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ICT, Education Reform, and Economic Growth: A Conceptual Framework

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Executive Summary

The 21st century presents tremendous challenges and significant opportunities to national policy makers as they formulate economic and social policies and programs. Increasingly, educational policy makers are being asked to formulate educational policies and programs—particularly those related to information, communication, and technology (ICT)—in ways that advance the nation's economic and social development goals. This first paper of a two-part set describes the factors that influence sustained economic growth and social development, illustrating these with national case studies. It presents a conceptual framework by which policy makers can analyze ICT-based education reform and craft educational policies that support national economic and social development goals. Finally, it provides recommendations that can help policy makers move toward an education system that is based on *knowledge creation* and that prepares their students to join the knowledge economy and information society. The second paper in the set uses this conceptual framework to show how programs of the Intel® Education Initiative can help educational policy makers and thought leaders prepare their teachers and students for the challenges and opportunities of the 21st century and contribute to national economic and social goals..

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Introduction

Over the past several decades, a converging set of global trends have created significant economic and social opportunities but also enormous challenges. 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 changed the way people live, work, and play. 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. At the same time, trade agreements and the reduced costs of communication and transportation have increased the flow of capital, goods, services, knowledge—and jobs—between countries. The result has not only been significant worldwide economic growth but also considerable social turmoil and dislocation.

These converging trends have put tremendous stress on educational and other social systems responsible for preparing society for the future and moderating the adverse impact of social and economic change. In the face of these trends, countries are confronted with the need to rethink their educational systems to prepare students for the global economy, maintain economic progress, and assure that their citizens will benefit equitably from these developments. To participate in this global economy and to improve their standard of living, students will need to leave school with a deeper understanding of school subjects, particularly science, mathematics, and technology. They will need skills necessary to respond to an unbounded but uncertain 21st century—skills to apply their knowledge to real-world situations, to think critically, to collaborate, to communicate, to solve problems, to create, and continue to learn.

This paper explores the relationships between technological innovation, education reform, and economic and social development. The intent is to help national policy makers and educational thought leaders address these global challenges and connect technology and education reform to sustained, equitable economic growth. Specifically, the goals of the paper are to:

- Describe factors that influence economic and social development—particularly those related to human capital development and technological innovation—and the implications these factors have for building 21st century skills and 21st century schools
- Present a conceptual framework of educational reform approaches that describes changes in curriculum and content, teaching and learning practices, technology applications, and social infrastructure that support national economic and social development goals
- Help policy makers and educational thought leaders identify, think about, and plan for changes in education policies and programs that address global and national economic and social trends and needs

Economic Growth and the Knowledge Economy

Creating the conditions that foster economic growth is a significant challenge for policy makers. But even more important is how to create sustained growth over an extended period of time and assure that its benefits are distributed equitably. Even a small change in growth can make a huge difference in an economy. A 3 percent annual growth rate doubles the size of an economy in 23 years, compared to 35 years needed to double an economy with a 2 percent growth rate. With a 5 percent growth rate, it takes only 14 years.

Growth in 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*.[1] This is the approach that China is currently taking to feed its growth. However, growth based on capital accumulation is subject to diminishing returns; additional increases in input result in smaller and smaller increases in output. Alternatively, 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: *capital deepening* (that is, the use of equipment that is more productive than earlier versions), *higher-quality labor* (a more knowledgeable workforce that is more productive), and *technological innovation* (the creation, distribution, and use of *new knowledge*).

The case of Singapore illustrates how growth can occur. Between 1970 and 1989, Singapore's per capita GDP grew at an impressive annual rate of 6.7 percent.[2] The groundwork for this was set in the 1960s, when the government of Singapore decided to use the competitive advantage of its then low-wage labor and its strategically-located deep-water port to develop its economy around the import of manufactured parts that would be assembled locally and re-exported as finished products—primarily computer components and consumer electronics. To accomplish this, the government invested savings from the nation's retirement program to build crucial infrastructure. The infrastructure—port facilities, roads, airports, telecommunications, and industrial parks—attracted additional private investment from transnational corporations that, in turn, built assembly facilities. However, by the early 1990s economists noted that much of Singapore's economic growth was due only to the accumulation of capital and labor rather than increased productivity, and they predicted that the country's growth would not be sustained.[3] In response to this, the government leveraged its initial economic gains to deepen its capital, primarily through attracting investments in new technology. It also improved the quality of its educational system, increasing students' understanding of science and mathematics, so as to support a more productive, technology-based economy.

