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# Closing the digital divide: evaluation of the World Links program

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## Abstract

In response to this digital divide between developed and developing countries in their use of computers to prepare students for the global economy, the World Bank and, subsequently, the World Links organization provided schools in developing countries with networked computers and training that supports integration of ICT into teaching. This article synthesizes findings from 3 years of evaluative research on the program. The findings are based on surveys of teachers, students, administrators, and technology coordinators, as well as a field test assessment of student learning. The study examines the services provided, documents their impact, and draws implications for policy in developing countries.

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## 1. Introduction

Information and communication technology (ICT) can make a tremendous contribution to human development—but only for those that have access. Technological innovation affects human development in two ways ([United Nations Development Programme, 2001](#)). It can directly contribute to human capabilities by increasing people's ability to participate more actively in the social, educational, economic and political life of a community. It can also support economic growth through the productivity gains that it generates. Conversely, human development—particularly the

development of a highly skilled workforce—can in turn contribute to technology development. Together, these two developments can create a “virtuous circle” that can reduce poverty and improve the human condition.

Unfortunately, these same technological resources are currently creating significant disparities between developed and developing countries according to a [United Nations Development Programme report \(1999\)](#). For example, the report points out that in South Africa, the best-connected African country, 75% of the schools have no telephone line. For the sake of comparison, there are 99 telephones for every 100 people in Monaco, but in Uganda, there are only two for every 1000. The report concludes that, “The global gap between have and have-nots, between know and know-nots, is widening” (p. 57).

This growing digital divide is further docu-

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mented by several more recent reports. [Bridges.org \(2001\)](#) states that while there were 167 million Internet users in North America and 113 million in Europe, there were only 16 million in South America and 3 million in all of Africa, according to data at the time of the report. While there has been a dramatic increase in Internet users in developed countries—from an estimated 4% of the inhabitants in 1995 to 28% in 2000—the number of users in developing countries has only inched forward to only 3.6% in 2000. Similarly, a study by the Organization for Economic Cooperation and Development ([OECD, 2001b](#)) shows that there has been a dramatic growth of Internet hosts—the source of content on the Internet. But while the number of hosts in developed countries has increased from 23 per 1000 inhabitants in 1997 to 82 per 1000 in 2000, the number in developing countries has only increased from 0.21 per 1000 in 1997 to 0.85 per 1000 in 2000. This lack of content originating in and oriented to developing countries is further compounded by the fact that 94% of the world's Internet content, as measured by the number of links to pages on secured servers, is in English.

The lack of access to technology reduces the prospect that citizens of developing countries will be able to participate in the growing global economy and minimizes the potential that technology has for improving their health, educational, governmental, and cultural institutions ([United Nations Development Programme, 1999](#)).

## 2. The World Links program

In response to this growing digital disparity and to requests from developing countries to assist them in preparing their youth to enter an information age and participate in the global economy, the World Bank's Economic Development Institute conducted a pilot program, initially called World Links for Development, from 1997 to 2002. The mission of the World Bank is to fight poverty and contribute to sustained development ([World Bank, 1999](#)). In its comprehensive development framework, the Bank posits that sustainable development requires many social and structural elements in

addition to strong economic performance. The development of educational capacity in client countries is a key element of the Bank's strategy. While the primary mechanism for Bank support is through its program of strategic loans, the Bank's Economic Development Institute (now the World Bank Institute, <http://www.worldbank.org/>) contributes to capacity building through training and outreach programs ([World Bank, 1997](#)).

The Economic Development Institute initiated the World Links for Development in the belief that technology could be used to improve educational outcomes in client countries and facilitate cultural understanding across nations ([World Bank, 1997](#)). The program was started by connecting a single high school in Uganda with one in the United States. By 1999, the program reached over 300 schools in 15 countries. In 2000, the World Bank created an independent non-profit organization called World Links (<http://www.world-links.org/>) to continue the program once the pilot was completed. World Links has since grown to serve over a 1000 secondary schools in 26 developing countries in Africa, Latin America, the Middle East, and South and Southeast Asia.

The World Links program aims to establish global, educational on-line communities for secondary school students and teachers around the world in order to expand distance learning opportunities, enhance cultural understanding across nations, build broad support for economic and social development, and train teachers to integrate information technology into the classroom. There are five components to the World Links program, each elaborated below:

- Internet connectivity for secondary schools in developing countries.
- Training and educational content to promote economic and social development.
- Regional and global partnerships with public, private, and non-governmental organizations.
- Telecommunications policy advice for the education sector.
- Monitoring and evaluation support.

Internet connectivity has been an essential component of the World Links program. For coun-

tries and schools with the most need, the program provided up-to-date multimedia computer equipment and networking for the school and computer laboratory. The program provided several alternative networking models, depending on the networking resources and bandwidth that were available.

Training was also an essential component. A central tenet of the program is that the introduction of technology will alone not improve education. Teachers from participating schools received training in the use of equipment and typical software. But more important was training on the integration of ICT into classroom teaching. The program adopted a constructivist approach to teaching with ICT that emphasized a shift away from teacher-centered lecture-based instruction towards student-centered, project-based learning (Carlson, 2002). Among the ultimate goals of the program was to encourage students' development of higher-order thinking and information-reasoning skills. These skills are cited as particularly important for participation in the knowledge-based global economy (OECD, 1996, 2001a; 21st Century Partnership, 2003). To accomplish this goal, World Links training was to provide teachers with pedagogical approaches to incorporate ICT into their teaching and support student acquisition of advanced skills instructional goals. By 2000, the World Links teacher training curriculum included the following four phases:

Phase I: Introduction to the Internet for teaching and learning.

Phase II: Introduction to educational telecollaborative projects.

Phase III: Integrating technology and curricula.

Phase IV: Evaluating and diffusing innovative classroom practices.

The program also created a set of regional and global partnerships, such as I\*EARN, GLOBE, and ThinkQuest, that created digital content, activities, and training materials for teachers and students. These partnerships and their services supported teachers in their implementation of ICT and the pedagogical strategies advocated by World Links.

The program also provided ministries of education and other governmental agencies with consultation and policy materials that supported the development of ICT and its use to improve educational systems. Among the advice was the advisability of drawing on World Bank lending resources to support additional programs that use ICT in light of the results of the pilot program in their country.

The fifth component of the World Links program was monitoring and evaluation. To inform the decisions of national policy makers and program managers, an evaluation was designed to examine the World Links program on the implementation and effectiveness of the intervention and barriers that need to be overcome to assure its success. The evaluation was conducted by the Center for Technology in Learning at SRI International (<http://www.sri.com/policy/ctl/>).

