1. MONITORING AND EVALUATION OF ICT FOR EDUCATION IMPACT: A REVIEW

ROBERT B. KOZMA

Executive Summary

- Research evidence shows that simply putting computers into schools is not enough to impact student learning.
- Nevertheless, specific applications of ICT can positively impact student knowledge, skills and attitudes.
- ICT use can benefit girls and boys, as well as students with special needs.
- ICT can contribute to changes in teaching practices, school innovation, and community services.
- Policymakers and project leaders should think in terms of combinations of input factors that can influence impact. Coordinating the introduction of computers with national policies and programs related to changes in curriculum, pedagogy, assessment, and teacher training is likely to result in widespread use and learning.

In a world of constrained resources, it is no surprise that *measuring impact* should be near the top of the development agenda. Without demonstrated impact, why would anyone invest in development work, with or without technology? How do we claim credible evidence of impact? In the ICT domain in particular: Are there specific ways to define and measure impact?

Technology advocates describe a range of potential impacts that ICT can have when applied to education. These include:

- Student outcomes such as increased knowledge of school subjects, improved attitudes about learning, and the acquisition of new skills needed for a developing economy. Beyond learning outcomes, ICT may help close the gender gap, and help students with special needs.
- Teacher and classroom outcomes such as development of teachers' technology skills and knowledge of new pedagogical approaches, as well as improved mastery of content and attitudes toward teaching.
- Other outcomes such as increased innovativeness in schools and increased access of community members to adult education and literacy.

With the promise of these outcomes, government policymakers and NGOs in developing countries have put computers in schools and connected them to the Internet provided students with multimedia tutorials and simulations, trained teachers and given them access to new resources, provided schools with management and productivity tools, and established community technology and multimedia centers in villages. These resources represent significant investments, particularly in light of limited resources and competing needs in developing countries. What have we learned from these experiences? To what extent has the potential of ICT been realized? And how do we use what we know to support the Millennium Development Goals?

In this chapter, we summarize the research results on the impact of ICT on students, teachers, schools, and communities. While the large majority of existing studies in these areas are from OECD countries, the results coming in from developing countries support similar conclusions. We will address some of the studies from the developing region to provide a basis for understanding the benefits and limitations of the various study designs that were deployed. Finally, we draw some conclusions of immediate relevance to policymakers.

1.1 STUDENT OUTCOMES

1.1.1 *Impact on learning of school subjects*

The most pronounced finding of empirical studies on ICT impact is that there is no consistent relationship between the mere availability or use of ICT and student learning. Two major studies in the U.S. found a positive relationship between availability of computers in schools and test scores.[1] A study in Australia[2] found *no relationship* between computer availability in schools and test scores. Two large studies, an international study by Fuchs and Woessmann involving 31 developed and emerging countries[3], and another by Wenglinsky surveying U.S. schools[4], found a *negative relationship* between the availability of computers in the home and achievement scores.

However, digging more deeply into these and other student outcome studies, it becomes clear that the relationship between ICT and student learning is more complicated. When looking at *communication or educational uses* of home computers the researchers[5] found a positive relationship with achievement. Also in this study, students who *occasionally* used computers in schools scored higher than either those who never used them or those who used them regularly. But even these results are misleading. Students in this study were tested on mathematics and reading but the data collected on computer use was general; even the educational use was not specific to math or reading. In order to understand the connection between the input (computer use) and the output (learning in school subjects), it is essential to have the learning measurement directly correspond to subject area in which the technology is used.

Some studies have looked at this direct relationship. For example, the Wenglinsky study cited above measured the amount computers were used in mathematics classes and scores on math tests. The study found a *positive* relationship between the use of computers and learning in both 4th and 8th grades. Similar positive relationships have been found in OECD countries between computer use for specific school subjects and scores in those subjects for mathematics[6], science[7], and literacy[8]. Still, some studies in mathematics have found negative relationships between computer use and scores[9].