Beyond capital deepening and higher-quality labor there is the third productivity factor—technological innovation. Technological innovation is different from the introduction of technology equipment (i.e., new capital); it is the application of this technology to develop new products and services and to create new knowledge. Knowledge has some special qualities that are important to economists. Unlike raw material, it can be used multiple times without depreciated value, and unlike equipment, it can be used by many people at the same time—that is, it is *non-rivalrous*. Knowledge can also be shared widely at little cost. These facts open the possibility of a productivity factor with

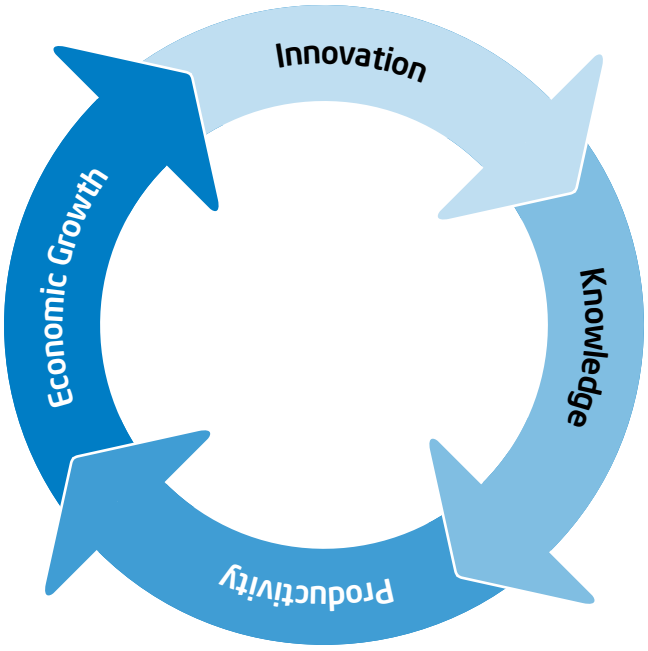
1. J. Stiglitz and C. Walsh, *Principals of Macroeconomics*, 3rd ed. (New York: Norton, 2002).
2. A. Heston, R. Summer, and B. Aten, . *Penn World Tables* (Philadelphia: Center for International Comparisons, University of Pennsylvania, 2002).
3. A. Young, . "Tyranny of Numbers: Confronting the Statistic Realities of the East Asian Growth Experience," *Quarterly Journal of Economics* 110 (1995): 641–80.

compounding rather than diminishing returns. That is, additional investments in knowledge creation can lead to continuous growth.

But technological innovation depends on both new technologies and a high-quality workforce. It is a specially prepared labor force that can take new technologies and ideas and turn them around to create yet more innovation. The synergy between new capital, new skills, and new knowledge creates sustained growth and an improved standard of living. Through this synergy, new knowledge is not only the input but an output of the economy. The creation and sharing of new knowledge feed into the economy to generate a knowledge-driven, virtuous cycle of sustainable growth. This is the basis for what economists call the *knowledge economy*.

Finland is an excellent example of how these factors operate together to support sustained, equitable growth. In the early 1990s there was a significant recession throughout the Finnish economy, with an average annual GDP growth rate of -3.68 percent from 1990 to 1993.[4] This set off a series of government policy decisions that helped create a fundamental structural transformation of the country's economy from that of a raw materials-based manufacturing economy to one that concentrated on high-tech products, particularly in the area of telecommunications. This resulted in a dramatic turnaround with a per capita annual GDP growth rate of 4.39 percent from 1994 to 2000[5] and, along with Singapore, Finland became one of the most competitive economies in the world. During this period, unemployment was cut in half, the balance of trade moved from a large deficit to a significant surplus, and the value of Helsinki's stock market rose well over 200 percent. Most notably, this economic growth was accomplished without creating great disparities in income, and it generated revenue to sustain a variety of social programs and services such as universal healthcare and free education through the university level.[6]

Figure 1.



