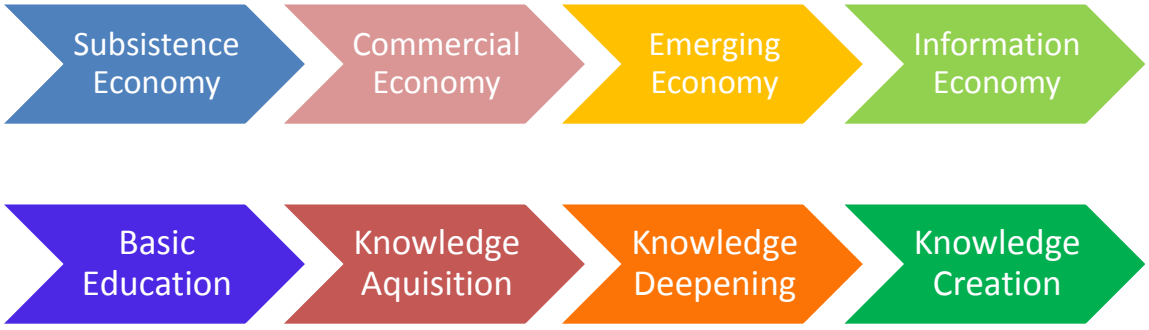
The four factors that drive economic growth—*capital accumulation, capital deepening, high quality labor, and knowledge creation*—can serve as the basis for four complementary, somewhat overlapping approaches to education policy and reform that can clarify the ways that education programs can contribute to economic and social development. Educational change can contribute to development goals by:

- Providing the skills needed for improved health and welfare and to participate in the formal economy: the ***basic education approach***.
- Increasing the knowledge level of the workforce and citizenry and their ability to use technology: the ***knowledge acquisition approach***.

- Increasing the ability of the workforce and citizenry to use knowledge to add value to economic output and apply it to solve complex, real-world problems: the ***knowledge deepening approach***.
- Increasing the capability of the workforce and citizenry to innovate and produce new knowledge and by increasing the capability of citizens to benefit from this new knowledge: the ***knowledge creation approach***.

Each approach has different implications for each component of the education system: educational policy, teacher professional development, classroom pedagogy, curriculum, assessment, school organization and administration, and ICT use. These implications are summarized in the attached Table. These approaches provide policymakers with a conceptual framework—a *knowledge ladder*— by which they can plan a trajectory of coordinated, progressively higher forms of educational change to support economic and social development, over time. The strength of the scheme is that it not only connects change to sustainable economic growth but it also addresses the other goals of the education endeavor: the preparation of students for active participation in civic discourse, the need to apply school knowledge to solve complex problems of our time, the enrichment of the cultural environment with new ideas and artifacts, and the development of students to their full potential, through lifelong learning. Here is a summary of each approach:

Basic education. The economic policy goal of this approach is to increase the number of people that enter the formal economy by providing them with basic literacy and numeracy skills. The social development goal is to provide life skills, increase civic participation, and improve health and welfare. Universal primary education is an important focus with this approach, including increased participation of girls in education. These are important components of both the United Nations' Millennium Development Goals and the Education for All program. A particular challenge is preparing a teacher corps that is at least minimally competent in subject knowledge and teaching skill. Student-teacher ratios are very high, so lecture is the dominant pedagogy. The curriculum focuses on basic skills in literacy and numeracy, as do assessments. With an emphasis on mass education, the system is often very hierarchical: teachers have little autonomy and are closely supervised by curriculum inspectors using highly specified curriculum schedules. School facilities are minimal. If available, computers may be used for administrative purposes or to provide local access to digital materials. Access to the internet is likely to be used for management and administrative support but could be used for access to remote resources and experts that could support teacher professional development. Information obtained via the internet could be locally disseminated using other, more accessible technologies such as print and radio.