Conclusions from such studies are limited by the fact that they use correlation analysis. With this type of analysis, factors are simply *associated* with each other. It cannot be concluded with confidence that one *causes* the other, the question often asked by most policymakers. For example, it may be that the brightest students use computers most and it is student ability that accounts for higher scores rather than computer use. Causality can only be assured with controlled experiments, where one group uses computers or uses them in a certain way and an equivalent group does not. An example of this type of experimental study was conducted in Vadodara, India[10] in which students in primary schools used computer mathematics games two hours a week and students in equivalent schools did not (Box 1.1). The students who used computers scored significantly higher than the comparison students on a test of mathematics. The bottom group of the students benefited most and girls benefited as much as boys. One important limitation of this field-based experiment is the lack of a theory (and supporting analyses) of why some students gained more than others. Only by doing more in-depth data collection and analyses would usable policy outcomes become apparent.

While the Vadodara study is quite useful, especially as it relates to the design of M&E projects, we can draw conclusions with the most confidence when they are consistent across a substantial number of experimental

1 National Center for Educational Statistics, 2001a, 2001b
2 Banks, Cresswell, & Ainley, 2003
3 Fuchs & Woessmann, 2004
4 Wenglinsky, 1998
5 Fuchs & Woessmann, 2004
6 NCES, 2001a; Cox 2003
7 NCES, 2001b; Harrison, et al., 2003
8 Harrison, et al., 2003
9 Angrist & Lavy, 2001; Pelgrum & Plomp, 2002
10 Linden, Banerjee, & Duflo, 2003

BOX 1.1 India: An experiment using ICTs in primary schools

Pratham, a Bombay-based NGO, provided computers to 100 primary schools in Vadodara, India. In half the schools, teachers received five days of training in the use of computers and they were supplied with specially developed educational games in mathematics. The selection of the schools was randomized for the purpose of the evaluation and controlled for key input factors, such as student gender and previous math scores. A control group of schools whose teachers received no training continued with the regular curriculum that concentrated on core competencies in numeracy and literacy. It was observed that computers were not used in these schools. But in the schools where teachers were trained, students played computer games for two hours a week. Students in the participating schools scored significantly higher on mathematics tests. Students scoring lower on the pretest benefited the most and girls and boys benefited equally. It is clear that in this study, the higher scores in the participating schools were due to the package of input factors that distinguished it from the other group: a combination of teacher training, the software, and the use of computers.

Adapted from: Linden et al., 2003

studies. Kulik[11] looked at a large number of studies in the U.S. that were carefully designed. His findings across 75 studies can be summarized as follows:

- Students who used computer tutorials in mathematics, natural science, and social science score significantly higher on tests in these subjects. Students who used simulation software in science also scored higher. However, the use of computer-based laboratories did not result in higher scores.
- Primary school students who used tutorial software in reading scored significantly higher on reading scores. Very young students who used computers to write their own stories scored significantly higher on measures of reading skill.
- Students who used word processors or otherwise used the computer for writing scored higher on measures of writing skill.

We can have substantial confidence in such findings, at least as far as OECD countries are concerned, and as long as the demographics, technologies and school contexts do not change substantially over time. Yet even though the U.S. findings tend to run parallel to the Vadodara example above, it is important to consider how context and developments over time may affect outcomes. For example, early educational applications of ICT in the 1970's and 1980's in the U.S. focused on tutorial, drill and practice, word processing, and programming. Later applications used networking and the increased power of computers for visualizations and multimedia, simulations, microcomputer-based science laboratories, and Web searches. These different applications are likely to focus on different classroom practices and outcomes. Such changes will continue to occur as the technology develops in the future, and their varied and differential use by target populations may well affect the outcomes produced. Naturally, the cultural and socio-economic context will also have a major role in the impact of any ICT intervention.

1.1.2 *Impacts beyond the curriculum: Student motivation, new skills*

ICT can also have an impact on students beyond their knowledge of traditional school subjects. A number of studies have established that computers can have a positive effect on student motivation, such as their attitudes toward technology, instruction, or the subject matter. For example, the Kulik[12] analysis found that students using computer tutorials also had significantly more positive attitudes toward instruction and the subject matter than did students receiving instruction without computers. This finding corresponds to that in a comparative study conducted in physics classes in Kenya,[13] where two randomly assigned classes used computer-based instruction, while a third equivalent group did not. Students in the computer sections learned physics concepts better and expressed positive attitudes about their physics learning, as ascertained in interviews at the end of the lessons.