4. Heston, Summer, and Aten, *Penn World Tables*.
5. Heston, Summer, and Aten, *Penn World Tables*.
6. M. Castells and P. Himanen, *The Information Society and the Welfare State: The Finnish Model* (Oxford: Oxford University Press, 2002).

What were the policy decisions that supported this dramatic turnaround? Early in the 1990s, the government of Finland created a vision for a Finnish Information Society. In implementing this vision, it made investments in technological infrastructure, education, and research and development, emphasizing the creation and sharing of new knowledge. Public research and development investments grew rapidly during this period. Funded by government revenue from the privatization of uncompetitive state-owned enterprises, these investments were structured to encourage cross-sector, private-public partnerships in research and innovation. Private research and development investments grew at an even faster pace, and Finland became a world leader in the support of research and development. The government encouraged entrepreneurial activity and the development of small and medium enterprises (SMEs) by supporting incubators for start-ups and by promoting capital investments and knowledge sharing between SMEs and large businesses. Knowledge sharing within and between organizations and companies, in turn, encouraged innovation and competition in product development and production. The result was broad-based growth with one of the world's lowest differentials between high- and low-income wage earners.

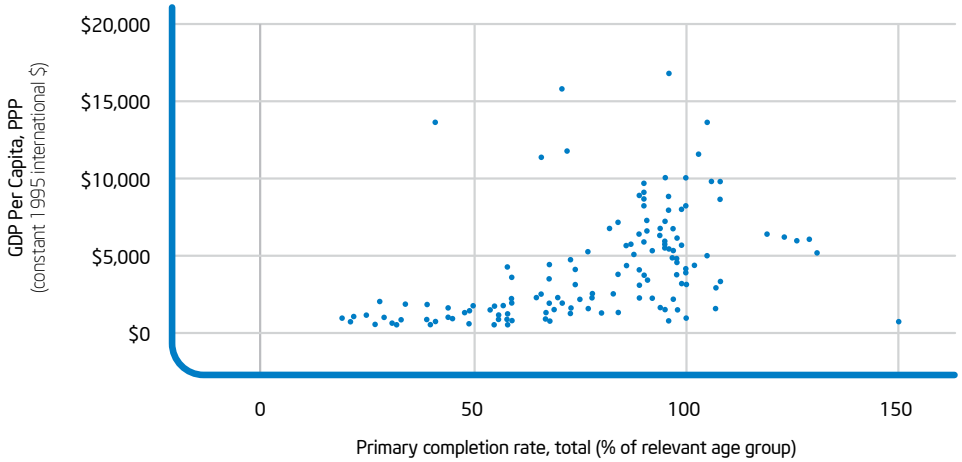
Singapore, on the other hand, has had one of the world's highest income differentials among industrialized countries. Economists noted that Singapore's early economic strategy created silos of capital deepening, narrowly concentrated within transnational corporations, and its growth was not broad-based. Ultimately, Singapore also picked up on the *knowledge creation* productivity factor. In the late 1990s the country's economic development plan shifted toward a knowledge-based economy and broader-based economic participation.

Education and Its Contribution to Economic Growth

Education has a high return on investment; this is supported by the results of both international microeconomic and macroeconomic studies. Microeconomic studies focus on the benefit of educational investments to individuals, while macroeconomic studies focus on returns to the economy more generally.

