Research Article

Technology and Mother-Tongue Literacy in Southern India: Impact Studies among Young Children and Out-of-School Youth[1]

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Abstract

The present research began with one main question: How can new technologies be effective for poor and illiterate children and youth in developing countries? We addressed this question through a research-based implementation project in India that included the development of local language multimedia software for literacy; a built-in, user-friendly interface; and the use of existing computer infrastructure. Two studies were undertaken in Andhra Pradesh state. One included a sample of youth and young adults who had never gone to school (or dropped out early) in peri-urban Hyderabad, and the other was composed of young second- and third-grade school children in rural West Godavari district. Based on a short-term intervention program, research results demonstrated a modest positive impact on the learning rate in reading with both groups of learners (when compared with control groups without the multimedia intervention). The findings provide support for the view that information and communications technologies for development can assist in promoting literacy among the poorest of the poor. In addition, the present results support the view that the digital divide, as it evolves over time, will only be narrowed when content-based solutions are sensitive to, and built on cultural and linguistic diversity.

Introduction

How can new technologies be effective for poor and illiterate children and youth in developing countries? Initial reactions from development specialists include the following (often) negative reactions: (a) infrastructure is not available, (b) costs are too high, (c) illiterates can't use technology, (d) technology can't really assist in literacy education, and (e) literacy needs more books than bytes. These and similar comments are among the reasons why relatively little work has taken place to use technology in support of literacy in developing countries. The research presented in this paper suggests that these types of general critiques may no longer be valid. To the contrary, new technologies may play an essential role in moti-

1. This research was undertaken as part of the Bridges to the Future Initiative (BFI) at the University of Pennsylvania. Project support has been provided by JPMorgan Chase, World Bank, Spencer Foundation, U.S. Department of Education, UNESCO, UNICEF, ICICI Bank, IIIT-Hyderabad, Azim Premji Foundation, and Byrraju Foundation. The authors would like to thank a number individuals for their support during the project, including Bhaskar Chatterjee, Russell Cole, Verghese Jacob, Gauri Kirtane-Vanikar, Pawan Kumar, Dominic Price, Philip Sirinides, E. S. Sridharan, I. V. SubbaRao and Namrata Tognatta.

vating poor and excluded populations into greater participation in high-quality learning and education.

In an era of increasing globalization, the term *digital divide* has become an increasingly frequent way to describe gaps between rich and poor countries, and between the rich and poor populations within countries (OECD, 2000). Indeed, access and use of new information and communications technologies (ICTs) is one way for some policy makers to think about "leapfrogging" to improve social and economic development. Yet it has also been pointed out that the large majority of spending in the new sector called ICT4D (i.e., ICT for Development) has focused on those most easily reached by ICTs (namely, those in cities with at least a secondary school education), rather than on reaching the very poor (Wagner & Kozma, 2005). Even Bill Gates rather famously said at an international conference on the "digital dividends" of ICT4D investments that he (and his foundation) found it more useful to put funds into the health sector than into technology as a means to help the poorest populations (Gates, 2000). About a decade later, Gates has proved largely correct, at least in terms of where funding has gone. Rather little investment in ICT4D has gone to the very poor (illiterate children with little or no schooling, girls and women in difficult domestic circumstances and living in predominantly rural areas, and those speaking minority languages). And, it is precisely these populations that are a major focus of the United Nations in its Millennium Development Goals (MDG) and the Education for All (EFA) initiatives. Further, there remains only modest evidence to date that supports the effectiveness of ICTs in the education of very poor populations (Wagner, 2005).

It was the challenge of thinking about how to best use new ICTs for development that led to a project called the *Bridges to the Future Initiative* (BFI), a multinational effort to bring improved literacy to poor and low-literate parts of the southern Indian state of Andhra Pradesh (AP) via technology in the mother-tongue language.[2] There are naturally many challenges associated with the effective use of ICTs among poor and disadvantaged children and youth who have had no previous experience with technology and have low levels of literacy, such as: How will illiterates manage a keyboard? In which language(s) should instruction take place? Who would provide the computers? What type of media should be used for those with no prior computer experience? The present research is based on the implementation of the BFI ICT-based literacy program in two contrasting Telugu-speaking populations in Andhra Pradesh state: one sample of youth and young adults who had never gone to school or dropped out early in a peri-urban area outside of Hyderabad, and the other composed of young second- and third-grade school children in a rural eastern part of the state.[3] It is useful to begin with some background on aspects of current thinking about the uses of technology for education and literacy in developing country contexts.

Technology and Education for Development: Some Key Issues

Growth in the use of new technologies in both industrialized and developing countries is dramatic—with the overall rate of a half-trillion constant dollars per annum and roughly similar national increases relative to GNP both across the globe and across all regions (WITSA, 2008; see Figures 1a & 1b). Donor agencies such as the World Bank continue to assist developing countries, though their general emphasis to date has been on access to infrastructure, networking, and government regulatory mechanisms (Khalil & Kenny, 2008; World Bank, 2003). Yet, in spite of these ICT investments, it has been estimated that only a small fraction (probably less than 5%)[4] has gone to assist poor and disadvantaged populations that are the focus of the UN MDG and EFA initiatives mentioned above. Indeed, there is considerable pressure from donor and government agencies alike to invest in ICTs that have immediate impact—namely, those that can be installed and secured relatively easily,

2. The BFI in India was led by the International Literacy Institute (www.literacy.org) at the University of Pennsylvania, in collaborative partnership with the Delhi-based University of Pennsylvania Institute for the Advanced Study of India, in collaboration with the state Government of Andhra Pradesh, India. Other countries have been involved in the BFI, and in particular, South Africa, where a similar project is currently underway.

3. Naturally, there were numerous hurdles that are largely beyond the scope of the current presentation, including the design of "extreme user-friendly" interfaces, mother-tongue digital materials, implementation strategies in communities with inconsistent electricity and no reliable Internet connectivity, and so forth. See Wagner and Kozma (2005) for further aspects of the implementation strategy.