11 Kulik, 2003.
12 Kulik, 2003
13 Kiboss, 2000

BOX 1.2 World Links Program in Less Developed Counties

The World Links Program, originally managed by the World Bank and subsequently by a spin-off NGO, places Internet-connected computers in secondary schools and trains teachers in developing countries in Africa, Latin America, the Middle East, and South and Southeast Asia. The goal of the program is to improve educational outcomes, economic opportunities, and global understanding for youth through the use of information technology and new approaches to learning. Services provided by the program include:

- Feasibility studies and consultation on connectivity solutions and telecenter management.
- Teacher professional development on uses of technology in the context of innovative pedagogy.
- Workshops for policymakers on coordination of policies and implementation strategies.

As of 2005, the program has involved over 200,000 students in over 20 developing countries. The three-year evaluation of the program used a combination of approaches that included surveys of teachers, headmasters, and students, as well as direct assessment of student learning. Teachers and students in participating schools were compared with computer-using classes in equivalent non-participating schools.

Adapted from Kozma, et al. (2004).

Students also learn new skills that go beyond traditional school knowledge. Many technology advocates argue for the inclusion of a more sophisticated set of "21st Century skills" in the curriculum in order to promote economic development[14]. They claim that the use of ICT can support the learning of such skills as technology literacy, information management, communication, working in teams, entrepreneurialism, global awareness, civic engagement, and problem solving.

One example that promotes these skills is the World Links program, in which African and Latin American secondary teachers and students use networked computers to support student-centred pedagogy (see Box 1.2). In the evaluation of this program[15], both students and teachers more often reported that World Links students learned communication skills, knowledge of other cultures, collaboration skills, and Internet skills. In addition to these self-reported data, a connected study in Uganda used a specially designed performance assessment to directly measure student learning of these skills[16]. The study found that World Links schools out-performed the non-World Links schools on measures of communication and reasoning with information.

1.1.3 *Impact on diverse students*

An important Millennium Development Goal is to achieve gender equity. If girls are to leave school ready to participate equally in the economy, they too will need the benefits of ICT: increased knowledge of school subjects and new skills, including ICT skills. However, much of the research in OECD countries shows a gap indicating that boys have more experience with technology than girls and that girls are more anxious about technology than boys[17]. Fortunately, studies also show that greater experience with computers results in improved attitudes among girls. Many technology-supported programs in developing countries focus on including girls' use of computers, and data on impact often shows no gender gap. For example, girls and boys learned equally from the use of computers in the Vadodara study cited earlier[18]. In the World Links evaluation, teachers reported no difference between girls and boys in a wide range of learning outcomes related to computer use[19]. In Andhra Pradesh (India), Wagner and Daswani[20] have reported that poor girls learn more than boys in a non-formal ICT-based literacy program, when controlled for years of schooling (see Box 5.1 in Chapter 5).

14 National Research Council, 2003; Partnership for the 21st Century, 2005
15 Kozma, et al., 2004; Kozma & McGhee, 1999
16 Quellmalz & Zalles, 2000
17 Blackmore, et al., 2003; Sanders, in press
18 Linden, et al., 2003
19 Kozma & McGhee, 1999
20 Wagner & Daswani, 2005

ICT can benefit very diverse types of students. There is also quite consistent evidence, at least in the Western research literature, that students with disabilities, indigenous (minority language speaking) students, and students from low income homes all experience growth in their sense of self esteem and autonomy in their learning when given access to computers in the context of student-centered pedagogy[21]. Further discussion of this area, with examples from developing countries, is provided in Chapter 5.

1.2 TEACHER AND CLASSROOM OUTCOMES

1.2.1 *Impact on teacher skills and motivation*

Many governments are using the introduction of ICT as a way of providing teachers with new skills and introducing new pedagogy into the classroom. For example, teachers participating in the *Enlaces* program in Chile receive two years of face-to-face training consisting of at least 100 hours[22]. As a result, teachers acquire familiarity with computers and use them regularly for tasks that are professional (e.g. engaging in professional circles, e-learning), managerial (e.g. student marks, parental reports) and out-of-classroom (e.g. searching for educational content on the web, lesson planning).