This article summarizes the findings from evaluative research that was conducted over a 3 year period (Kozma and McGhee, 1999; McGhee and Kozma, 2000; Quellmalz and Zalles, 1999, 2000). The focus of the evaluation was on documenting the services actually provided by the program, studying the classroom implementation of the program and the effect that it had on classroom practice, examining initial indications of student and teacher outcomes and long-term impacts, and analyzing the barriers that may limit the effectiveness of the program. Our findings indicate that the program provided a variety of intended services to schools and teachers and that these were effectively implemented in participating schools and classrooms. The use of ICT in these schools was associated with student-centered, constructivist pedagogical practices. The data we were able to obtain indicate that students acquired the skills they would need to participate in the global knowledge economy. A range of barriers—from the need for more reliable connections in schools, to the need for more time in the curriculum for computer-based activities and national policies that integrate ICT into education reform—limited the program's implementation and impact. But the extent of the program's success despite these barriers has implications for the use of ICT to support education

improvement in developing countries and for the policies that can increase its impact.

### 3. Study design

As mentioned above, the goal of our evaluation was to document the implementation of the World Links program and assess its effectiveness. The focus of the evaluation was on the services provided by the program, the extent to and ways in which these services were implemented in the classroom, and student and teacher outcomes and the extent to which they could be attributed to the program. In addition, we were concerned with the barriers that teachers encountered in implementing the program. Our purpose was to provide program staff with information that could be used to improve the program and to provide governments with information about the value of ICT investments in education and policies that may be needed to increase the impact of these investments.

The evaluation of the World Links program was situated within a conceptual framework in which the impact of educational improvement efforts is influenced by a number of variables, in addition to the intervention itself, which mediate the impact of the program (see Fig. 1). The ultimate goal of the

World Links program was to contribute to such outcomes as improving the technological and information skills of students and teachers and long-term impacts such as improved test scores, increased cross-cultural understanding, and improved job prospects in the developing knowledge economy. However, these ultimate goals are mediated by a variety of intermediate factors, most salient being the extent to which the services provided by the program are implemented and supported by the participating schools. In addition, there are other “exogenous” variables unrelated to the program which may influence the implementation of the program and its outcomes and impacts, factors over which the program and the Bank may have very little influence. We used this conceptual framework to guide the construction of our research instruments. Within this framework, our focus was on the services of the program, the ways their implementation affected classroom practice, and the impact of these practices, particularly on the skills students would need to participate in the knowledge economy.

Previous research suggests that the services provided by the World Links program—specifically the ICT infrastructure and teacher training—would have an effect on classroom practice, particularly the training of teachers to integrate ICT into their

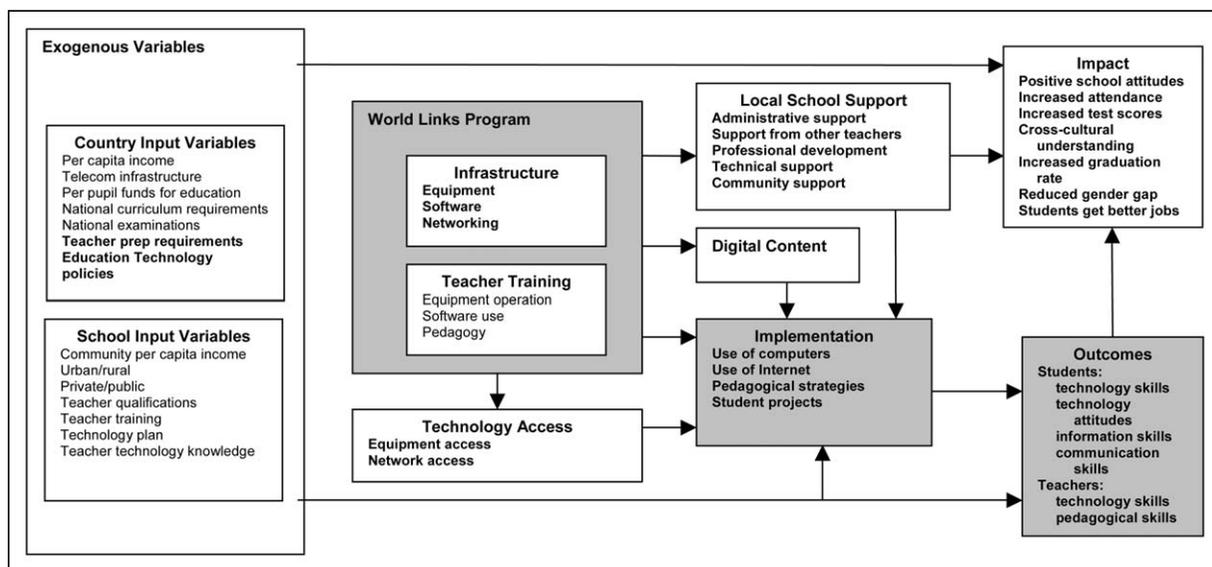


Figure 1. Conceptual Framework for World Links Evaluation

classes. Classroom studies (Means and Olson, 1995; Sandholtz et al., 1997; Means et al., 2001; Schofield and Davidson, 2002) have shown that such interventions can have a direct effect on the pedagogical strategies used by teachers, the extent to which computers are used within these strategies, the amount of time students are engaged in the use of computers, and the kinds of projects that students conduct with computers. The examination of this relationship was a primary focus of the evaluation.

The classroom implementation, so influenced, may have a subsequent effect on short-term outcomes, such as the acquisition of certain knowledge, skills, and attitudes. Ultimately, the intervention may have longer-term impacts on student retention rates or their preparation for the work world. The goal often cited in the literature is to provide students with the ability to access, analyze, evaluate, communicate, and use information to solve problems and create new knowledge (Educational Testing Service (ETS), 2002; International Society for Technology in Education (ISTE), 2000; OECD, 2000; Quellmalz and Kozma, 2003)—skills that are needed to participate in the global knowledge economy. However, the relationship between the use of ICT and various outcomes and impacts is an area where research results are less conclusive, with some studies finding negative results (Pelgrum and Plomp, 2002; Wengliński, 1998) and some finding positive results (NCES, 2001; Wengliński, 1998). The conflicting results suggest that the mere introduction of computers is insufficient to affect outcomes; the way computers are used in the classroom matters. In our evaluation, we examined this relationship between the use of computers, the use of specific pedagogical practices, and certain student outcomes. We designed this as a comparative study so that some attributions could be made to the services provided by the program.

The evaluation was also situated within a practical context of limited time and budget. As in many evaluations, these pragmatic constraints influenced the way in which we were able to assess the goals and examine the relationships imbedded in our conceptual framework. We had to rely on the self-report of participants for much of our data. How-

ever, we triangulated findings by the use of multiple sources (students, teachers, technology coordinators, and administrators), periods (the program in 1999 and 2000), participating countries, and methods (Tashakkori and Teddlie, 1998; Shavelson and Towne, 2001). Survey instruments were designed to collect information on the services provided by the program, teacher and student classroom practices and the extent to which computers contributed to these, the effect of the program and the use of computers on teacher and student knowledge, skills, and attitudes. We collected data from students, teachers, technology coordinators, and administrators. Also, sets of performance assessments were specifically designed to directly measure the impact of the program on student learning. To address certain research questions related to relative effects of the program vs. the mere use of computers, we included comparison groups of teachers and students who used computers but did not participate in the program, as described below.