Knowledge acquisition. This approach begins to use education as a way to move the economy toward growth based on increased productivity. The policy goal is to improve economic productivity by preparing a workforce that is more knowledgeable, skilled and capable of taking up new technologies. The social goal is to provide opportunities for advancement and foster social integration and equity. Related educational policy goals include increasing secondary school enrollments, improving education quality, and increasing math and science skills, including technology literacy. In many ways, this approach merely overlays technology onto the traditional educational system; changes are minimal otherwise. Changes in the curriculum may include adding ICT as a subject in the curriculum or including time in the curricula of other subjects for the incorporation of ICT. The curriculum otherwise continues to be divided by traditional subject areas and assessment consists of factual recall or the solution of simple, one-step problems. Changes in pedagogical practice involve the use of various technologies, tools, and e-content as part of whole class, group, and individual student activities but the use is supplemental. ICT may also allow access to remote learners or resources. Changes in teacher practice involve the use of technology for classroom activities and presentations, for management tasks, and to acquire additional subject matter for their own professional development. Pedagogy otherwise consists of the teacher delivering information that is received by student. Little change in social structure is required of this approach other than, perhaps, the spatial placement and integration of technology resources in the school. Often computers are put in separate laboratories, since ICT is offered as a class and technology is not integrated into the curriculum.

Knowledge deepening. The other two approaches to education reform have the potential for a more profound effect on economic growth and an increased standard of living. They also have more significant implications for changes in the education system. The policy goal of the *knowledge deepening approach* is to increase the ability of the workforce to add value to economic output and of a citizenry to improve society by applying the knowledge of school subjects to solve complex problems encountered in real world situations of work and life. Rather than the superficial "coverage" of a large number of topics in the traditional education, the curriculum in this approach focuses on the deep understanding of a smaller number of key concepts, principles, and procedures and on how these ideas are organized and interconnected within and across subject areas to form complex knowledge systems. Collaborative classroom activities, projects, and investigations that engage students in the solution of extended, open-ended, real world problems are an important component of this approach. Technology can play an

important role, as students use visualizations and simulations to explore, understand, and apply complex knowledge, so ICT becomes integrated into the curriculum and into daily classroom practice. Networking can help teachers and students connect classroom activities and learning to the outside world. Extended assessments, consisting of several parts, parallel the complex tasks students will encounter in the real world. And because this type of learning is more complex, teachers need to possess both a deep understanding of their subject area as well as the cognitive and social processes students employ and the problems they face when they engage in this type of learning. Flexibility in school schedules and curriculum implementation can support these classroom efforts.

Knowledge creation. The policy goal of the fourth approach—*knowledge creation*—is to develop a workforce and citizenry that are continually engaged in and benefit from knowledge creation, innovation, and learning. The implications of this approach for educational change are profound and transformational. If students are to participate in an economy and society in which the creation, sharing, and use of new knowledge and cultural contributions are the basis for sustained development, their educational preparation must go beyond the learning of established knowledge. Knowledge creation does not conflict with knowledge deepening; rather, it builds on a base of deep understanding of school subjects. Beyond the deep understanding of key concepts and principles and their use to solve complex problems, students engage in the sustained, collaborative process of building on current knowledge and cultural artifacts to create and share new contributions. The value of that contribution is judged by the community of users. Knowledge creation skills include the ability to use a range of technology tools; to search for, organize, and analyze information; to communicate effectively in a variety of forms; to collaborate with others of diverse skills and backgrounds; and to think critically, innovatively, and creatively. But paramount among the knowledge creation skills are those that allow students to continue their learning throughout their lifetimes. With knowledge creation approach, teachers design a learning community in which students are continuously engaged in building their own and each others' knowledge and learning skills. Indeed, schools are transformed into learning organizations in which all actors are involved in the learning process. Teachers and students use a variety of electronic devices, digital resources, and social and knowledge network environments to design ICT-based learning resources and tools that support the development of knowledge creation and critical thinking skills; support continuous, reflective learning processes; and support interaction with knowledge communities that extend beyond the confines of time and place. From this perspective, teachers are themselves master learners who are constantly engaged in educational experimentation and innovation in collaboration with an extended network of colleagues and experts to produce new knowledge about learning and teaching practice and to model the learning process for their students.