Analysis of microeconomic data from 42 countries found that an average rate of return for an additional year of schooling was a 9.7 percent increase in personal income.[7] A cross-country macroeconomic study found that there was an additional .44 percent growth in a country's per capita GDP for each additional average year of attained schooling—a return on

Figure 2. **Education vs. Per Capita GDP**
Primary School Completion Generates High Economic Output



7. G. Psacharopoulos and H. Patrinos, "Returns to Investment in Education: A Further Update" (working paper 2881, World Bank Policy Research, Washington, DC, 2002).

investment of 7 percent.[8] Figure 2 displays the relationship between primary education completion and per capita GDP, using 2004 World Bank Indicator data. Other studies have found returns that go as high as 12 percent.[9]

In other studies, the *quality* of education had an even stronger relationship to growth than did the duration of school participation; the *amount learned* was more important than the number of years of schooling. Higher test scores of one standard deviation equated to 1 percent growth in per capita GDP.[10]

However, the limitation of both microeconomic and macroeconomic studies is that they treat the educational system as a black box. They do not describe *how* curriculum, teaching, assessment, teacher quality, or ICT can actually influence what students know and are able to do as a result of their educational experience, or how these factors contribute to economic growth and social development. Yet the details of these connections are very important to educational policy makers and implementers who are charged with preparing citizens to participate in the information society and creating a workforce that is globally competitive. What kind of education reform will contribute to sustained and equitable economic growth? How can teachers and schools better prepare students to meet the challenges of the future? What are the skills students will need to succeed in the 21st century global economy and information society?

Basic literacy and numeracy skills were sufficient for the large majority of laborers who were needed to staff the factory floors in the manufacturing economy. This large workforce was supplemented by the relatively few who had higher degrees in engineering, business administration, and law and who managed and supported the manufacturing effort and kept it efficient. Consequently, the education system could serve the economy by identifying a few highly promising students for advanced study and providing basic skills to the rest.

But this is no longer sufficient for the 21st century knowledge economy and information society. High-level service providers—sometimes called knowledge workers—require a different set of skills than those that were sufficient for the manufacturing economy. Educators and business leaders have described these types of skills (See Box 1) which include technological and media literacy, effective communication, critical thinking, problem solving and collaboration.[11] These are the skills needed to produce new intellectual and creative works that have value to others; these are the skills that students will need in the 21st century.

Building 21st Century Skills and 21st Century Schools

In the face of global social and economic challenges, many governments around the world are looking to reform their educational systems to prepare students for the 21st century. Often, these reforms incorporate ICT and attempt to connect education change with economic growth and social development. The three factors that drive productivity-based economic growth—*capital deepening*, *higher-quality labor*, and *knowledge creation*—can serve as the basis for three complementary, somewhat overlapping approaches to education reform that can contribute to economic and social development by:

8. R. Barro, Education and Economic Growth (Paris: OECD, 2000).
9. R. Sianesi and J. Van Reenen, The Returns to Education: A Review of the Empirical Macro-Economic Literature (London: Institute for Fiscal Studies, 2002); P. Stevens and M. Weale, Education and Economic Growth (London: National Institute of Economic and Social Research, 2003).
10. Barro, Education and Economic Growth.
11. L. Resnick and J. Wirt, "Changing the Workplace: New Challenges for Education Policy and Practice," in Linking School and Work: Roles for Standards and Assessment, ed. L. Resnick and J. Wirt, 1–22 (San Francisco: Jossey-Bass, 1996); S. Lall, ("Skills, Competitiveness and Policy in Developing Countries" (working paper no. 46, Queen Elizabeth House, Oxford, 2000); Partnership for the 21st Century, Learning for the 21st Century (Washington, DC: Partnership for the 21st Century, 2003); National Center on Education and the Economy Tough Choices, Tough Times: The Report of the New Commission on the Skills of the American Workforce(San Francisco: Jossey-Bass, 2006).

- Increasing the technological uptake and basic literacy skills—or the *knowledge-acquisition approach*
- Increasing the ability of the workforce to use knowledge to add value to economic output by applying it to solve complex, real-world problems—or the *knowledge-deepening approach*
- Increasing the capability of the workforce to innovate and produce new knowledge and by increasing the capability of citizens to benefit from this new knowledge—or the *knowledge-creation approach*

Each approach has different implications for educational policy, teacher professional development, classroom pedagogy, curriculum, assessment, ICT use, and school organization and administration. While these approaches and their implications are not empirically derived, they provide policy makers with a conceptual tool that allows them to think about reform in ways that connect with economic and social development goals and provide a "knowledge ladder" by which policy makers can play progressively higher forms of productivity-based educational change. Table 1 on p. 16 summarizes these implications.