4. Wagner (2005a).

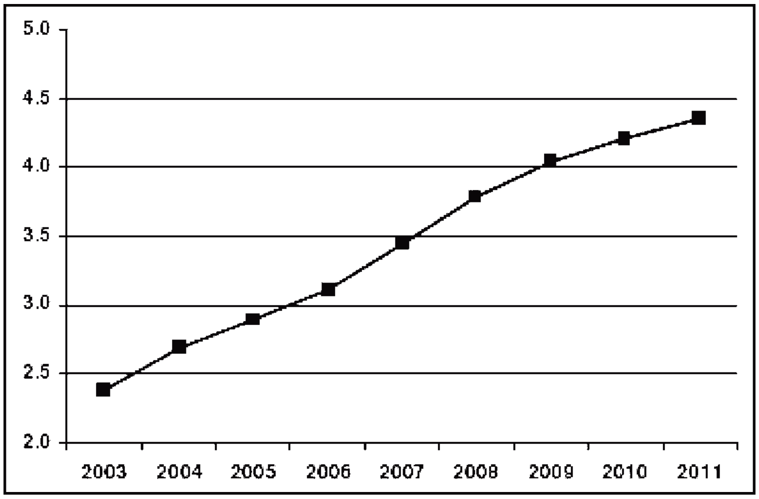

Figure 1a. Overall Global ICT Spending, 2003–2011 (in US$ Trillions).
Source: WITSA, 2008.

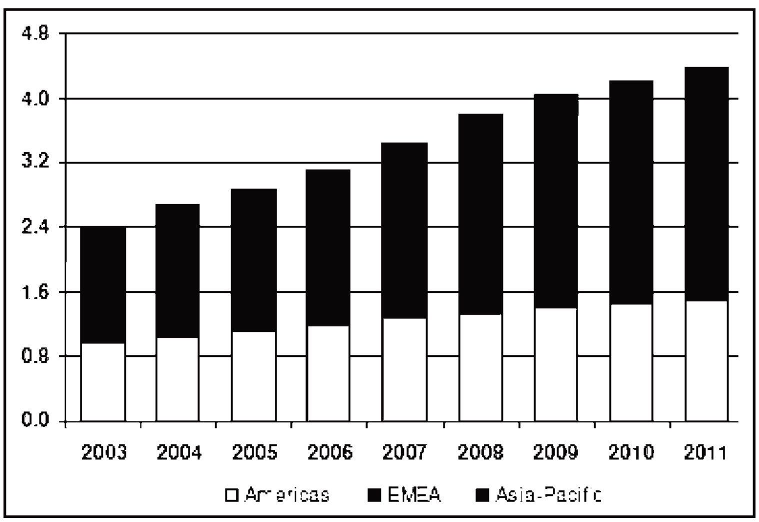

Figure 1b. Global ICT Spending by Region, 2003–2011 (in US$ trillions).
Source: WITSA, 2008.

such as with secondary school youth in urban areas. From an EFA perspective, one could argue that these are the groups *least* in need (Wagner, 2009).

Of course, a common concern about ICT4D programs for the very poor is that they might be "too illiterate" (in both the traditional and technological literacy senses of the term) to take full advantage of the power of new technologies (UNDP, 2001). Thus, there are a number of key issues that need to be addressed if one is going to take on the challenge of a "pro-poor" ICT4D project (Unwin, 2004). From this perspective, access and connectivity (i.e., the ICT infrastructure) are not as central as developing *content* in relation to user needs and user skills (Geldoff, 2009; Haddad & Jurich, 2002). To reach the poor in any country, one must not only locate and target this population, but also determine their needs, as well as ways to communicate in their indigenous languages (UNESCO, 2010). Typically, this would put an emphasis on women and girls in rural areas—those who most often speak languages other than the national official language. Ample research on women and ethnolinguistic minority populations suggests that these are among the most marginalized poor, whether in industrialized or developing countries (Hornberger & Corson, 2008).

From an ICT4D perspective, the scientific challenge is to determine what kinds of approaches would be most effective. If the target population is illiterate or barely literate, then one would have to create content that allowed interaction and learning with little or no technological skills, creating an extremely user-friendly interface (e.g., Kam et al., 2009; Medhi et al., 2008). Further, one would need to focus on local languages (and literacy) to assure understanding of content that is within the skill competencies of learners (e.g., Alidou et al., 2006; Crouch et al., 2005; Glewwe et al., 2009; Wagner, 2010), even those who are presumed to be illiterate and low-literate.[5] And, one

5. Some efforts have been devoted to the poor and illiterate, occasionally making the claim that ICTs can overcome (by sheer innovation and motivation) cognitive and attitudinal constraints that are implied by paying attention to the cultural, linguistic, and skill backgrounds of learners. Indeed, this is one of the problems, in our view, with those who ap-

would have to pay close attention to the cultural context in which learners are motivated (or not) to participate in organized educational programs.

Finally, there is the choice of context for such a study. To address possible linkages of ICT implementation to improved literacy in children and in adults, a country like India would be ideal. India has huge educational needs, as well as a growing ICT infrastructure and a desire among educationists to bring technology to bear on national problems like basic education and literacy. India is also a country with a great diversity of languages (and orthographies) spread across far-flung regions that are often at the edge of the electric and Internet grids. If an example in South India could show the way to using ICT to truly help the poor, we reasoned, the model could be picked up and taken across to other parts of India, and into other countries.[6]

Language and Educational Context in India

Indian languages belong to two distinct language families. Languages like Hindi, Bengali, Gujarati belong to the Indo-Aryan family of languages, which is a subfamily of the Indo-European family of languages. Languages like Tamil and Telugu belong to the Dravidian family of languages. These two language families have coexisted for centuries, with the speakers of different languages communicating with each other across languages.[7] In the process, many linguistic features have been borrowed across language families and assimilated.[8] In Andhra Pradesh, the majority language is Telugu (spoken as mother-tongue by about 85–90% of the population), with Urdu, Hindi, and tribal languages spoken by the remainder as first languages. Second language fluency, to varying degrees, consists primarily of English and Hindi, which are taught in schools.

In 1964, the Indian government decided to introduce in the school system what has come to be referred to as the "three-language formula," which requires all school children to study three languages during the first 10 years of schooling. The formula envisaged the mother-tongue of the learners (or the state's official language) as the first school language and medium of instruction at the primary stage, followed by the national official language, Hindi, as the second language at the upper primary stage, with English as the third language to be introduced any time between grades six to 10 (Daswani, 2001). One of the major languages of India, Telugu is the third largest language in the country (70 million speakers, or about 8% of the Indian population). Telugu is a "scheduled"[9] language, as well as a regional language. Additionally, it is the official state language of AP, and has a long literary tradition. In the Telugu script, as in other Indian languages, each consonant in the alphabet can combine with the 14 vowels. Each of the 14 vowels has a unique combining graphic shape that can be attached to any consonant.