The World Links program provided 200 hours of teacher training which included an introduction to ICT, use of the Internet for teaching and learning, use of tele-collaborative learning projects, integration of ICT into the curriculum and teaching, and innovative pedagogical approaches. The evaluation of the World Links program[23] found that a large majority of teachers and their administrators reported that teachers learned these new computer and teaching skills, and gained more positive attitudes about technology and about teaching.

1.2.2 *Impact on classroom practice*

The use of ICT has often been thought to bring significant changes into classroom practice. This was evident from school surveys conducted in 26 countries[24] and a series of case studies conducted in 27 countries in Europe, Asia, North America, South America, and Africa[25]. These studies and others show that innovative classroom use of computers depends not just on the availability of computers in schools but also on other factors such as administrative support, teacher training, and supportive plans and policies.

The extensive teacher training provided by the World Links program resulted in teachers not only *learning* new skills but also *changing their classroom practices*. World Links teachers and students more often used computers to engage in a wide variety of new practices than did non-participating teachers who also had access to computers. These practices included conducting research projects, gathering and analyzing information, collaborating on projects with students in other countries, and communicating with parents and other community members[26].

However, there are also significant barriers to widespread ICT-supported change in classrooms in developing countries, such as lack of time in the curriculum and school day, lack of skilled personnel, and lack of infrastructure, including power, telecommunication access, and Internet service providers[27]. National policies can address many of these barriers and make a difference in widespread use of ICT to change classrooms.

When countries commit to coordinating the introduction of computers with changes in the curriculum, pedagogy, and teacher training, changes in classroom practices are more likely to be widespread. For

21 Blackmore, et al., 2003
22 Hepp, et al., 2004
23 Kozma, et al., 2004
24 Pelgrum & Anderson, 1999
25 Kozma, 2003
26 Kozma, et al., 2004
27 Williams, 2000; Kozma, et al., 2004

BOX 1.3 Thailand: Use of Handheld Devices

In the *Thai Project on the Uses of Low-cost Technology in Science and Mathematics*, an evaluation study was undertaken to measure the effectiveness of using low-cost handheld devices (e.g., calculators, probes or sensors) to assess the design patterns of sticky rice baskets for maintaining appropriate temperature and humidity of steamed sticky rice. Teachers encouraged the students to identify local problems of their own interests, and had local people, and science faculty of the university act as learning resources for the students' investigations. Learning with handheld devices not only encouraged students to explore with greater pleasure and curiosity, but also helped them gain a deeper understanding of Thai heritage and develop higher-order thinking skills.

The project was one example of the efforts of the Thai Institute for the Promotion of Teaching Science and Technology (IPST) to explore the potential uses of handheld technology across science and mathematics enrichment programs. It was designed for upper secondary students at 7 schools and began in the year 2000. The major inputs included handheld tools supported by Texas Instruments (Thailand), a series of teacher professional development and curriculum materials incorporating the uses of handheld devices, and a supportive network amogn government schools, IPST, resource teachers, and universities. Monitoring and evaluation were undertaken through school visits, classroom observations, teachers' and students' portfolios, and feedback from school principals. Judging also from a number of award-winning student science projects, it could be said that these achievements resulted from the effective uses of technologies, handhelds in particular. An increasing number of schools, particularly those having limited access to ICT infrastructure and connectivity, can now incorporate handhelds into their school curriculum in lower secondary science and mathematics classrooms. Provision of time, recognition of success from the principal in the pedagogical uses of technology, and a collaborative network among stakeholders sustained the uses of technology in schools.

Adapted from Waitayangkoon, 2004.

example, Costa Rica introduced computers in primary schools in rural and marginal urban areas along with the Logo programming language and other software tools to support constructivist pedagogy and collaborative classroom activities to develop students' cognitive skills and creativity[28]. The *Enlaces* program in Chile is a nation-wide effort that introduced networked computers into secondary and primary schools in conjunction with a national reform effort that encouraged the use of project-based learning and small group collaboration[29]. As a result, computers are widely used in Chile along with new classroom practices.