### *3.1. Surveys of students, teachers, and administrators*

The purpose of the surveys was to collect self-reported responses about the program services received, the implementation of these services in the classroom, and the outcomes and impact of the program on students and teachers. Survey data were collected during the 1998–1999 and 1999–2000 operational years. During 1998–1999, survey data were collected from samples of administrators, teachers, technology coordinators, and students from five countries. During 1999–2000, survey data were collected from more countries (12 in all) but only from teachers.

In 1998–1999, the evaluation was conducted in five of the 13 currently participating countries: Chile, Paraguay, Peru, Senegal, and Uganda. In each of the five countries in which the evaluation was conducted, six World Links schools were asked to participate in data collection. Because the responses were self-reports, the data were triangulated with multiple types of respondents. At each school, samples of students and teachers were surveyed along with the headmaster or headmistress and the school's technology coordinator. In total,

26 World Links schools participated in the evaluation. There were nearly 20,000 students served by these schools, more than 12,000 girls and nearly 8000 boys. There were over 1200 teachers in these schools. A total of 661 World Links students and 83 World Links teachers responded to the survey from these schools. Also 25 administrators and 23 technology coordinators responded. The response rate was at or above 80% for all schools. Because we wanted to assess the extent to which student and teacher outcomes could be attributed to the World Links program, two other groups were identified for comparison purposes. One was a group of non-participating or “least participating” teachers and students within World Links schools. These were teachers and students in participating schools who did not participate in the program or participated in a minimal way; respondents in this group included 191 teachers and 441 students. A second comparison group was administrators, teachers, and students from nine schools that did not participate in the program but were asked to participate in the evaluation based on their comparability to World Links schools. Within these schools, 90 teachers, 378 students, and nine administrators responded to surveys. To assure particularly useful comparisons, both computer using and non-computer using teachers and students were surveyed in non-World Links schools. Of the total respondents in non-World Links schools, 32 teachers and 247 students were computer users.<sup>1</sup>

Relating to pedagogical practices and outcomes, survey questions were constructed so that identical responses could be collected from both World Links participants and non-participants and both computer users and non-users. For example, questions were asked of all respondents about the use of practices such as collaborating with other students on a project, gathering data for a research project, writing project reports, and so on. If the

respondents used computers, they would then be asked what role computers played in these practices. If they were participants in the World Links program, they would then be asked the extent to which their participation contributed to the practices. Consequently, the occurrence of certain practices could be compared between program participants and non-participants and between computer users and non-users to see if there were differences. Subsequent questions could provide additional information about the extent to which the respondents felt that the use of computers or the participation in the program contributed to any differences that existed.

In 1999–2000, 12 of 15 countries that were participating in the World Links program at the time were included in the study. These were: Brazil, Chile, Colombia, Ghana, Mauritania, Mozambique, Paraguay, Peru, Senegal, South Africa, Uganda, and Zimbabwe. The intent of this study was to see if 1998–1999 findings held for new countries that had subsequently joined the program. As mentioned above, data were collected only from teachers. The design included both World Links and non-World Links schools: 98 and 42, respectively. In World Links schools, four teachers were included for each school. To examine the impact of the program on a broader range of teachers in participating schools, two of the four were teachers who had received formal training from the program; one had received training from a colleague; and one teacher had not received training. A total of 383 World Links teachers participated in the survey and 158 teachers responded in non-World Links schools; the response rate was 97%.<sup>2</sup>

### 3.2. *Assessment of student learning*

Because we wanted to go beyond self-report of the impact of the program on student outcomes, we devised a direct measurement of student

<sup>1</sup> The total number of respondents by country in 1998–1999 was: Students—Chile (255), Paraguay (222), Peru (390), Senegal (262), and Uganda (350); teachers—Chile (48), Paraguay (47), Peru (109), Senegal (76), and Uganda (84); technology coordinators—Chile (6), Paraguay (4), Peru (6), and Uganda (6); administrators—Chile (6), Paraguay (6), Peru (7), Senegal (8), and Uganda (6).

<sup>2</sup> The total number of teacher respondents by country in 1999–2002 was: Brazil (56), Chile (40), Columbia (42), Ghana (40), Mauritania (36), Mozambique (32), Paraguay (36), Peru (56), Senegal (56), South Africa (56), Uganda (55), and Zimbabwe (36).

achievement. There were some unique challenges in the design of student learning assessments for this study. First, the World Links program was implemented in a wide range of subject areas, including science, social studies, language, and computer science. Furthermore, different countries had different curricula and expectations for student learning. Both these factors made it problematic to design an instrument that would measure the learning of specific school subject matter. However, an overriding consideration in designing the student assessment was the interest in measuring one of the most important outcome goals of the program: to prepare students for work in the knowledge-based global economy. Consequently, rather than measure the learning within the multitude of subject areas in which the program was implemented, the assessment of student learning focused on ICT skills and the use of ICT to search for, organize, and communicate information. These are the kinds of skills that are most likely to be influenced by the program, regardless of the subject area in which it is implemented, and they are the skills identified in policy documents (ISTE, 2000; OECD, 1996, 2001a; World Bank, 2002) as those needed for workers in the global knowledge economy.

With this goal in mind and drawing on the Educational Technology Standards for Students developed by the International Society for Educational Technology (ISTE, 2000), the SRI team identified key skill components for three outcome areas: reasoning with information, communication, and technology use. The SRI team then designed sets of performance assessments that engaged students in complex tasks of searching for, organizing, and analyzing information and designed indicators that measured skill components, such as formulating a search query and communicating an argument (Quellmalz and Zalles, 1999, 2000). As a culminating task in one of the assessments, World Links students were asked to write a newsletter for other students about the plight of two endangered species. In response to this task, students gathered information from Web pages about the two endangered species, specified a line of inquiry for further research and a Web search query phrase, and then prepared a news article making evidence-based predictions about the likelihood that the two

species would survive. Students were also asked to insert and annotate a relevant graphic. A parallel “paper-and-pencil” version of the task was designed for students in the comparison group who did not use ICT. The assessments were pilot tested in a World Links school in Uganda and in Paraguay. Scoring rubrics were developed and scorers were trained to assess the quality of students reasoning with information, communication, and technology skills.

The student assessment field test conducted in 2000 involved six World Links schools and four comparable non-World Links schools in Uganda. There were a total of 200 students assessed; 121 from World Links schools and 79 from non-World Links schools. Students in non-World Links schools were not assessed on their technology skills.

## 4. Results

### 4.1. Services provided

Our evaluation began with an analysis of the services that the World Links program actually provided to participating schools. The World Links program is a distinctive blend of infrastructure and human capacity development. Perhaps, the most visible contribution of the World Links program is the donation of computer hardware and software. Equipment was provided only to those schools where the current lack of equipment limited their participation in the program. At the time of the 1998–1999 survey, the technology coordinators in 60% of the schools reported that their schools had received equipment from the program. The coordinators reported having received an average of nearly nine computers for each school. The large majority of these computers were located in a computer laboratory along with other computers that the school had previously acquired.