Moving Toward Knowledge Creation

The specific approach a country might take at a given time will depend, in part, on where their education system currently falls within the continuum. The Knowledge Ladder is developmental in that each stage draws on the human, physical, and technological resources to support social and economic development which, in turn, generates the resources that are reinvested to improve education that, in turn, contributes

to further economic growth, creating an ongoing virtuous cycle. An intriguing prospect is that education systems can "leap frog" from a basic stage to a much more advanced one without going through the intermediate stages. However, the ability to make significant leaps is often constrained by current capacity. For example, it may be difficult to incorporate pedagogies that emphasize deep understanding of school subjects if teachers themselves have only a rudimentary education. Incorporating knowledge building skills into the curriculum may be constrained by assessments that measure only the basics of literacy and numeracy. Providing computers to all classrooms in the system may not be possible if the economy has not yet produced the skilled technology workers that would install and maintain the system. And preparing students for a knowledge economy may not make sense if, for example, the economy is not yet creating knowledge-worker jobs and businesses and homes do not yet have access to the internet that would allow them to take advantage of knowledge products and services. Realistically, governments and education systems are faced with the need to make the long term commitment and the arduous path that incrementally moves the system forward, building teacher expertise, advancing the curriculum, refining the assessments, and developing technological capacity, as economic development can support it.

Nonetheless, a ministry of education is likely to find that different components within their education system are more or less advanced. This is an important source of education change. The key to moving toward the system forward is to leverage current strengths in one or more areas to advance other components of the system. This is illustrated in the diagram below.

For example, a country may have made the commitment to move toward knowledge creation and policymakers may have articulated a vision of an educational system in which students, teachers, and citizens generally would be engaged in continuous, lifelong learning and in the creation and sharing of new ideas. Yet key components of the system may fall far short of this vision. For instance, the curriculum and textbooks may emphasize the memorization of isolated facts and the application of principles disconnected from the real world. High-stakes student examinations may also emphasize memorization. Schools may be organized as hierarchical structures, providing little participation in governance for either teachers or parents. These are serious impediments to moving the system toward knowledge deepening and knowledge creation. Yet at the same time, the system may have certain strengths, relative to knowledge creation goals. Teachers may have a high degree of professionalism and training and may be engaged in pedagogical practices that go beyond memorization to promote understanding. ICT may be readily available in classrooms and may be used by teachers and students as part of collaborative projects.

The key to progress is leveraging strengths to make improvements. The Ministry of this country could leverage a strong vision of educational change to work with teachers to advance their own professional development and to use initial advances in pedagogy to move from knowledge deepening practices in the classroom to knowledge creation. At the same time, efforts will need to be mounted to change curriculum and assessment and to restructure schools in support of knowledge deepening and knowledge creation practices. The curriculum would have to move from one that focuses on the memorization of isolated facts and disconnected principles to understanding the deep interrelationships between concepts, facts, and principles and their application in

everyday life, the type of knowledge that can contribute to improved productivity and increased growth.

In time, the education system can build on gains won with the knowledge deepening approach to make further changes in their curriculum, teaching practices, assessments, and use of technology. Students could build on their deep knowledge of school subjects and their own learning goals to develop skills in collaboration, inquiry, information management, and critical thinking and creatively apply these skills to generate new knowledge and support their continued learning. These skills could be fostered by collaborative investigations and research projects in which students designed and developed intellectual and creative works that can be shared with others inside and outside of school. Teachers could model and otherwise support this process through guidance, mentoring, and coaching. Students could be centrally involved in assessing the quality of their own and each others' learning, as they are guided by teachers to develop and increasingly refine their understanding of what constitutes a high quality contribution of new knowledge. This would prepare students to be knowledge producers and lifelong learners. Increased availability of ICT in schools, homes, businesses, and social venues would allow students to use a variety of tools and digital resources to support their inquiries and create knowledge products that draw on and add to the knowledge and works of others inside and outside the school. As part of this approach, teachers could leverage their deep pedagogical and subject matter knowledge to engage in continuous experimentation and innovation within their classrooms so as to generate best practices and exchange them with colleagues. As such, teachers would lead the way in working with administrators, students, and community members to ultimately transform schools into learning communities that serve as model organizations for the rest of the information society.