The formal education system in India is modeled on the British system that was introduced in 1857. From 1857 to 1922, the government-supported

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proach the ICT4D effort with what one might call a missionary zeal, including those simply supporting Internet access for poor children (Mitra, 2005), or those who would simply promote hardware solutions, as in the critique of OLPC (James, 2009). There have been research-based efforts to use ICTs to support literacy in developing countries, but few have come up with solid empirical support to date (see Farrell, 2004; Barrera-Osorio & Linden, 2009). Some have looked at same-language subtitling (Khotari et al., 2004), while other recent efforts have been devoted to a better understanding of Web-based literacy skills (Leu et al., 2009).

6. Indeed, the methodology of the present BFI project is now underway in South Africa.

7. Nearly all Indians speak languages that belong to these two major language families—languages that have long written and literary histories. The orthographies of these languages derive from a common source: the Brahmi script. Nonetheless, apart from these two major language families, a small number of Indian languages are classified as part of the Tibeto-Burman and Austro-Asiatic language families, which are spoken by about 3% of the population, and include a large number of "tribal" dialects. Many of these are unwritten; though some have been alphabetized, very few of these have written literary histories.

8. Speech sounds, grammatical features, and vocabulary all have been borrowed across language boundaries. According to the 1981 Census of India, there are 105 Indian languages, each spoken by more than 10,000 people. Of India's 50 written languages, only 14 have long literary traditions; the other 36 written languages have relatively recent literary histories. Of the remaining living languages, 32 have alphabets, but very little written literature. Fourteen languages do not, as yet, have an alphabet (Daswani, 1994).

9. The constitution of India, adopted in 1950, recognized 14 official Indian languages that were termed "scheduled languages." There are now 22 scheduled languages in India.

English-medium school system flourished and covered all areas of education, from primary schooling to university education. After Indian Independence in 1947, and especially after a linguistic reorganization of states in 1957, the educational system made significant strides in the direction of education through the official languages, such as Telugu in AP state. Nonetheless, the English language continues to be used as the medium of instruction in many universities, in national institutes of science, technology, and specialized research, and in a growing number of private schools in AP state and elsewhere.[10] As a system, Indian schooling covers 12 years of instruction. The educational structure divides the 12-year period into four stages: Primary (grades 1 to 5), Upper Primary (grades 6 to 8), Secondary (grades 9 to 10), and Senior Secondary (grades 11 to 12).

Despite decades of effort and billions of rupees spent, India still has the largest number of out-of-school children in the world. A recent study conducted by the UNESCO Institute of Statistics (UIS, 2005), estimates that around 25 million school-aged children are presently not attending school. In other words, one out of every four school-aged children is not in school. The initial enrollment rate of students in primary school in India is high, but by the age of 10–11 years (about fifth grade), about 40% of the students enrolled have dropped out (Kriplani, 2005). As in many poor parts of India, children in AP state have even higher rates of dropout, about 59%, by fifth grade. The large majority of children who drop out come from poor and rural families, and more than 75% of these school dropouts are girls (Chudkar, 2009; Govinda, 2002).

Major reasons for the early dropout are similar to that of poor areas worldwide, namely poverty, parental illiteracy, insufficient educational facilities (especially in rural areas), inadequate curriculum, school language (as against the home language), and migration. In the case of the present study, a separate report confirms these findings in AP state (Wagner & Daswani, 2006). Nonetheless, the term "dropout" does not adequately reflect the complex factors that lead children to drop out of school. A primary factor in this phenomenon can be termed "pullout," when indigent parents in rural areas pull their children out of school around age 9 or 10 years. The male children are pulled out for economic reasons because, by age 10, they are able to help the family by earning a wage, however small. The female children are pulled out for economic and cultural reasons. Girls are given the task of minding younger siblings at home while the parents go out to work. Also, in a tradition-bound AP society, girls, as they approach the age of puberty, have to be protected and readied for their future role as wife and mother. Another factor that contributes to large-scale dropout may be termed as "pushout"—a function of the school system itself.[11] In multilingual settings such as India, where numerous dialects and local varieties of major literary dialects are spoken, the formal education system tends to employ the standardized version of the language used as the medium of instruction. Teaching-learning materials are typically written in the formal style of the standard written languages, generally ignoring the linguistic competence of the learners in their mother tongues.

Thus, as has been found in many poor multilingual societies, first generation learners in AP state who come from poor families often find the formal school textbooks and curriculum, and the language of schooling beyond their comprehension. These children speak a local dialect or a tribal language at home and in their social settings. When they enter school, they are faced both with the task of contending with instruction in the standard language, and with a formal instructional system. Moreover, the primary school curriculum is typically irrelevant

10. The growth of "English-medium" schools (where English is the language of instruction) has been exponential in recent years in India. This is so despite a significant problem of quality control, where a typical small school might have no teacher who is effectively fluent in English, and yet parents support their children's learning with very scarce funds in the (mainly erroneous) belief that English-medium education is best for their children's chances in life, even in poor communities such as the ones in which we worked in Andhra Pradesh state.

11. Daswani (2001). The BFI intervention focused on improving skills, so that the "pushout" children could rejoin the mainstream formal school at the relevant cohort-group level. This is similar to what other NGOs are trying to do in "bridge" programs, although those are mainly conducted without the advantages of ICTs. Even though our focus in this work was on skill gains over time, we found that the CAI treatment was influential in helping youth re-enter the school system after the BFI program. We gathered evidence that a substantial portion, up to 30% of the OSY, returned to school after the BFI program. However, there was no possibility of a control group to which we could compare this finding.

to the learning needs of these children, because the curriculum is determined centrally by the department of education and focuses entirely on the needs of urban children who come from literate families, and who are likely to continue in the school system. Unable to comprehend the school language and curricular demands of the system, the poor rural children often fail in the early grades and are pushed out by the system.

The BFI project in AP state consisted of two geographical and age-related samples. In Study 1, the BFI project was conducted in a peri-urban area just outside the highly urban area of Hyderabad, known as the Ranga Reddy district. In Ranga Reddy, the AP government has an ongoing "bridge course" program[12] for bringing out-of-school children and youth (OSY) back into the formal school. The BFI project, in partnership with the AP government, aimed to help this OSY population return to school by implementing computer-aided instruction (CAI) in the mother-tongue language. Based on a substantive needs assessment (Karnati, 2008), a target sample of OSY was found with very low literacy competencies. In Study 2, the project was undertaken with young primary school children (PSC) who were just beginning to learn basic skills in the poor rural area of West Godavari district, located near the Eastern coast of India, just north of Tamil Nadu state.[13]

As described further below, these two samples of children and youth provided an unusual opportunity to test the impacts of the same ICT-based intervention. It is relatively rare that the same ICT intervention has been able to be implemented with populations with such a wide range of ages, and with such different educational histories. Our overriding purpose was to see if CAI designed in a highly user-friendly and context/language-sensitive fashion could increase learning when compared to similar, but non-CAI, educational experiences. By conducting these two studies in "typical" poor areas of India, our goal has been to see not only if the model worked, but if it worked well enough to be considered for scaling up into other parts of India, and into similar contexts in other developing countries.