Box 1.

21st Century Skills

- Technological and media literacy: select correct tools; operate equipment and applications; use them to manage, analyze, integrate, evaluate and create information in a variety of forms
- Effective communication: crafting and executing effective oral, written, and multimedia communication in a variety of contexts
- Critical thinking: Sound reasoning in understanding and making complex choices; understanding the interconnections among systems
- Problem solving: identify and analyze complex, ill-structured problem situations, plan solutions, make decisions, apply solutions flexibly, evaluating results and revise solution
- Collaboration: Demonstrating teamwork and leadership; adapting to varied roles and responsibilities

Knowledge Acquisition

This approach requires the fewest changes in the educational system of the three approaches. The policy goal of this approach is to improve economic productivity by preparing a workforce that is capable of taking up new technologies. Related educational policy goals include increasing school enrollments and improving basic literacy 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. Changes in teacher practice involve the use of technology for classroom activities and presentations, and 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 classroom.

The technologies involved in this approach often include student use of computers along with productivity software; drill and practice, tutorial, and Web content; and the use of networks for management purposes. Teacher competencies related to the *knowledge-acquisition* approach include basic digital literacy skills along with the ability to select and use appropriate off-the-shelf educational tutorials, games, drill-and-practice, and Web content in computer laboratories or with limited classroom facilities to complement standard curriculum objectives, assessment approaches, unit plans, and didactic teaching methods. Teachers should also be able to use ICT to manage classroom data.

By providing technological literacy skills, this approach can increase the capacity of the workforce to take up technologies that are introduced into the economy. But because this approach does not include other 21st century knowledge and skills, its impact on the economy may be modest. Nonetheless, the approach may be an important beginning for some countries on the road to long-term development.

Singapore provides an example of a country that began its education reform with the *knowledge-acquisition* approach. From the beginning of Singapore's modern economic development, the government tasked the education system to supply targeted economic sectors with skills necessary for their labor force. Anticipated skill needs were translated into production goals for secondary, polytechnic, and university institutions. Early in this development trajectory, the goal was to prepare a workforce with the basic skills needed for assembly work at transnational corporations. The education system focused on increasing primary and secondary enrollments, and the curriculum focused on increasing skills in literacy and numeracy. This set the stage for further economic development.

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 by applying the knowledge of school subjects to solve complex problems encountered in real-world situations of work and life. The traditional curriculum is bounded by school experience, and the focus is on factual recall. But knowledge of school subjects remains inert and cannot be applied outside the class or contribute to productivity or innovation. In contrast, the *knowledge-deepening* approach supports economic productivity and social development by deepening students' understanding of school subjects and making these subjects more relevant to the problems and challenges of the community and the workplace. Rather than the superficial "coverage" of a large number of topics, the curriculum focuses on a smaller number of key concepts, principles, and procedures and how these ideas are organized and interconnected within and across subject areas to form complex knowledge systems. Classroom activities and projects that engage students in the solution of extended, open-ended, real-world problems are an important component of this approach. Learning inside the school is connected to out-of-school examples and experiences. For older students, internships and apprenticeships can extend classroom learning outside the school context and schedule.

Technology can also play an important role, as students use visualization and simulation to explore, understand, and apply complex knowledge. 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. These assessments call for the adaptive application of concepts, principles, and procedures that cut across subject domains to fit the circumstances of novel problem situations;

mathematics, science, language, and reasoning are all used together rather than tested separately, facilitated by ICT. Because this type of learning is more complex, teachers need to possess both understanding of their subject area as well as the processes students employ and problems they face when they engage in this type of learning. Teachers should be able to integrate open-ended software tools and subject-specific applications with student-centered teaching methods and collaborative projects. They should also be able to use ICT to create and monitor students' individual and group project plans, as well as access experts and collaborate with other teachers. Flexibility in school schedules and curriculum implementation can support these classroom efforts.