1.3 BROADER CONTEXTUAL OUTCOMES

1.3.1 *Impact on schools*

It is sometimes claimed that the introduction of ICT into schools can significantly transform school organization and culture[30]. However, the causality in this relationship is likely bi-directional: the introduction of technology promotes organizational change in schools, and transformed school organization can increase the use and impact of ICT. An OECD study of ICT-supported school change in 23 countries[31] provides evidence that the introduction of computers can be used as a lever to launch the cycle of ICT-supported organizational change in schools. To date, there is a dearth of research in developing countries on the school-level impact of ICT and future research needs to address this deficiency. In one recent example (see Box 1.3) in Thailand, there was an effort to utilize low-cost handheld devises. While the work is intriguing,—as with many studies to date, the M&E aspect is too limited for firm conclusions to be drawn.

1.3.2 *Impact on communities*

The introduction of ICT via community technology centers or multimedia centers, in a variety of geographical locations, can also address MDGs related to education and economic development, according to a significant body of research in developing countries[32]. Typically, these programs utilize a mix of technolo-

28 Alvarez, et al., 1998
29 Hepp, et al., 2004
30 OECD 2001; UNESCO, 2005
31 Venezky & Davis, 2002
32 Pringle & Subramanian, 2004; Slater & Tacchi, 2004; Wagner, et al., 2004

gies—such a radio, video, computers, and Internet access—that are used by established community-based service agencies. They provide community members with information and services related to ICT skills, adult literacy, and education for out-of-school youth, especially girls. However, most of the literature in this area is descriptive and does not systematically assess the impact of ICT on education and community development. Impact research is needed. At the same time, it is important to note that many of these efforts are still in the early phases, and evaluations should be sensitive to fact that these services do not result in "quick fixes".

1.4 SUMMARY AND IMPLICATIONS

1.4.1 *Impact of ICT on education*

The research to date on ICT on education has provided us with important findings that are relevant to policymakers and to the Millennium Development Goals. The most important may be summarized as follows:

- The mere availability or use of computer does not have an impact on student learning. However, results are clear that *certain* uses of computers in specific school subjects have a positive impact on student learning in those subjects.
- Specifically, computers have a positive impact on student attitudes and the learning of new kinds of skills, when ICT is used in conjunction with student-centered pedagogy.
- Computers may benefit girls and boys equally and can be effectively used by students with special needs.
- Teacher training is important. Through it, teachers can learn ICT skills and new pedagogical skills and these often result in new classroom practices.
- ICT can also be used to launch innovation in schools and provide communities with new educational services.

1.4.2 *Limitations of current research*

There are important limitations to the research conducted on impact to date, and these have implications for future studies.

- Most studies have been conducted in OECD countries, and these represent the particular circumstances and concerns of policymakers and researchers in these (largely) industrialized countries. While M&E studies are starting to emerge in developing countries, more are needed in order to support—or call into question—claims of success.
- Studies that rely on correlation analyses are open to multiple conclusions. Well-designed experimental studies would provide greater confidence, but at increased cost (see Chapter 3).
- Case studies provide the most detail about *how* ICT is used in classrooms, and they can provide practitioners with information to use when implementing ICT programs. Priority should also be given to conducting case studies and structuring them to be useful to practitioners.
- Impact research results are not static, but rather—and especially in the fast-moving area of ICT—must be seen as subject to change over time. For example, the impact on grades of touch-typing skills or web access in the year 2000 is likely to be very different from that 5 or 10 years later, when speech recognition is widely available, whether the person is living in Brazil or the United Kingdom.

1.4.3 *Implications for policy*

- Since computer availability alone will not have an impact, policymakers and project leaders should think in terms of *combinations* of input factors that can work together to influence learning. Coordinating the introduction of computers with national policies and programs related to changes in curriculum, pedagogy, assessment, and teacher training is more likely to result in widespread use and impact.
- Policymakers in developing countries also need to address the barriers to ICT use. These will vary from country to country, but they may include a lack of skilled support staff and adequate infrastructure.

- Program monitoring and evaluation can provide policymakers and program directors with important information on the success and impact of their policies and programs related to ICT. These efforts should be adequately funded and they should be integrated into the initial planning process.

KEY REFERENCES FOR THIS CHAPTER:

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