Designing a Technology-based Learning Intervention

The BFI model of computer-aided instruction, with built-in mother-tongue literacy content, was designed to take advantage of the existing ICT infrastructure located in secondary schools in Ranga Reddy, and in primary schools in West Godavari.[14] In Study 1, in Ranga Reddy, each of the BFI sites had two instructors who supervised the facilities and provided (minimal) support to the learners; the program took advantage of after-school time of two hours per day.[15] In Study 2 in West Godavari, there was a single school teacher-monitor in each of the participating primary schools, and the children had about 20 minutes per day on the computer as a supplement to the regular school instruction. The BFI multimedia software was developed by educational specialists working in close relationship with Telugu-speaking teachers from AP state education authorities for the development of content validity.[16]

12. In a "bridge course," the idea is to provide a bridge of learning, so that children and youth can find a way back into the formal educational system. Bridge programs may be established and managed by either government or (more likely) nongovernmental agencies.

13. The project in West Godavari was supported through collaboration with the Byrraju Foundation, which has supported numerous socioeconomic activities in the district, including that of the BFI.

14. In Study 1 in Ranga Reddy, as in other urban and peri-urban areas of Andhra Pradesh state, there exists a "Thousand Schools" initiative, wherein the state government has set up computer labs for secondary school children. The BFI was able to obtain access to these special sites where personal computers were made available for two hours after the school children had left for home. At this point, usually in the late afternoon, the OSY children, as part of the BFI project, were allowed access to the computer labs, which had about 10–12 PCs in operation. In Study 2, in rural West Godavari, access was provided through the assistance of both the state government and the Byrraju Foundation. The latter provided the technology for use in the primary schools. Byrraju also facilitated the quasi-experimental comparison of those children with BFI mother-tongue multimedia, and those without.

15. The "Thousand Schools Computerization Project" program in Ranga Reddy did not have regular school instructors in the computer labs. Rather, the "instructors" were part-time high school graduates, with some Microsoft training, but lacking in any teacher qualifications for the most part. They were there to provide security so that the PCs would not be stolen, to assure that the machines were working, and to report them to the maintenance group if they were not functioning properly.

16. The chief designer was co-author C. J. Daswani, who led a team of state education specialists, as well as multimedia technical support in Hyderabad.

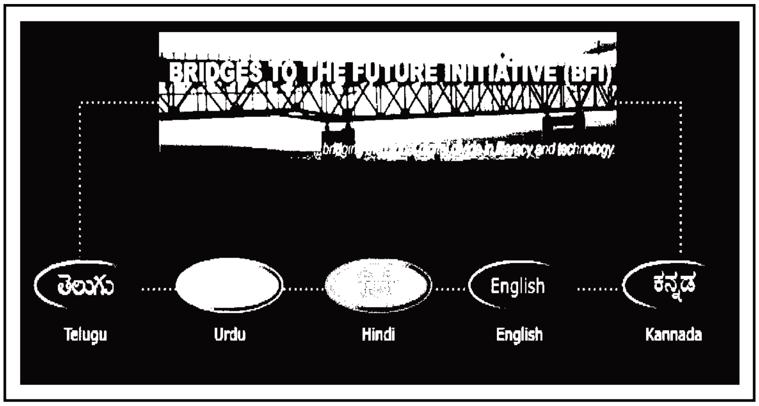

Figure 2. Language Choice.

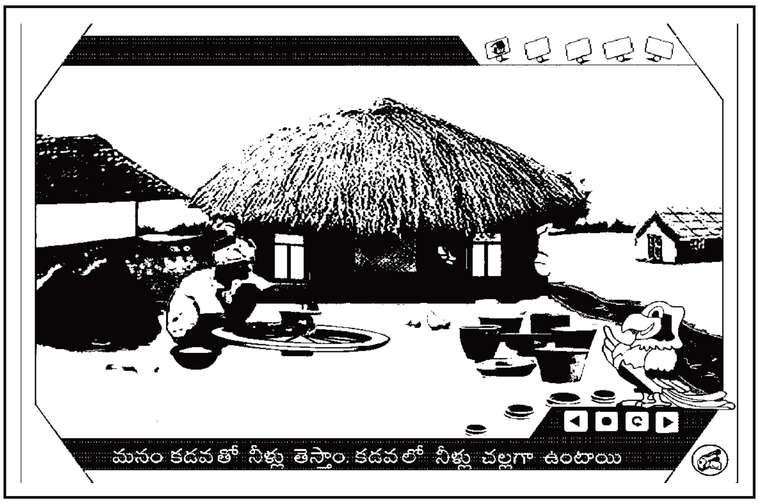

Figure 3. BFI Lesson Screen Shot.

A key and intensive part of the BFI project was the design and development of Telugu-language computer-assisted instruction (CAI) modules (using Flash animated scenes) that built on the oral competence of the learners in their mother tongue.[17] The BFI curriculum focused on the cognitive areas of learning, as established by the "Minimum Levels of Learning"[18] (MLL) standards. The content of the lessons was organized thematically and situated in an episodic story line; an example might be a story of a typical Telugu-speaking rural family that migrates to the city. The original design was intended to be quinta-lingual (including the five languages used most in the region), which may be seen in Figure 2.[19]

As the BFI animated story was narrated, the text was highlighted simultaneously (see Figure 3). The audio component of the BFI multimedia software enabled emergent readers to read along with the voice-over. Simple words introduced in the story were later selected for learning activities, such as word-picture matching, sentence completion, and word building.[20] Once the learners were able to match the written word with the corresponding image, each word was broken into its component syllables. This exercise was designed to drill the various forms of each letter, so as to enable the learner to quickly identify the letter within known words, moving from known to new words and texts. The content, storyline, and activities covered 12 broad multi-media lessons. Each of the lesson modules required about two weeks to master, pro-

17. The BFI-India project was originally designed to be multilingual, but resource constraints led to a focus on Telugu, with a small portion of the program in English. The BFI is sometimes confused with a similar-sounding program run by Tata Consultancy Services, called the computer-based functional literacy (CBFL) program, which also operates in local languages in Andhra Pradesh and several other Indian states. There are a number of important differences between BFI and Tata's CBFL, the most important being the focus on individualized learning via CAI in BFI, in contrast to group teaching with CBFL. Also, CBFL assumes that "literacy" can be achieved when learners "master 300–500 words," while the BFI offers CAI instruction for up to five years of basic education. For more on CBFL, see http://www.tataliteracy.com/tata_solution_overview.htm

18. Minimum Levels of Learning (MLL) are nationally accredited education standards in India meant to ensure equity in learning, which are adapted locally in each state's language. For more on MLL and related recent efforts in primary schooling and adult literacy, see Chudkar (2009).