Again, Singapore illustrates this approach. As the country's initial, low-wage, export-based strategy achieved full employment and the economic development policy shifted toward high value-added production, the government upgraded its education requirements. Secondary schools were targeted to produce higher levels of skills in science, mathematics, and language, and universities were to produce more engineers and scientists. The Education Ministry instituted a number of reforms to improve the quality of its education system and support students' development of critical thinking, creativity, and enterprise. As a consequence, Singapore students now score at the top of international assessments of science and mathematics.

Box 2.

21st Century Schools

McKinsey and Company recently conducted an analysis of high-performing education systems around the world, including those of Singapore and Finland. While there are important differences between these two systems, there are a number of features that they share with each other and with other high-performing systems. Among them are:

- They go to great extents to recruit the most capable students to become teachers. For example, Finland recruits students from the top 10 percent of secondary students; only 1 out of 10 applicants are accepted. In Singapore they recruit from the top 30 percent and only 1 out of 6 are accepted, but they are given a salary while they are in training. In these and other high-performing countries, teachers receive high entry-level salaries.
- They put significant resources into making these teachers effective instructors. In Finland, teachers work together, plan their lessons jointly, observe each others' lessons, and help each other improve. Teachers are given one afternoon a week for joint planning and curriculum development. Singapore designates master teachers in each school to mentor teachers, and all teachers receive 100 hours of paid professional development training each year.
- They structure schools to assure that each student receives an excellent education. In Finnish schools, special teachers provide additional one-on-one and small group instruction to low-performing students. Singapore provides extra classes for its lowest performing students. Singapore also invests in research on the practices of its best schools and assures that the lessons from these are transferred to other schools.

McKinsey & Company (2007). *How the world's best performing school systems come out on top*. http://www.mckinsey.com/clientservice/socialsector/resources/pdf/Worlds_School_Systems_Final.pdf

Knowledge Creation

The policy goal of the third approach—*knowledge creation*—is to create a workforce and citizenry that are continually engaged in and benefit from knowledge creation and innovation. The implications of this approach for educational change are profound. If students are to participate in an economy and society in which the creation, sharing, and use of new knowledge 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 learning of key concepts and principles and their use to solve complex problems, students engage in the sustained, collaborative process of building on current knowledge to create and share new knowledge. *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: their ability to set their own goals, determine what they already know, assess their strengths and weaknesses, design a learning plan, stay on task, track their own progress, and build on successes and adjust to failures. These skills will enable students to sustain their own personal development and contribute to that of the economy and society in a constantly changing world.

With this approach, teachers design a learning community in the classroom in which students are continuously engaged in building their own and each others' knowledge learning skills. Indeed, schools are transformed into learning organizations in which all actors are involved in the learning process. They are also able to play a leadership role in training colleagues and in creating and implementing a vision of their school as a community based on innovation and continuous learning, enriched by ICT. From this perspective, teachers are master learners who constantly engage in educational experimentation and innovation in collaboration with their colleagues and outside experts to produce new knowledge about learning and teaching practices. 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. These teacher- and student-designed resources support the development of knowledge creation and critical thinking skills of students; support students' continuous, reflective learning; and support the creation of knowledge communities composed of students and teacher colleagues.

Finland exemplifies this approach. Along with Singapore students, Finnish students score among the highest in the world on international assessments of science, math, reading, and problem solving. Finland's Ministry of Education attributes the country's excellent performance to widespread access to high-quality education across the country, high-quality teachers with a high degree of autonomy, development-oriented assessment that gives students feedback on their progress, and an approach to education that treats students as autonomous learners who are guided to develop their study skills and plan their life career. The Ministry conceptualizes learning as an individual and community process of *knowledge creation*, a skills- and goal-oriented process that includes independent and collaborative problem solving. School experiences are connected to the outside world through internships and apprenticeships. Singapore too is now moving in this direction, and its curriculum has been broadened beyond a set of core knowledge to include information skills, critical thinking skills, creativity, communication skills, knowledge application skills, and self-management skills. To develop these skills and attitudes, cross-discipline project work was introduced into the classrooms in Singapore. Assessments were revised to measure students'

skills in analyzing and applying information, thinking, and communicating.