One of the outcomes of the World Links program—one that significantly increases its efficiency—is the additional resources that the donation of equipment and participation in the program fostered. The relatively modest donations from the program were leveraged to get additional

resources, as they were often matched by significant local or national contributions. For example, the computer laboratories were often built with funds from a country's Education Ministry or from local resources. In Senegal, the Ministry of Education built or remodeled laboratories at each of the World Links schools at a cost in excess of \$ 20,000 for each school. Contributions of additional equipment in Uganda were often made by old girls and old boys clubs, as well. Other local funds, typically student fees that ranged from \$ 1 to \$ 50 a year, covered operating costs, such the cost of paper, ink, and dial up access. In most cases, students were able to use the resources even if they could not afford to pay the fee. In some schools, parents and students supplemented computer resources through fund-raising events. For example, in a poor, all-girls school in Peru, students raised funds by performing musical and theatrical shows for parents and neighbors.

While equipment donation was, perhaps, the most visible component of the program, it was through the professional development of teachers that the World Links program made its most significant contribution. In the 1998–1999 survey, World Links technology coordinators reported that 336 of the teachers in their schools, or an estimated 28% of their entire teaching staff, had received training as part of their school's participation in the program. During the first year, most of the training topics focused on the use of technology; 92% of the teachers said they received training on the use of the Internet and 75% received training on the development of Web pages. Teachers also said they received training on the use of computer hardware (70% of the participating teachers) and applications software (64%). The workshops also focused on constructivist approaches to learning that emphasized project-based learning and student collaboration. Nearly, 90% of the teachers said they received training on how to design and lead collaborative student projects; 70% received training on how to use student groups in their teaching; and 59% received training on how to collaborate with other teachers on the development of instructional materials.

These percentages were smaller for the larger group of teachers in 12 countries that responded to

the survey in 1999–2000, due in part to the inclusion of a broader range of teachers in the World Links schools. In these schools, 62% of the teachers said they received training on designing and leading collaborative groups; 52% received training on using student groups in teaching; and 45% received training on collaboration with teachers to develop instructional materials.

As a result of their experience, 93% of World Links teachers in the five countries studied in 1998–1999 expressed satisfaction with the way the program was implemented. In the 1999–2000 survey, 90% the teachers in the 12 countries expressed satisfaction.

Administrators also received training as part of their school's participation in the World Links program; only two of the 18 administrators who responded to the question in the 1998–1999 survey said they did not. Training in the use of Internet software and in the design of collaborative student projects were mentioned most often as the topics of the training. Correspondingly, all 21 administrators who responded to the question said they were supportive of the program and 91% said they were satisfied with its implementation to date.

The school technology coordinator played a crucial role in teacher professional development. Technology coordinators were frequently teachers who had some prior computer experience. Often they taught mathematics or science courses. The coordinators served a large number and a wide variety of functions with 70% or more saying that they trained teachers in the use of hardware, applications software, the use of the Internet, and in the design of collaborative projects and ways to integrate technology into the curriculum. The coordinators also worked extensively with students. More than 80% of the coordinators said they trained students in the use of hardware, software, and the Internet. Many coordinators also serviced the hardware, with 57% saying that they maintained the computer equipment and 52% saying they administered the school's network. These teachers often provided these special services while continuing their teaching duties.

In summary, while many schools received computers from the World Links program and leveraged these donations to obtain more resources, the

primary service provided by the program was teacher training. Training covered both the use of hardware, software, and the Internet, as well as the use of computers within new, constructivist-oriented pedagogical strategies.

#### 4.2. Implementation

The second focus of the evaluation was on the extent to which these services were used in the classroom. We found that World Links training and the availability of networked computers were associated with significant differences in what World Links teachers and their students did in their classrooms, compared to computer-using teachers and students in non-World Links schools. In the 1998–1999 survey, World Links students in five countries were much more likely than computer-using students in non-World Links to report that they engaged in a number of pedagogical practices in their classrooms (see Table 1). Some of these differences related to the use of various technologies. For example, while 52% of the World Links students said they used the Internet and 40% said they used a search engine, only 16% of the computer-using non-World Links students said they used the Internet and 19% said they used a search engine. Similarly, while 34% of the World Links students said they used email, only 21% of the computer-using non-World Links students said they did so. But some of the most dramatic differences relate to other learning activities. For example, 38% of the World Links students reported that they gathered data for a research project, 31% collected information about another country or culture, and 23% collaborated on a project with students from another country. On the other hand, 22% of computer-using non-World Links students reported that they gathered data for a research project, 18% collected information about another country, and only 4% collaborated on a project with students from another country. These differences held up when World Links teachers were asked parallel questions about the classroom practices of their students in the 12 countries participating in the 1999–2000 study (see also Table 1).

As a result of the program's emphasis on collab-

orative, project-based learning, World Links students frequently conducted projects with other students, often with students from other schools and other countries. The titles of some of the student projects in Uganda were *Women in Mathematics*, *The Democracy Schools Project*, *The Utopian Vision*, *Refugees*, *The Wetlands*, *Faces of War*, and *Culture and Technology*. In Senegal, topics included *Technology and the Generation Gap*, *Oppression and Human Violence*, *Women and Development*, and *Girls' Education in Senegal*. These projects were shared with students in Europe, Canada, the United States, and South Korea for their reaction. Box 1 describes a few of the World Links ecology-related student projects in a bit more detail. In these projects, students worked together while using computers, software applications, and the Internet to collect information, analyze it, write up reports, and post their results on the Internet or communicate with students elsewhere.

In summary, participation in the World Links program lead to the classroom use of a variety of computer applications and resulted in significant differences in the use of collaborative, project-based pedagogical practices, relative to their use by non-participating schools.

#### 4.3. Outcomes

The goal of the World Links program was to influence the learning outcomes of secondary school students and teachers in developing countries and, ultimately, to have an impact on other variables such as school attendance, examination scores, graduation rates, and the employment of students. While outcome and impact variables are the most difficult to measure and most susceptible to a range of influences apart from the program, we attempted to get an initial indication of the program's effect by asking students, teachers, and administrators questions about them. In addition, we compared reported outcomes in participating schools to those in non-participating schools. As well, we directly measured student outcomes in a sample of World Links and non-World Links schools in one country. We used the triangulation of these responses as an indication of their veracity.