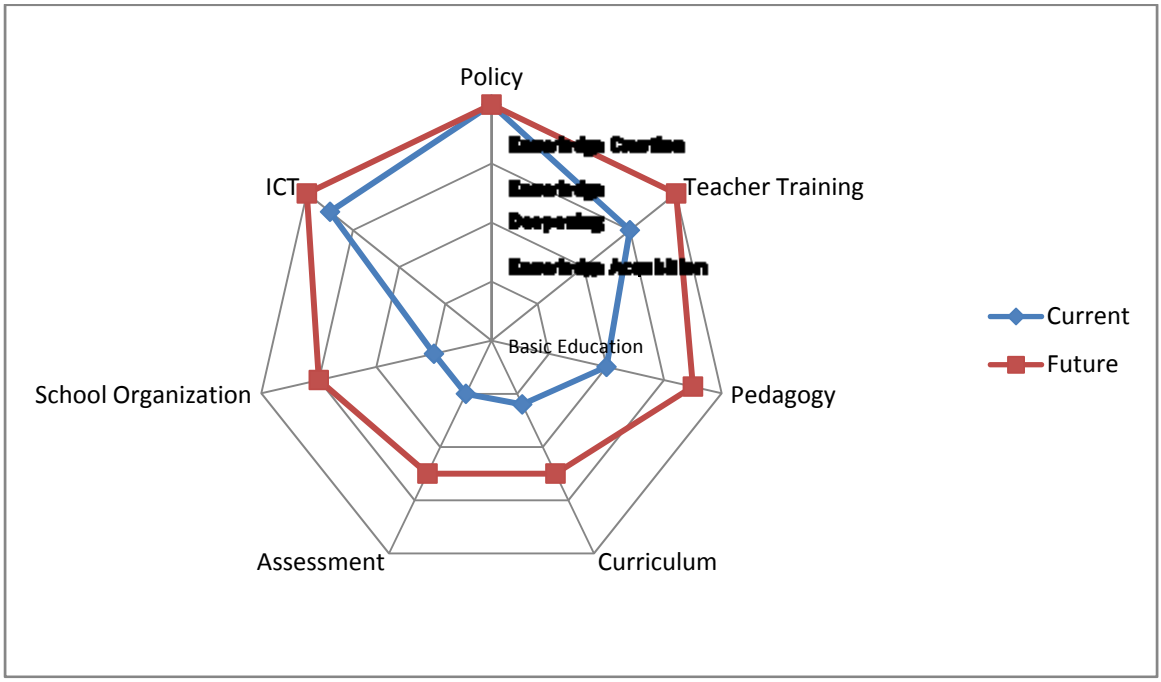


Diagram of Education Reform Components

Policy Implications

As in the business world, the mere introduction of ICT into schools will not have an impact on development. Impact will come only if technology is introduced along with a coordinated set of other changes in educational practices and organizational structures. The *knowledge ladder* gives policymakers a way of thinking about the introduction of ICT in a coordinated way that is sensitive to the current development context and can advance economic and social development goals. Here are four guidelines that help policymakers do that.

Create a vision and align education policies with national goals. To maximize the impact of education investments, education policies must be aligned with national social and economic development goals. These national goals should be based on the current development context but lay out a vision and trajectory by which the country builds on its current resources and competitive advantages to accumulate additional resources that can support improved social welfare and economic growth. The *development ladder* provides a framework for crafting these development goals. Education policy can be an important—indeed, central—part of the vision and trajectory. In some countries, this is facilitated by a cross-ministerial decision-making and coordinating committee that may consist of the ministers of economic development, finance, ICT, education, and others. It may be chaired by the prime minister. In other countries, it may be facilitated by a multi-stake holder commission composted of cabinet officials and representatives from business, academia, non-governmental organizations, foundations, and civil society. In either case, education policymakers should participate in these deliberations and align subsequent policies with the results. The *knowledge ladder* provides education leaders with a means for connecting education policy to economic and social policy.

Align education programs with education policies. Once an education policy position is determined, that is aligned with development goals, programs and initiatives can be planned that implement change. The *knowledge ladder* allows policymakers to think about the implications of a particular policy position for each of the components of the educational system: professional development, pedagogy, curriculum, assessment, social organization, and ICT use. Specific initiatives can be crafted that connect change in each component with that in the others and contribute to overall economic and social development goals. This process can be facilitated by a cross-unit committee, perhaps headed by the minister of education or permanent secretary, composed of the departments of curriculum, assessment, teacher training, higher education, and technology. This committee can use the *knowledge ladder* to design specific programs and initiatives in their departments that work together to advance the broader economic and social goals of the country.