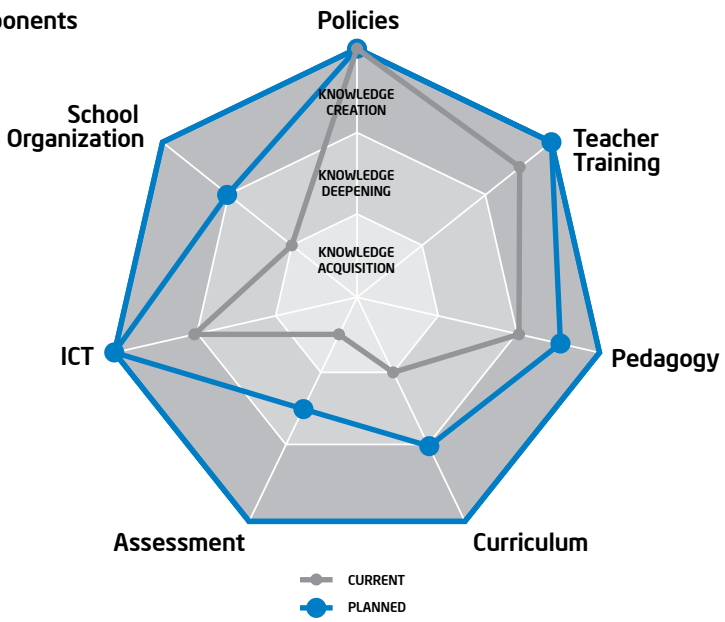
Moving Toward Knowledge Creation

How should other countries respond to the global trends that have taken us into the 21st century? How can they turn the challenges of the decade into growth and improvement? In their details, each response will be unique and will depend on a nation's history, social priorities, resources, and political will. Schools in Egypt, Bolivia, or Kenya are different than those in Finland or Singapore. But the three approaches provide policy makers with a range of policy options they can use to connect education reform with economic and social development. Each approach is connected with a particular approach to productivity-based economic growth. And while there can be productive synergy across categories, each approach emphasizes a different configuration of goals and resources that support reform and development. Together, the three approaches present a progressive "knowledge ladder" by which a country can move from traditional educational approaches to more powerful ways of increasing the impact of the education system on the economy and society, as illustrated by Finland and Singapore.

The specific approach a country might take at a given time will depend, in part, on where its education system currently falls within the continuum. Most likely, a ministry of education will find that within its education system, different components are more or less advanced along this continuum. Yet these components often work together—or are at odds with each other—to advance or constrain the advancement of the entire system. The key to moving toward *knowledge creation* is to leverage current strengths 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 policy makers 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

Figure 3. Diagram of Education Reform Components



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 in 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 among 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 could build on gains won with the *knowledge-deepening* approach to make further changes in its 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 design and develop intellectual and creative works that can be shared with others inside and outside the 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 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.

Conclusions

Policy makers and ministry officials face many important decisions as they cope with sweeping global trends. But none is more important to economic and social development than those they make in education policy. By examining the relationships among reforms in policy, teacher training, pedagogy, curriculum, assessment, ICT, and school organization, and by aligning these changes with important economic and social goals, policy makers can create 21st century schools and nurture the development of 21st century students. However, the experiences of Finland and Singapore offer three important policy lessons.

Policy leadership

Policy leadership and vision is key to any successful effort to use education reform to contribute to economic and social development. Many countries, including Singapore and Finland,

have developed educational reform policies and ICT master plans that provide a vision of what classrooms and schools will look like in the future. They also create and allocate resources that support the implementation of this vision. Changes can occur within classrooms and schools without such policies, but invariably their impact on society and the economy is minimal. If no such master plan currently exists in a country, establishing one is the first step toward an effective and sustained effort to use ICT to improve education and foster development.