19. Due to funding constraints, only Telugu (and some English) was fully implemented for this study.

20. Text, sound, graphics, and video clips comprised an integrated multimedia system. A more detailed description of the multimedia design is available in Wagner and Daswani (2006).

ducing a program that covers about 24 weeks in total. The OSY learners had about two hours per day when they attended the program; the PSC learners, by contrast, had only about 20 minutes per day. Since each learner was sometimes sharing (via dual headphones) the same PC at any given time, the "effective" time for each learner was about 90 minutes (for OSY) or 10 minutes (for PSC) per day.[21]

As with literacy, functional math was woven into the lessons in practical and familiar day-to-day computation situations. Images of coins and bank notes were used to stimulate learners' knowledge of basic counting skills. This was followed by an introduction to numerals and numbers, leading to the four mathematical operations: addition, subtraction, multiplication, and division. It should be noted that the time allocated for reading was considerably higher (about twice as high) than that for math learning, and that even less time was allocated for writing exercises in the BFI program.[22]

A voice-over feature that was in synchrony with each word as it was highlighted was designed to assist emergent readers. At each step throughout the instructional modules, the learner was guided to the next step or task by audio instructions. The interactive multimedia lessons allowed the learner to replay a scene, move forward, skip back, or pause as she navigated through the lesson at an individualized learning pace. At each stage in a lesson, the learner had to complete a task before progressing to the next stage. A tool bar with icons leading to the glossary, help feature, activity site map, and exit option were available to assist with difficult concepts and self-learning. The interactive aspect of the CAI made the learning content adaptable for out-of-school young adult learners who had dropped out at different grades (Study 1), and for primary-school learners in rural areas (Study 2). Observations of learners participating in the ICT-learning environment suggested a high degree of attention and motivation.[23]

Finally, there is the matter of cost. In most educational interventions, the focus is mainly on inputs of expertise as related to individual learning and motivation. Yet in the ICT for education domain, costs are often a determining factor, as decision makers often think of technology as an expense (such as PCs) that must be "traded-off" against other inputs, such as teacher professional development, improved textbooks, and so forth. There are few recent reviews of comparative costs in this domain, in part because prices fluctuate dramatically along with changing technologies (Perraton & Creed, 2002). Furthermore, cost depends on what you "count" in the intervention. In the case of the BFI model, we assumed existing ICT infrastructure (i.e., we did not buy any PCs for this work); we received gratis (from government) personnel support for the ICT learning sites; curriculum specialists were seconded to the project gratis to help in various local language design issues; and the project raised external funding (at usual higher-education levels) for the multimedia development and the research evaluation studies. What remained in costs for the expansion of the project was the cost of CDs (about $1/CD) and headphones ($1/pair). Thus, while the total budget of in-kind and real costs was substantial, depending on who is paying for which costs, the per-user costs may be seen as modest.[24]

21. Only one learner at a time had access to the keyboard and the mouse, so that it was possible to assure that there was only one "active" learner and one "passive" learner during each segment of time allocated. As one reviewer pointed out, the degree of effectiveness or discreteness of individual (as contrasted to dual) learning remains open. There was, no doubt, some amount of interaction between the learners, even if one learner controlled the mouse and keyboard. In other words, the present study had only an estimate of effective time on task. Nonetheless, the contrast in Study 1 between the limited time on PCs needs to be understood as contrasted with the much longer time (4.5 hours) that each learner received in the non-CAI contexts for OSY. The contrast was even larger for the children in Study 2, where the CAI-supported PSC group had only 10 "effective" minutes per day, as contrasted with five hours of schooling per day. It must be admitted, as in many other ICT-supported education projects, that the issue of effective use (by time or consequences) remains a major hurdle for empirically studied intervention studies.

22. In the subsequent BFI project in South Africa, much more attention has been focused on writing via multimedia programming. See a sample of multimedia from South Africa at http://www.literacy.org/media

23. Indeed, one of the persistent problems encountered by the BFI project team was finding ways to limit the amount of time that out-of-school learners wanted to engage in the CAI content. It was difficult to insert new learners, as there had to be a plan to find ways of informing learners that their time was finished.

24. Of course, the costs per user will also depend on the number of users, which, in the Indian case, is expected to be quite substantial. Further, if one looks at start-up costs relative to expansion or roll-out costs, the numbers change as well. Cost, as in all interventions, is a nontrivial dimension of ICT and education work. However, it must be emphasized

Figure 4. Context for Out-of-school Youth (Ranga Reddy, near Hyderabad).

Methodology

As noted earlier, two evaluation studies were undertaken: the first on an OSY sample in the Hyderabad area of Ranga Reddy, the second with young PSC sample in the rural West Godavari district. Both studies employed the same intervention and outcome measures. In Study 1, it was hypothesized that the use of CAI would reduce learning time, as OSY can learn literacy skills in their mother tongue at their own learning pace (with no teacher, only an assistant who maintained the computers), as compared with the time taken by the model employing (poorly) trained teachers in an ordinary classroom setting. Both groups of poor and poorly schooled OSY in Ranga Reddy were largely dropouts from the school system, so that one important factor in the use of ICT was the role of motivation, such that these youth would come back to school and invest in their own education. In the case of Study 2, the situation was different; samples of children were already in primary school in a rural part of AP state. In this second study, it was hypothesized that the use of CAI would supplement formal teaching instruction and provide a new opportunity for self-learning where class sizes were large (often 50–60 students in a classroom). Details on the sample populations, test instruments, and evaluation techniques follow.