The *knowledge ladder* is particularly good at helping ICT leaders make specific technology decisions in a way that advances development goals. Questions about the number of computers, where they are located in schools, the networking architecture, how teachers are trained are considered in terms of how they fit into a particular model—*Basic Education, Knowledge Acquisition,* etc—rather than, or in addition to, technical or budgetary considerations. An ICT master plan can spell out these programs, align them with policy goals, and connect them to a vision of social and economic development.

Use ICT as a lever for change. Change is not easy in education. Over decades, an education system becomes a tightly connected set of policies and programs finely tuned to the current situation. Teachers are trained to teach certain things in a certain way that are specified by the national curriculum. The national assessment measures student achievement, as specified by the curriculum. Schools are organized in a way that makes the system work efficiently. Attempted change in one component is often inhibited by the mutually reinforcing nature of these connections between components of the system. Teachers may explore interesting things new pedagogical approaches with computers only to realize that these are not included in the national curriculum or measured on the national assessments, so the explorations are abandoned and the computers may be put in the closet.

Yet development requires change. If education is to contribute to development, education change is crucial. ICT leaders can use the *knowledge ladder* to make decisions about the number and location of computers, the type of network, the training of teachers, and the purchase of software. But the *ladder* can also be used to position ICT as a lever for changing other components of the education and, ultimately, overall change in the system and do it in a way that supports broader development goals. As technology is introduced or expanded, ICT decision makers can work with others in the system to use the opportunity to coordinate changes in pedagogy, for example, through teacher professional development that not only includes training on the new technology but shows how it can be used in the classroom to promote new teaching methods that advance development goals.

Private-public partnerships. The changes discussed here often require a significant shift in priorities and resources. This shift is particularly challenging for less developed countries. But no government, however advanced, can bring about all of these changes on its own. The effort requires a multi-sector approach to educational improvement that involves government, business, and civil society. All sectors benefit from education change that promotes development and all sectors must participate in that change. Again, ICT can play a central role in building partnerships. By connecting education change to development goals, education policymakers can use the ICT opportunity to recruit partners who bring technological resources, expertise, and help that can support education change and, in turn, advance development goals.

Summary. By creating a vision and a master plan for ICT-based education reform and by coordinating this with other policies and programs, the government can lay the foundation for growth-based economic and social development. By leveraging initial strengths in their education system to develop other educational components and by partnering with the private sector, the government can move toward an educational system that is based on knowledge creation and that prepares their students to join the knowledge economy and information society of the 21st century.