Table 1  
Classroom practices as reported by students and teachers

How often did you use computers to do each of the following:	Percentage of each group who responded “1–3 times a month” or “once a week or more” <sup>a</sup>		
	World Links students 1999	Non-World Links computer-using students 1999	World Links teachers 2000 <sup>b</sup>
Use applications software	52 <sup>c</sup>	42	71
Use CD-ROMs	34 <sup>c</sup>	21	50
Use e-mail	47 <sup>c</sup>	25	62
Use a search engine to find information on the Web	40 <sup>c</sup>	19	56
Use bulletin boards or listservs	26 <sup>c</sup>	15	35
Use the Internet	52 <sup>c</sup>	16	59
Use drill and practice materials	51	46	56
Use spread sheets to analyze data	34 <sup>c</sup>	31	28
Produce a Web page	23 <sup>c</sup>	9	16
Collaborate on a project with other students in the same class	47 <sup>c</sup>	30	53
Collaborate on a project with students from another school in your own country	25 <sup>c</sup>	13	27
Collaborate on a project with students from another country	23 <sup>c</sup>	4	23
Exchange information with another students from another country	28 <sup>c</sup>	8	29
Gather and analyze resource materials on a problem or topic	41 <sup>c</sup>	25	44
Gather data for a research project	38 <sup>c</sup>	22	40
Gather evidence to argue a position about an issue	34 <sup>c</sup>	25	39
Write project reports	35 <sup>c</sup>	24	35
Use graphics in a report	34	28	35
Collect information about another country or culture	31 <sup>c</sup>	18	26
Draw conclusions or make predictions using data you gathered or obtained from resource materials	35 <sup>c</sup>	28	34
Communicate with your parents or other members of the community about what you do in school	41 <sup>c</sup>	31	28

<sup>a</sup> The response options provided to respondents were: not at all, 1–5 times during the year, more than five times during the year but less than once a month, average of 1–3 times a month, and average of once a week or more.

<sup>b</sup> Teachers were asked about the extent of student practices and were provided with the same response option as students.

<sup>c</sup> World Links and non-World Links students are statistically different (pair-wise *t*-test,  $p < 0.05$ ) for full range of responses.

Nonetheless, these findings must be considered preliminary until direct measures of learning can be systematically and widely collected.

#### 4.3.1. Student outcomes

In the 1998–1999 survey, a majority of students in the World Links program said that it had a significant effect on a variety of knowledge, skills, and attitudes (see Table 2). Perhaps, it is not surprising that 66% of students rated the program very highly for its impact on their attitudes toward technology and over 60% said their technology skills improved. However, the most highly rated out-

come of the program was on students’ opinion about their ability to get better jobs upon graduation; 77% of the World Links students rated this outcome as very high. In addition, 71% rated the program very high on its effect on their communication skills and 61% on its effect on their ability to reason with information. A large majority said that the program improved their attitudes toward school (66%) and their school attendance (64%). And 60% rated the program very highly in its effect on their knowledge about other cultures as a result of their participation. In the 1998–1999 survey, an overwhelming 92% of the students in

Table 2  
Student outcomes attributed to World Links

How much impact the participation in the World Links program has on students: Percentage of each group that responded “very much”<sup>a</sup>

	World Links students 1999	World Links teachers 1999	World Links administrators 1999	World Links teachers 2000
Improved technology skills	63	88	65	69
Improved attitudes towards technology	70	86	71	78
Improved ability to reason with information	61	71	65	63
Improved communication skills	71	74	73	70
Increased knowledge or awareness of other cultures	60	67	47	61
Improved attitudes toward school	66	78	76	67
Improved school attendance	64	31	50	44
Improved ability to get better jobs upon graduation	77	48	25	59

<sup>a</sup> The response options provided to the respondent were: not at all, somewhat, and very much.

World Links schools expressed satisfaction with their participation in the program.

Teachers and administrators generally agreed with students’ opinions of the program’s impact (see also Table 2). In the 1998–1999 survey, 88% of the teachers and 65% of the administrators rated the program very highly for its positive impact on student technology skills and 86% of the teachers and 71% of the administrators rated it highly on its impact on students’ attitudes toward technology. Similarly, these respondents rated the program very high on its effect on students’ ability to reason with information (71% of the teachers and 64% of the administrators), on their communication skills (74% of the teachers and 73% of the administrators), and on their attitudes toward school (78% of the teachers and 76% of the administrators). Two thirds of the teachers rated the program very highly on its impact on students’ knowledge of other cultures and on their school attendance. Teachers were less enthusiastic than students on their assessment of the program’s impact on student school attendance and on students’ ability to get better jobs. Administrators were less optimistic about the program’s impact on students’ job prospects, on their school attendance, and on their knowledge of other cultures.

These positive assessments of the program’s impact were shared by the larger group of teachers from 12 countries that responded to the survey in

1999–2000 (Table 2). A large majority of the teachers rated the program very highly on its impact on all the outcomes, especially its impact on students’ attitudes toward technology, their communication skills, their technology skills, and their attitudes toward school.

#### 4.3.2. Student outcomes compared

While the questions reported above asked for opinions about outcomes specifically linked to the World Links, the questions described in this section asked respondents to report on learning outcomes related to their use of computers but without reference to the program. Consequently, the questions could be asked of students and teachers who did not participate in the program as well as those who did.

Table 3 compares the responses of three other groups of students from the 1998–1999 survey: students who participated in the World Links program, computer-using students who were in the same schools but did not participate in the World Links program, and computer-using students in non-World Links schools. On a wide range of knowledge, skills, and abilities, World Links students rated their learning high as a result of using computers and higher than did students in the same school who did not participate in the program. A majority of World Links students rated their learning highly and had higher end-of-year ratings on

Table 3  
Student learning outcomes as reported by various groups of students

Use of computers has improved your knowledge, skill, and abilities in the following areas:	Percentage of each group that responded “very much” <sup>a</sup>		
	Participating World Links students 1999	Non-participating World Links students 1999	Non-World Links computer-using students 1999
Knowledge about academic subjects	40 <sup>b,c</sup>	33	36
Planning, regulating and monitoring of your own learning	54 <sup>b,c</sup>	43	35
Finding, comparing, and evaluating information	53 <sup>b,c</sup>	52	42
Analyzing and interpreting information	57 <sup>b,c</sup>	49	42
Writing reports	67 <sup>c</sup>	54	57
Communicating with others	60 <sup>c</sup>	60	55
Using images, drawings, or graphics to represent ideas	52	54	51
General knowledge about current events	53 <sup>c</sup>	44	37
Knowledge about other cultures, countries, or languages	53 <sup>b,c</sup>	44	34
Collaborating with others	63 <sup>c</sup>	58	51
Using computers	77 <sup>b</sup>	67	73
Using computers software	58 <sup>c</sup>	52	49
Using Internet	66 <sup>b,c</sup>	58	45

<sup>a</sup> The response options provided to respondents were: not at all, somewhat, very much.

<sup>b</sup> World Links and non-participating World Links students are statistically different (pair-wise *t*-test,  $p < 0.05$ ) for full range of responses.

<sup>c</sup> World Links and non-World Links computer-using students are statistically different (pair-wise *t*-test,  $p < 0.05$ ) for full range of responses.

their ability to plan their own learning; their abilities to analyze and to interpret information; their abilities to communicate, to write reports, and to use graphics to represent ideas; their ability to collaborate with others; their knowledge of other cultures; and, of course, their skills in using computers, software, and the Internet. Only 40% of the World Links students gave a high rating to the impact of computers on their knowledge of academic subject matter, but this was still higher than students in the two other groups. And only for the use of graphics did World Links students report no more learning than one or both of the other groups.