Study 1 Sample: Out-of-school Youth in Ranga Reddy

In partnership with the Government of Andhra Pradesh (GOAP), the Telugu multimedia software was adopted by 114 out-of-school children and youth (OSY) in Ranga Reddy district of Andhra Pradesh, near Hyderabad (see context in Figure 4). There were nine sites that made up the CAI treatment group, all located within GOAP secondary schools. The comparison sites were eight "bridge programs" with out-of-school children and youth, managed by a local NGO to bring out-of-school children and youth back to school. Teachers at the comparison (control group) sites[25] taught basic reading, writing, and math in Telugu, based on the same government standards that were used in the development of the BFI learning software.

In Study 1, substantive fieldwork was undertaken in nine secondary schools sites with computer labs on an initial total sample of 167 out-of-school children and youth, ranging from seven to 19 years of age; with absenteeism and dropouts, the final longi-

that costs are complex in all interventions, and the cost of research must also be factored in, even if practical applications only happen "downstream." The BFI was fortunate in that it was relatively cheap to expand due to available (and underutilized) PCs in the parts of Andhra Pradesh state where we had decided to operate.

25. The comparison groups in each study, and the children within each group, could not be randomly assigned for the present study. Thus, control groups for the quasi-experimental design were chosen from a full sample of classrooms in schools drawn from the same populations and communities from which the CAI-assisted learners were drawn. While imperfect as a "gold standard" randomized experimental design, this was the only framework for a reasonably fair comparison of BFI CAI and non-CAI to be made. As described in a World Bank/InfoDev publication (Wagner, 2005a), very few experimental and quasi-experimental designs have been carried out in the ICT for education domain, and in this sense, the BFI impact study makes an important contribution. Yet even in the one exceptional randomized experimental study on technology and education in India (Banerjee et al., 2005), little is provided in the way of details on the ICT content provided, rendering the results of little utility for subsequent educational work.

Figure 5. Learning Context for First Grade Children (West Godavari).

tudinal sample was 138 children and youth (CAI, *N* = 103 and non-CAI, *N* = 35). Sites were chosen in predominantly Telugu-speaking areas.[26] The number of learners at each learning site ranged from seven to 16 learners (an average of 11 learners per site). The two groups had approximately equal proportions of male and female learners (55% girls, 45% boys). Both interventions demonstrated variability in the amount of prior schooling, ranging from zero to seven years, and both the samples averaged about three years of school. In other words, on average, the two groups had dropped out of school at third grade. While the CAI group had more learners who had not received any schooling, the control group had a number of learners who had completed seven grades of school.[27] The main intervention difference between the CAI and non-CAI group was in the number of hours of instruction (i.e., time on task). The CAI group participants received one-and-a-half hours of CAI per day, whereas the non-CAI group received four-and-a-half hours of teacher-based instruction per day.[28] The Appendices (Table A1a) provide the frequency counts for the main demographic variables, as well as for grade achievement and hours of CAI attendance (Table A2). As noted above, with respect to teaching and instruction, the CAI group had no regular teachers (only computer assistants), while the non-CAI group had teachers who were trained to teach the bridge curricula.[29]

Study 2 Sample: Primary School Children in West Godavari

In Study 2, the CAI intervention was implemented in a controlled, quasi-experimental study to examine the effectiveness of the BFI multimedia among primary school students (5–7 years old). In contrast to Study 1, which focused on OSY who were not enrolled in school, the second study used a sample of regularly attending primary school children (PSC:

26. Data were collected on each participant's "home language." All were apparently fluent in Telugu language and script, but some (about 15% of each tested group) indicated that Urdu or other languages were spoken in the home. This degree of bilingualism appeared to be roughly equivalent across both the CAI and non-CAI groups.

27. The non-CAI "bridge program" group had several additional students who had completed 7th grade (see Appendix, Table A1a), most likely due to the interest of some of these relatively capable children in getting back into school to complete their certificates. Overall, however, there was little discernable difference in schooling or other demographics between the CAI and non-CAI groups, as they came from the same communities and socioeconomic class, and had similar age and schooling levels (on average). Both groups were, with only a few exceptions, mother-tongue Telugu speakers.

28. The CAI sites located in secondary schools were open for the OSY for two hours daily, with an estimated 90 minutes dedicated to BFI multimedia. The non-CAI sites received five hours of class time, of which an estimated four-and-a-half hours were dedicated to teaching, and then half an hour for a mid-day meal. The main focus of instruction in both the CAI and non-CAI classes was basic skills. However, the CAI groups focused somewhat more on reading (than writing or math), since that was the emphasis of the multimedia tools.

29. Teachers in the "bridge programs" were typically trained by local NGOs, though some were previously employed in the government school system. In the BFI CAI programs, as noted in the text, there were no formal teachers; rather, there were assistants employed by an agency that provided computer maintenance and security. Thus, from an instructional perspective, the BFI students were essentially self-learning, especially when compared to the non-CAI learners.

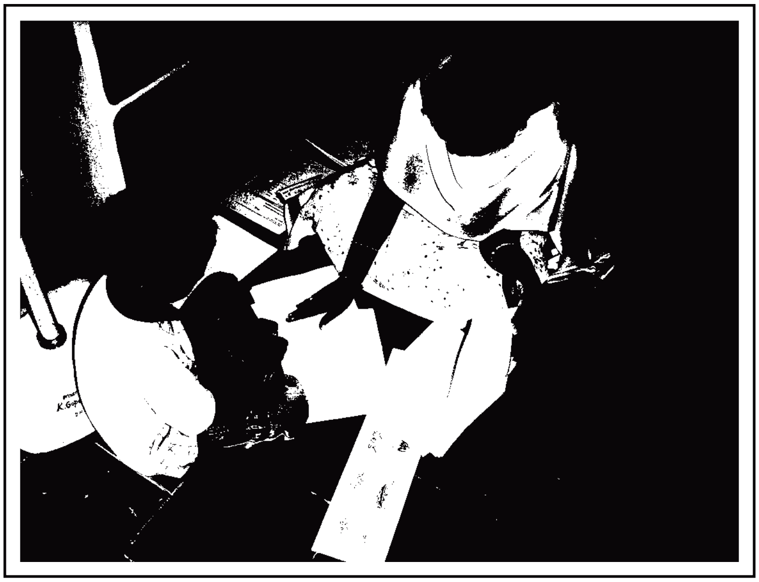

Figure 6. Testing Context for First Grade Children (West Godavari).

see context in Figure 5). The same assessment instruments were utilized in the PSC Study 1 as in the OSY Study 2. The children were second- and third-grade students from five selected schools in West Godavari, a Telugu-speaking region of Andhra Pradesh.[30] Three of the five were BFI-related schools (N = 139 students), while the other two were non-BFI schools (N = 93 students).[31] Schools with BFI CAI inputs were matched to schools of same-aged children who had no CAI inputs for the first four months of the school year. Each of the schools in this study was selected and matched based on location, socioeconomic background, and number of students in the school. As far as possible, schools were selected that had similar properties, both in terms of physical environment and teacher training. The average age for students in CAI-supported schools was 6.56 years, and 6.59 years in the non-CAI schools. The gender balance between the groups was unequal, due to the inclusion of one school for boys only (CAI had 67% boys; non-CAI had 47% boys). The Appendices (Table A1b) provide additional age, grade, and gender frequencies for each of the five schools, as well as for the overall sample.