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Table

The Knowledge Ladder: Education Reform, ICT, and Economic and Social Development				
	Basic Education	**Knowledge Acquisition**	**Knowledge Deepening**	**Knowledge Creation**
Policies	Policy goals are to increase primary school participation, to increase the number of people that enter the formal economy, and provide the basic skills that would improve health and welfare.	Policy goal is to increase primary graduation and secondary enrollment. Provide students with better quality of education that can improve quality of life. Prepare students to contribute to economic productivity by taking up new technologies. Education policies focus on hiring more qualified teachers, ICT skills, and scores on standardized tests, primarily in reading and math.	Policy goal is to upgrade the productivity of the workforce and prepare students to add value to economic output and improve the quality of their lives. Education policies focus on increased secondary school graduation and improved understanding of school subjects and problem solving skills of students and connecting school learning to real world problems and contexts.	Policy goal is to increase innovation and knowledge creation to drive the knowledge economy. The system prepares students to be creative, innovative, lifelong learners. Increase rates of tertiary enrollment. Education policies are focused on research, development, and the generation and sharing of new knowledge, and continuous learning.
Professional Development	Supply the education system with a corps of teachers with at least minimum subject matter knowledge and teaching skill.	Teachers are expected to have an adequate knowledge of their field. Teacher training emphasizes the comprehensiveness and accuracy of teacher subject knowledge. Teachers may be tested on this as part of certification. People with subject knowledge or experience may enter the teacher workforce without significant pedagogical training.	Teachers are expected to have a deep understanding of both their field and principles of pedagogy. Professional development emphasizes both the deepening of teachers' subject knowledge as well as their understanding of student learning processes. This is done through a combination of continuing formal and informal experiences.	Teachers are model learners. As experienced professionals, they are primarily responsible for their own and each others' development, as colleagues and mentors. They collaborate with each other and with outside experts to build a professional community. They are engaged in creating and sharing their own body of professional knowledge and best practices.
Pedagogy	Because enrollments are increasing dramatically, class sizes have a large student-to-teacher ratios and teaching often relies on lecture to efficiently deliver content.	Teaching is focused on information delivery. Pedagogy is teacher-focused, based on their content knowledge. Lectures are common but information may be presented in a variety of forms. Alternatively, instruction can be individualized and self-paced.	Teaching is conducted in the context of complex, open-ended questions and problems and it is anchored in real world contexts. Classroom activities engage teams of students in the application of key concepts and principles to analyze systems and solve problems across subjects. Internships and apprenticeships can be an important way to connect school learning to the real world.	Teaching consists of challenging students and guiding them to build on their knowledge and explore new topics. Collaborative projects and investigations involve searching for information, collecting and analyzing data, generating knowledge products, and communicating with outside experts and audiences to share results.
Curriculum	Curriculum centers on basic literacy and numeracy skills needed to enter the workforce and provides basic life	The curriculum enumerates a large number of facts and concepts within school subjects and emphasizes their	The curriculum identifies key, interrelated concepts and principles that organize the subject area. It	The curriculum is flexible and responsive to student goals and local contexts. It emphasizes the

	skills.	acquisition. ICT is included as a subject in the curriculum.	emphasizes deep understanding of these within and across subjects and their application to solve complex real world problems. Curriculum implementation is responsive to local contexts.	development of collaboration, inquiry, information management, creativity, and critical thinking skills. Learning how to learn is essential.
Assessment	Tests measure basic literacy and numeracy skills.	Assessments are composed of a large number of brief tasks that require the recall of facts and the application of principles to solve simple, one-part problems. Accuracy is emphasized. Students are tested frequently and receive regular feedback on progress.	Assessments are composed of a few extended, open-ended, multi-part problem-based projects that embed key concepts and principles and correspond to real world situations. These tasks are integrated into the learning experience as well as used for summary assessment.	Assessment tasks consist of investigations, reports, presentations, creative works, performances, and other knowledge products. These products are evaluated through self, peer, and public review, as well as expert review. Assessments also emphasize student goal setting and self monitoring.
School Organization	Schools are hierarchically structured around the standardized delivery of content. Curriculum inspectors assure the curriculum is covered as prescribed.	Schools are hierarchically structured with a high level of accountability and little autonomy or flexibility. School and teacher performance is measured and rewarded by student test score gains.	Teachers have flexibility over implementing the curriculum and making it responsive to student interests, community needs, and contemporary issues. Structural flexibility allows teachers to adjust student groups or the class schedule to allow more time for projects, planning, and collaboration.	Schools are learning organizations and teachers are engaged in continuous innovation. Administrators, community members, teachers, and students create a shared vision and goals for their learning community. Within this vision, teachers have autonomy in implementing goals and accountability for results.
ICT Use	Strategic use of minimum technology: radio and TV can supplement limited number of teachers. Some stand alone computing for administrative purposes. Potential of minimum networked technology to provide access to remote resources for administration and teacher professional development.	Technology is used primarily for delivery of instruction and management. The ratio of students to computer may be low, if used by teachers for delivery, or high, if used by students for individualized instruction. Networking is used to support management and accountability.	Networks are used to support collaborative projects and connect students and teachers to outside contexts. Simulations and multimedia are used to support deep understanding of interrelated concepts, address misconceptions, explore systems, and solve real world problems.	Pervasive technology , social networks, wikis, blogs, etc, are used to support knowledge production, collaboration, and knowledge sharing by students and teachers. Networks are used to help teachers and students build knowledge communities.