Similarly, teachers who participated in the World Links program were significantly more likely than computer-using teachers in other schools to report higher ratings for their students' learning and attitudes in a number of areas. Table 4 shows that a majority of the World Links teachers from the five countries participating in the 1998–1999 survey rated the use of computers as having a high impact on student learning in all but

two of the indicators—student planning of their own learning and their analysis of information. They rated the impact of computers on student learning higher than teachers in one or both of the other groups for communication skills, knowledge of other cultures, collaboration with others, and Internet skills. Similarly, World Links teachers from the 12 countries who responded to the 1999–2000 survey were more likely than non-World Links teachers to highly rate the impact of computers on student communication skills, knowledge of current events, knowledge of other cultures, collaboration skills, and Internet skills.

#### 4.3.3. Student outcomes assessed

While the survey responses of students, teachers, and administrators all attested to the impact of computers and the World Links program on student learning, this is not as compelling as a direct measure of student learning. In 2000, the performance of 121 students in six World Links schools and 79 students in four comparable non-World

Table 4  
Student learning outcomes as reported by various groups of teachers

Use of computers has helped your students improve their knowledge, skills, and abilities in the following areas:	Percentage of each group that responded "very much" <sup>a</sup>				
	Participating World Links teachers 1999	Non-participating World Links teachers 1999	Non-World Links computer-using teachers 1999	World Links teachers 2000	Non-World Links teachers 2000
Knowledge about academic subjects <sup>b</sup>	56	48	37	39	34
Planning, regulating, and monitoring their own learning	47	52	31	43	30
Finding, comparing, and evaluating information	53	54	42	50	54
Analyzing and interpreting information	47	50	36	48	55
Writing reports	56	54	73	55	59
Communicating with others	79 <sup>c</sup>	55	42	67 <sup>d</sup>	46
Using images, drawings, or graphics to represent ideas	53	61	74	56	56
General knowledge of current events	65	59	48	62 <sup>d</sup>	36
Knowledge about other cultures, countries, or languages	75 <sup>c,e</sup>	46	22	53 <sup>d</sup>	38
Collaborating with others	80 <sup>c,e</sup>	51	48	65 <sup>d</sup>	35
Using computer software	81	71	77	64	58
Using the Internet	75 <sup>c,e</sup>	44	35	67 <sup>d</sup>	35

<sup>a</sup> The response options provided to respondents were: not at all, somewhat, very much.

<sup>b</sup> The wording of this statement was slightly different for the 1999–2000 survey. It stated "performance on tests of academic subjects".

<sup>c</sup> World Links and non-World Links computer-using teachers are statistically different (pair-wise *t*-test,  $p < 0.5$ ) for full range of responses.

<sup>d</sup> World Links and non-World Links teachers are statistically different (pair-wise *t*-test,  $p < 0.5$ ) for full range of responses.

<sup>e</sup> World Links and non-participating World Links teachers are statistically different (pair-wise *t*-test,  $p < 0.05$ ) for full range of responses.

Links schools in Uganda were measured, scored, analyzed, and compared (Quellmalz and Zalles, 2000). Table 5 shows the number of performances of each component that were exhibited in these open-ended tasks and the percent that was rated as “adequate” or “above adequate” by raters.

The World Links schools out-performed the non-World Links schools on all components of reasoning with information and communication that were measured by the assessment. The differences were greatest in the components of reasoning with information that involved finding and categorizing relevant information (85% for World Links, 59% for non-World Links), making comparisons (63% for World Links, 46% for non-World Links), and using information to make supported predictions (62% for World Links, 50% for non-World Links). Overall, the percentage of “adequate” or “above adequate” responses by students in World Links schools on reasoning with information was 14% higher than the ratings of student responses from non-World Links schools and 5% higher on communication.

The lowest scores for both World Links and non-World Links schools were for ratings of how well the students’ news articles presented and supported their predictions. Consequently, the differences between the two groups were least pronounced for this outcome area. While slightly higher than the non-World Links group, only 37% of the World Links students’ news articles were rated as presenting an “adequate” or “above adequate” predictions.

World Links school students out-performed non-World Links students on ratings of the logical development of their news articles. Seventy-four percent of the news articles written by World Links students were rated as “adequately organized” or “well organized”, in comparison to 65% of the news articles written by students in the non-World Links schools.

The students in World Links schools did quite well in their display of technology skills, as scored by raters. Seventy-four percent of the World Links students received ratings of “adequate” or “above” on tasks requiring searching for information on the Web. Sixty-three percent received “adequate” or “above adequate” ratings on either formulating or

identifying an appropriate phrase for a Web search query on a specific topic.

#### 4.3.4. *Teacher outcomes*

Students were not the only ones to benefit from participation in the World Links program; teachers benefited in a number of ways. As mentioned earlier, a major component of the World Links program is its emphasis on the professional development of teachers and on improved pedagogy.

As a result of their participation in the World Links program, a large majority of the World Links teachers in the 1998–1999 survey felt that they greatly improved not only their ability to use computer hardware (70%), applications software (67%), and the Internet (73%) but their ability to use student groups in their teaching (63%) and to design and lead collaborative student projects (68%), as shown in Table 6. A majority of teachers (52%) indicated that the program increased their ability to collaborate with other teachers on the development of materials.

A very large percentage of administrators felt that the World Links program greatly affected teachers’ computer skills (82%), their ability to use the Internet (80%), their attitudes about technology (85%), and their attitudes about their own teaching (90%). A majority felt that the program improved teachers’ software skills (67%) and their ability to use student groups in their teaching (60%). Both teachers and administrators in the 1998–1999 survey agreed that program had limited impact on teachers’ ability to integrate computers into curriculum integration and assessment.

Teachers from the 12 countries participating in the 1999–2000 survey agreed with their colleagues in the earlier survey on most questions (also in Table 6). These teachers rated the program’s impact as higher on integration of computers into the curriculum but they also felt that impact on assessment design was limited.

#### 4.3.5. *Summary*

In summary, data from administrators, teachers, and students indicate that students who participated in the World Links program learned a range of new skills, more so than those in non-participating schools. These findings were confirmed by a larger

Table 5  
Summary by outcome area and skill components for the student assessment in Uganda

Outcome area	Skill component	WorLD schools		Non-WorLD schools	
		Number of responses “adequate” or “above” (total responses)	Percentage of responses “adequate” or “above”	Number of responses “adequate” or “above” (total responses)	Percentage of responses “adequate” or “above”
Reasoning with information	Finding and categorizing relevant information	142 (167)	85	67 (114)	59
	Comparisons	178 (282)	63	89 (193)	46
	Predictions	135 (217)	62	76 (153)	50
	Formulating or identifying a research question	83 (107)	78	51 (71)	72
Communication	Supporting a prediction	43 (115)	37	28 (77)	36
	Totals	581 (888)	65	311 (608)	51
	Organization	85 (115)	74	50 (77)	65
	Argument	43 (115)	37	28 (77)	36
Technology use	Totals	128 (230)	56	78 (154)	51
	Searching for information on the Web	147 (198)	74	— <sup>a</sup>	— <sup>a</sup>
	Formulating or identifying a search query	64 (102)	63	— <sup>a</sup>	— <sup>a</sup>
	Totals	211 (300)	70	— <sup>a</sup>	— <sup>a</sup>

<sup>a</sup> Technology use outcome data were not gathered from non-World schools.