Assessment of Skills

A basic skills assessment instrument measuring reading, writing, math, and technological literacy (the latter only in the case of the CAI group) was used as the outcome measure in both studies. The assessment was designed so that items were presented in increasing difficulty within each cognitive domain. Careful attention was paid to item validity, such that each item on the assessment test was neither too easy nor too challenging. The basic skills instrument was pilot-tested on a non-participating OSY sample in Ranga Reddy, and then with a PSC nonparticipating sample in West Godavari by project researchers.[32] The outcome measures were implemented in Telugu by a local team of educators in each study site, and were adapted from literacy assessment measures used previously by the research team.[33] The basic skills assessment instrument contained 65 items.[34] See Figure 6 for a view of the testing context in West Godavari.

30. Study 2 was conducted in school classrooms. Each of the schools was a Telugu-medium school in which all subjects were taught in Telugu. Thus, even if some children came from bilingual (Urdu or Tamil, in addition to Telugu) homes, it was clear that each came to the study with sufficient skills to handle the BFI software. There is no reason to believe that there were any systematic differences between the CAI and non-CAI groups based on language background.

31. Children in the BFI CAI-supported schools had access to the specially developed Telugu-supported multimedia, as in Study 1. The non-CAI schools had some access to technology, but only English-language games were available on those machines until about halfway through the school year, by which time the evaluation study had been completed.

32. Testing staff in Ranga Reddy consisted of one of the research team (Romilla Karnati) in a supervisory role, working alongside a team of women evaluators working with a local NGO based in Andhra Pradesh state. All testers were fluent in Telugu, and in Urdu for the small number of learners for whom this was their mother tongue. Similarly, with the assistance of the Byrraju Foundation, and with Gauri Kirtane-Vanikar, then a Penn graduate student, a sample of children was pilot-tested using the same materials as with the OSY, to be certain of task appropriateness.

33. The International Literacy Institute has been engaged in literacy assessment in a number of countries over many years. Issues related to literacy assessment using this methodology may be found in Wagner (2003, 2010).

34. In Study 1, the CAI subsample had an additional technological literacy subtest consisting of six items, the results of

The reading subtest consisted of two subcomponents: decoding and comprehension. The decoding items included letter identification, word-picture matching, and word recognition in Telugu.[35] The comprehension passage was a short text with a social moral. The passage had five sentences with four following multiple-choice questions related to it. There was no time limit, and both the students' reading and the examiner's questions were conducted on an individual basis. The students could refer to the short passage for the answers to reduce dependence on memory. The writing subtest included writing letters and words, while advanced writing included writing sentences and a short paragraph. Ten words were selected for reading and writing simple words based on linguistic styles. The short writing paragraph was based on a familiar picture.[36] The math subtest consisted of math word problems and simple arithmetic computations. The math word problems and computation items assessed simple addition, subtraction, multiplication, and division.

The same skill assessment instrument was used in each study to measure learning gains over time.[37] In Study 1, the reliability of the outcome measure was determined using Cronbach's *alpha* coefficient,[38] and it was found to be high in all three subtests. The alpha statistics were 0.92, 0.83, and 0.87 for reading, writing, and math subtests, respectively. In Study 2, the test was proven to be reliable for both male and female students, as well as across schools, with alpha coefficients ranging from 0.74 to 0.94. Also, two equivalent forms of the basic skills assessment were used to measure program efficacy, so that, on subsequent testing, each learner would be given a different (but equivalent) assessment to measure progress.[39]

Data Collection

The criterion measures for both studies consisted of scales in three different academic content domains: reading, writing, and math. In Study 1, qualitative and quantitative data across two time points were collected. Pretests and posttests were separated, on average, by 29 days for CAI and 39 days for non-CAI (see Table A2).[40] The basic skills assessment

which will be reported elsewhere; the non-CAI subsample had no previous experience with computers and so was not given this subtest. Study 2, with primary school children, did not utilize the additional technology subtest.

35. Letter identification consisted of eight letters carefully selected from a pool of 14 vowels and 32 consonants from the Telugu script, based on frequency of use, similarity of appearance, nasal sound, and vowel length. In the case of word-picture matching and word recognition, words were selected from target words chosen from the Andhra Pradesh state-prescribed textbooks. Ten words were selected, ranging from simple words with one conjugated letter to two-letter conjugated words.

36. A scoring rubric with a maximum possible score of 5 points was used to score the picture-writing paragraph. All the other writing items were scored at 1 point each.

37. Minor adjustments were made between Studies 1 and 2 to deal with ceiling effects. Items with constricted variance were removed from the reading and writing scales. An additional item was added to the math scale.

38. Cronbach's alpha coefficient is commonly used as a measure of the internal consistency or reliability of a psychometric test score for a sample of examinees.

39. Learners were randomly assigned either Form A or Form B at pretest, and the alternate assessment at posttest. This procedure is typical in longitudinal studies, as it prevents "leakage" from one student to the other (students do not know which test they will be taking), and it assures that, on the second testing occasion, the students are taking a different (but equivalent) test they have not previously seen. In terms of test "friendliness," it was commonly observed that students were at ease with the tests and testing procedures. With respect to psychometrics, t-tests were performed on the three subtests separately at pretest and posttest to determine if significant differences in subtest scores were found according to test form assignment. In none of the t-tests was there a significant difference ($p < 0.05$) in subtest scores across forms. In fact, the lowest p-value noted in these t-test comparisons was $p = 0.28$ (when comparing the math scores) from Form A to Form B at pretest. The lack of a statistically significant difference in the mean subtest scores across forms indicates that these two forms are equivalent and therefore usable in a pretest-posttest analysis. Further, the correlation between each item and total score on both Form A and Form B had medium to high correlations of 0.67 and above, thus indicating that items on both forms were measuring similar content and skills. The correlation matrix between items at both pretest and posttest correlated highly within domains (convergent validity), but not so highly between domains (divergent validity) at both times. Thus, the basic skill assessment forms were valid and measured cognitive competencies reliably, irrespective of which form was administered.