Policy coordination

To maximize the impact of education investments, reform policies must be coordinated with other policies and programs, both within the education ministry and with other related ministries. The mere introduction of technology in education, no matter how advanced, will not result in educational improvement or reform. Teacher training alone will not bring about change. The impact of any reform program will be greater if its introduction is linked to a curriculum that emphasizes deep understanding and knowledge creation, a pedagogy that emphasizes student engagement, teacher training that emphasizes continuous learning, ICT that is integrated into the curriculum, and student assessments that focus on knowledge application as well as recall of facts and procedures.

Furthermore, it is important to note that the relationship between education and economic growth is a necessary but not sufficient one—while education can be an important contributor to growth, many other factors are involved.

The full impact of education reform will be realized only if educational policies and programs are also coordinated with those in other ministries, such as telecommunications, economic development, human resource development, and rural and urban development. Telecommunications policies can increase network availability for schools and community centers. Economic and human resource development policies can support lifelong learning and use of ICT for this purpose. Urban and rural development policies and programs can promote the use of community technology centers as a way of improving skills and providing technology access to disadvantaged communities. A national, interministerial coordinating committee or council can facilitate policy and program harmonization and promote the sharing of resources.

Private-public partnerships

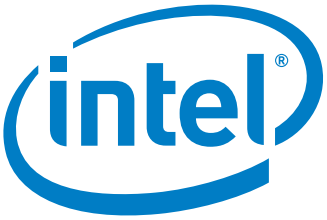
The changes discussed here require a significant shift in priorities and resources. This shift is particularly challenging for less-developed countries. The government of any country, no matter how developed, cannot bring about all these changes on its own. The effort requires a multisector approach to educational improvement that involves government, business, and civil society. The private sector, particularly the technology industry, can make a significant contribution to this process. Traditionally, private companies have contributed to economic growth through innovation and improved productivity that benefit their bottom line. But strategic investments in education reform by private companies can launch sustainable development and result in huge, long-term benefits for the country, the economy, and the company. These types of investments are wise not just because they develop new markets but also because they reduce inequities and minimize turmoil that can threaten social and economic stability.

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 its 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 prepares their students to join the knowledge economy and information society of the 21st century.

Education Reform, ICT, and Economic and Social Development
Developing 21st Century Skills

	Knowledge Acquisition	Knowledge Deepening	Knowledge Creation
Policies	The policy goal is to prepare a workforce capable of taking up new technologies and contributing to economic productivity. Education policies focus on increasing students' enrollments, ICT skills, and scores on standardized tests, primarily in reading and math.	The policy goal is to upgrade the productivity of the workforce so that it can add value to economic output. Education policies focus on improving the understanding and problem-solving skills of students and connecting school learning to real-world problems and contexts.	The policy goal is to increase innovation and knowledge creation to drive the knowledge economy. Education policies are focused on the research, development, generation, and sharing of new knowledge, and continuous learning. Schools, teachers, and students participate in these endeavors.
Professional Development	Teachers are expected to have a comprehensive 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. Continuing professional development may not be required if mastery is achieved.	Teachers are expected to have a deep understanding of 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	Teaching is focused on information delivery. 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 involve 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 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	The curriculum enumerates a large number of facts and concepts within school subjects and emphasizes their acquisition. ICT is included as a subject in the curriculum.	The curriculum identifies key interrelated concepts and principles that organize the subject area. It 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.	The curriculum is flexible and responsive to student goals and local contexts. It emphasizes the development of collaboration, inquiry, information management, creativity, and critical-thinking skills. Learning how to learn is essential.
Assessment	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, multipart problem-based projects. These projects embed key concepts and principles and correspond to real-world situations, and tasks are integrated into the learning experience.	Assessment tasks consist of investigations, reports, presentations, creative works, 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.
ICT Use	Technology is used primarily to deliver instruction and management. The ratio of students to computers 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 problems.	Pervasive technology and social networks 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.
School Organization	Schools are hierarchically structured with a high level of accountability and little autonomy or flexibility. Curriculum inspectors assure the curriculum is covered as prescribed. School and teacher performance are 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.



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