Table 6  
Impact of the World Links program on teachers as reported by various groups

Impact of the program on teachers' skills, abilities, knowledge, and attitudes:	Percentage of each group that responded "very much" <sup>a</sup>		
	World Links teachers 1999	World Links administrators 1999	World Links teachers 2000
How to use computer hardware	70	82	76
How to use software applications	67	67	71
How to use the Internet	73	80	72
How to develop Web pages	47	53	50
How to use student groups in teaching	63	60	63
How to design and lead collaborative student projects	68	58	63
How to design and use student assessment materials	46	35	45
How to collaborate with other teachers in developing materials	52	44	46
How to integrate computers into the curriculum	39	40	53
Attitudes about technology	72	85	84
Attitudes about teaching	75	90	82

<sup>a</sup> The response options provided to respondents were: not at all, somewhat, very much.

sample of teachers in many more countries that participated in the program during the second year of the evaluation. Even more important, World Links students performed better than non-World Links students on direct assessments of ICT skills and their use to reason with information and communicate ideas. Teachers too acquired significant ICT and pedagogical skills as a result of their participation in the program. All these results, taken together, affirm the positive—although still preliminary—effects of the World Links program.

#### 4.4. Barriers and differences between countries

While the primary focus of the evaluation was on program practices and outcomes, we felt that an assessment of the problems and barriers that confronted teachers would provide information for World Links program improvement and for the formulation of national policies that would increase the effectiveness and impact of such ICT-based programs and investments.

Teachers were asked about the reasons that they may have used computers in their teaching less than they had planned. Of the 83 World Links teachers who responded to the survey in 1998–1999, 16 (or nearly 20%) indicated that they had not yet

implemented computer-related activities with their students, and 53 (or 64%) mentioned that they had encountered one or more problems that reduced their ability to use computers in their classes.

Among the 16 teachers who said they were not able to implement computer-related activities, the most often cited major barrier was not the lack of equipment but the lack of time; 62% of these teachers indicated that, given curriculum and testing requirements, difficulty in finding time for computer activities was a major barrier (Table 7). Similarly, many of these teachers said that finding time to complete computer activities within the school's daily schedule (59%) and finding time in their own schedule to prepare for implementing technology in their classes (56%) were major barriers. Related to these issues, 42% said that a barrier was the lack of a national policy on the use of computers in schools. Overall, relatively few of these teachers identified infrastructure problems, such as the lack of computers in working condition, unreliable electricity, or lack of access to the Internet, although these varied by country, as described below.

The 53 teachers who said they were able to implement computer-related activities but implemented fewer than planned responded similarly. Of these teachers, 51% indicated as a major

Table 7  
Barriers to implementing computer-related classroom practices

To what extent were the following barriers:	Percentage of each group who responded "major barrier" <sup>a</sup>		
	World Links teachers who did not yet implement computers 1999	World Links teachers who did implement computers 1999	World Links teachers 2000
Lack of computer hardware/software	32	29	60
Lack of computers in good working condition	36	32	56
Lack of reliable electricity	24	18	18
Lack of adequate telephone line or services for access to the Internet	38	53	52
Lack of internet access for other reasons	31	24	52
Lack of the insufficient training for using computers and software	32	24	23
Lack of or insufficient technical support for using computers and software	31	24	23
Lack of or insufficient training or support for integrating computers into the curriculum	54	39	38
Lack of or insufficient training or support for using computers in collaborative student projects	38	22	35
Difficulty finding time to prepare for implementing technology in your classroom or at your school	56	43	44
Difficulty completing computer activities within the school's daily schedule	59	42	51
Difficulty finding time for computer activities, given other curriculum and testing requirements	61	51	49
Computer activities do not match well with your instructional goals and methods	15	10	10
Concern about whether technology would be valuable to your students	21	0	7
Concern that using technology in your school will affect the stability of your current job	4	0	4
Lack of access to existing computers	12	12	20
Lack of support from other colleagues	22	20	15
Lack of administrative support in school	37	17	15
Lack of a national policy on the use of computers in schools	42	29	36

<sup>a</sup> The response options provided to respondents were: not a barrier, minor barrier, and major barrier.

barrier the difficulty in finding time for computer activities, given other curriculum and testing requirements; 43% cited the difficulty in finding time to prepare for implementing technology in their classes; and 41% mentioned the difficulty in finding time within the school's daily schedule. As with WorLD teachers who were not able to use computers at all, relatively few computer-using teachers identified infrastructure problems, such as the lack of computers in working condition, unreliable electricity, or lack of access to the Internet, *per se*. However, 53% did say that a major barrier to using the computer as much as they had planned was the lack of adequate telephone lines for use with the Internet. Indeed, this was the most frequently cited major barrier for this group of teachers.

There were differences among the five countries in the kinds of barriers that teachers encountered in the 1998–1999 study. Teachers in Senegal (53%) and Chile (90%) most often identified the lack of time to integrate ICT into the curriculum as a barrier. Teachers in Senegal (53%) also most frequently identified lack of computers in good working order. On the other hand, teachers in Uganda (78%) and Paraguay (60%) most often identified inadequate telephone or Internet service as a barrier. Finally, 67% of the teachers in Peru identified the lack of training and support for integrating computers into the curriculum, the barrier most often mentioned by teachers in this country.

In contrast with the 1998–1999 teachers, World Links teachers from 12 countries who responded to 1999–2000 survey were most likely to identify the lack of computer hardware (60%), software (56%), and reliable Internet connections (52%) as major barriers to their use of ICT in their classes. These findings suggest that as the World Links scaled up the program, the organization was involving countries and schools within countries that were less technologically prepared and in more need of assistance. But even in these schools, the teachers agreed with their colleagues in the 1998–1999 study that a major barrier was finding time in the school's daily schedule to implement computer-related activities in their classes (51%) and that they had difficulty finding time given curriculum and other testing requirements (49%).

There were also differences among countries in the 1999–2000 study. Teachers in Mauritania (100%), Zimbabwe (67%), Ghana (74%), Chile (59%), and Peru (53%) most often mentioned the lack of hardware and software among the barriers listed in Table 7. All the teachers in Mauritania also mentioned the lack of computers in working order as a barrier. Inadequate phone lines or other Internet connection problems were most often mentioned by teachers in Brazil (88%), Colombia (65%), Mozambique (62%), and Paraguay (62%). Teachers in Senegal mentioned the lack of training and support for integration into the curriculum as a barrier; 78% of them mentioned this problem. And teachers in South Africa (62%) and Uganda (55%) were most likely to mention lack of time to integrate computers into the curriculum as a barrier.

The barriers to teachers' use of ICT were sometimes significant. However, it is also important to identify those factors that teachers did not consider as barriers. As important as those things that teachers considered to be barriers are those they did not. Regardless of country or year of the survey, few of the World Links teachers felt that computers did not match their instructional goals or methods (as contrasted to curricular goals). Few were concerned that the use of computers would have no value for their students. And very few were concerned that the introduction of computers in schools would affect their jobs status or stability.

## 5. Summary and conclusions

The findings from this study indicate that when technological infrastructure is developed in conjunction with appropriate teacher training, significant educational change can be achieved in developing countries. Despite the identified barriers and problems encountered by World Links teachers, we can infer from our data that students in World Links schools were more likely than computer-using students in non-World Links schools to use a variety of technologies, such as email, search engines, and the Internet. They were also more likely to engage in classroom practices that are often cited as important for preparing stu-

dents for the global knowledge economy, activities such as gathering data for a research project, collecting information about another country or culture, and collaborating on a project with students from another country.

By all indications, students not only engaged in these practices but acquired the skills that they will need to enter the global workforce. Students, teachers, and administrators agreed that the World Links program contributed to student outcomes such as improved skills in reasoning with information, communication skills, knowledge of other cultures, better attitudes toward school and technology, and, of course, improved technology skills. Furthermore, teachers and students (in the case of the 1998–1999 study) in the World Links program were more likely than those in non-World Links classrooms to say that students improved their communication skills, knowledge of current events, knowledge of other cultures, collaboration skills, and Internet skills. Finally, and most importantly, World Links students scored higher than non-World Links students in direct assessments of reasoning with information and communication skills.

Our findings support the argument that developing countries can benefit from investments in equipment, software, and network infrastructure. The findings also demonstrate the benefit of training teachers not only in the operation of hardware and software but in the integration of technology into classroom instruction. Finally, the findings demonstrate that the payoff of these investments is increased skills of both students and teachers. Taken together, these findings support the value of the World Links program and suggest that World Links and other programs which aim to build the technological infrastructure and teacher skills in developing countries can contribute to the improvement of education and reduction of the digital and perhaps economic divide between developing and developed countries.

But the barriers cited by World Links teachers, as well as findings from other studies (Means and Olson, 1995; Sandholtz et al., 1997; Means et al., 2001; Schofield and Davidson, 2002; Kozma, 2003) suggest that there are other actions and policies that if employed could increase the impact of

World Links and other such programs. On the technology side, better ways are needed to connect schools in developing countries to the Internet, especially low-cost, high bandwidth solutions that might benefit schools in remote areas that do not currently have reliable phone lines.

But the most-often cited barriers were not technological. World Links teachers consistently cited the lack of time for computer activities, given curriculum and examination requirements, the lack of time in the school day, and the lack of time for preparation. These findings suggest that teachers in developing countries are encountering the same barriers as teachers in developed countries are (Means and Olson, 1995). In turn, these time-related barriers suggest an underlying lack of priority for the use of ICT in current national and local policies. The lack of national ICT policy was also a barrier often cited by teachers. This barrier is most vividly illustrated by an incident during a field site visit by one of the authors (Kozma) to a World Links school in Uganda. When asked why a computer lab was empty during the school day, even though it was packed after classes, the teacher said that there was little fit between the use of computers and the national curriculum and examination system in Uganda. The use of computers was not in the curriculum nor would it be tested on the national exam. Consequently, it was difficult for the teachers of this school to justify using computers during regular school time.

Developing countries can draw on the experiences of other countries where ICT has come to have a more important role in education. In a growing number of developed countries, national policies identify a high priority for the use of ICT in education; see for example Singapore (Ministry of Education and Singapore, 2002), Finland (Ministry of Education and Finland, 1999), and US (US Department of Education, 2000). These policies and priorities are often expressed as an education technology master plan. These plans provide a vision for the use of technology in education and institute programs to support the realization of this vision (Jones, 2003). To maximize the impact of investments in educational ICT, the ICT policy needs to be coordinated with the policies of other ministries (such as telecommunications, human

resources, and science and technology) and with other policies within the ministries of education on matters related to teacher training, curriculum, and assessment.

Teacher training—both in-service and pre-service—needs to incorporate the use of ICT in classroom teaching. World Links teachers identified the lack of sufficient training and support for the integration of computers into the curriculum as another barrier. If computers are going to have a significant impact on the learning of students, it will be because they are integrated into the curriculum, not just as a separate subject such as computer literacy or keyboarding, but as tools to support the learning of science, mathematics, social studies, language, and creative arts. In the work world, technology is dramatically changing the way these school sub-

jects are applied to solve everyday problems. The integration of ICT into the learning of these school subjects can make a significant contribution to the preparation of students in developing countries for participation in the global knowledge economy and information society (21st Century Partnership, 2003; ISTE, 2000).

Classroom integration will depend on the integration of ICT into the formal national curriculum and testing program. Policies in an increasing number of developed countries (Jones, 2003) are incorporating the use of ICT throughout the curriculum as part of an explicit effort to reform education and improve student learning. Often these changes are coordinated with student-centered pedagogies. Some countries, specifically Singapore and Norway, are beginning to review their

### **Box 1. Selected Examples of WorLD School Projects on Environmental Issues**

#### **Ciencia a Conciencia (Conscientious Science)**

**Participating schools in:** Paraguay, Mexico

**Description:** Students learn collaboratively about various environmental issues including: deforestation; pollution; ozone layers; toxic wastes. They share results of findings and explore solutions to these problems. Findings from the collaborative learning activities are posted on the Web site.

**Web site:**

<http://www.enlaces.edu.py/cndelm/131198/circulos.htm>

#### **Wetlands Project**

**Participating schools in:** Uganda, Australia, USA

**Description:** The project brings together students around the theme of learning about and protecting local wetlands and waterways. Reports are prepared by students on: wetland conditions; legislation to protect wetlands; public awareness raising on the impact of human activities on the ecology; water levels and water quality of wetlands/waterways; and steps to take to ensure future protection of wetlands. Findings are shared among the participating students on the web-sites.

**Web sites:**

<http://www.viser.net/gs21/ugdepletion.htm> (school)

<http://www.camperdowncoll.vic.edu.au/global/wateryworlds/wetlands.htm> (project)

#### **Flora y Fauna**

**Participating schools in:** Peru, Chile, Brazil, Argentina, U.S.A.

**Description:** An interdisciplinary project where students learn about “Flora and Fauna” from various approaches including: mathematics (statistical/geometric/measurement aspects); literature (metaphoric use of plants & animals in literature); language (translation).

**Web site:**

<http://www.geocities.com/Athens/Atlantis/6126/proyecto.htm>

approach to national assessments and examinations so as to incorporate the use of and learning from ICT.

If developing countries set their national priorities to emphasize the use of ICT in education and these are coordinated with other policies related to teacher training, curriculum, and assessment, the foundation will exist for teachers to integrate computer activities into their daily practice. This in turn will prepare students for the global knowledge economy and contribute significantly to closing the digital divide between developed and developing countries. Without such national policies, priorities, and resources, in all likelihood the digital divide will continue to grow.

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