40. The difference in average time between testing was simply a question of human resources to get the work done in disparate locations and with different schedules. Since learning time is measured as an independent parameter, it is statistically controlled in the study and should not affect the impact comparison.

took about 15 minutes to administer. A socio-demographic survey took about 20–30 minutes, depending on the learner's responses (Karnati, 2008). The data was collected on-site in secondary schools, while the social surveys were collected either on-site or at the learner's home.

In Study 2, data were collected at three time points in primary schools, each separated by two months, starting at the beginning of the 2006 academic year. A team of six trained staff carried out the assessments in Telugu, typically taking around 20 minutes for each assessment. Scores were measured over a four-month period. Of the total sample, 70% were present for all three assessments, with 20% measured twice, and 10% measured only for the first data point (pretest).[41]

Results and Discussion

In Study 1, there were no differences between the two groups' pretest in any of the subtests. The statistical analysis used in Study 1 compared the learning gains between the CAI group and non-CAI control group over two time intervals. The learners in Study 1 were all participating on a voluntary, nonformal education basis.[42] As a result, there was a large difference in the mean number of hours of instruction in each condition: Non-CAI learners received, on average, about five times more instructional hours than CAI learners. In the data analyses, individual hours of instruction for the CAI group and non-CAI group were included in the regression model described in the following section.

The analyses of Study 2 followed a framework similar to the Study 1, although an additional follow-up assessment (making three waves of testing) was added at the conclusion of a four-month intervention time period (pretest at the outset, eighth week posttest, and 16th week follow-up posttest) that enabled individual growth modeling for repeated measures. In addition, an independent t-test of pretest scores in Study 2 between CAI and non-CAI control group students revealed a non-equivalence of group means. In order to make the two groups equivalent at intake, participating students were only included in the final analysis if each one could be matched to someone in the other group with the same scale score at intake. Use of matched pairs was performed independently for each of the three criterion scales, and ensured that each group began this study at equivalent average skill levels.[43]

41. It was not possible in either study to randomly assign learners to a particular treatment condition; however, through matching and statistical adjustment, a non-CAI group was created as the control group in each study. In Study 1, we tested the comparison groups at intake and found equivalence. We also included the pretest scores as a covariate in subsequent regression analyses. In Study 2, matching and growth curve modeling was used. While the skills assessment instruments were proven to be reliable over time and across subgroups, ceiling effects for some students diminished its ability to detect significant change over time.To remove the ceiling effect from this analysis, students who received scores in the top 20% of the scale at intake were removed at all time points prior to the analysis (see Appendix, Table A3). This statistical manipulation was necessary so that the scale would be sensitive to change among students who improve as a benefit of the CAI treatment. The top 20% was chosen because it represented the hypothesized size of the treatment effect.

42. The issue of learner (and parent) motivation is complex. Our research suggests that most poor parents are quite aware of the "value-added" aspect that more education brings for their children's future economic possibilities—at least in principle, if not in fact. Our observations suggest that children and youth motivation derives considerably from the novelty of the ICT itself. The attraction of the computer screen and the reality of one-on-one learning situation are appealing to such participants. The importance of the "computer" is common knowledge in India today, even in rural areas; parents are already aware of this, as well. In some instances, motivation was so high for participation in the BFI-supported centers that time management became an important administrative issue.

43. Table A3 (Appendix) provides a description of sample size and average ability levels in each academic domain that resulted from the matching process. These analyses were conducted to determine whether the CAI treatment was effective in raising content scores over time. Due to the longitudinal nature of the research design, an individual growth curve model was used to model repeated measures as a within-subject effect. This is a type of hierarchical linear model (HLM) that includes an additional random effect that allows the repeated measures to be nested within a student. One benefit of this strategy is that it uses all available data, avoiding unnecessary elimination of subjects due to augmentation or attrition. This was helpful because only 70% of the sample was present for all three measures. The HLM was also extended so that students would be nested within schools, accounting for natural similarity of students who attend the same school. Fixed effects in the model included the BFI CAI treatment condition, time, the interaction of treatment and time, student age, and gender.

Table 1a. Study 1: Results from Regression Analyses for Reading.

CAI vs. non-CAI Reading Growth Rate Regression Analysis

Parameter	Estimate	Std Err	t Value	Prob
Intercept	1.20	1.54	0.78	0.44
CAI	−1.31	1.37	−0.96	0.34
Hours	0.00	0.01	0.04	0.97
CAI*Hours	0.03	0.02	1.92	0.06
Male	−0.60	0.47	−1.26	0.21
Age	−0.04	0.10	−0.36	0.72

Note: N = 103 for CAI and N = 35 for non-CAI
R-Square = .04

Table 1b. Study 1: Results from Regression Analyses for Writing.

CAI vs. non-CAI Writing Growth Rate Regression Analysis

Parameter	Estimate	Std Err	t Value	Prob
Intercept	−2.96	1.29	−2.29	0.02
CAI	1.55	1.15	1.35	0.18
Hours	0.02	0.00	3.48	< .001
CAI*Hours	0.00	0.02	0.00	1.00
Male	−0.49	0.39	−1.23	0.22
Age	0.11	0.09	1.28	0.20

Note: N = 103 for CAI and N = 35 for non-CAI
R-Square = .13

Study 1: Out-of-school Youth

In Study 1, regression analyses[44] were conducted to determine if the students in the CAI group were learning at a faster rate than the students in the non-CAI control group (see Table 1). A positive and statistically significant estimate for the interaction variable CAI*hours would indicate that the subtest score gains per hour (the learning rate) were significantly higher than the gains in the control group. This relationship was marginally significant in reading ($p < 0.06$),[45] indicating that an additional hour of CAI instruction time likely resulted in an increase in reading scores. With a larger sample size and greater time on task, we believe it is likely that these relationships would be statistically significant.[46]

Study 2: Primary School Children

Table 2 presents analyses for Study 2, where both groups showed an overall improvement in writing and math, as would be expected for primary school children, but not in reading.[47] The interaction of time and CAI treatment was significant for reading,

44. The linear regression equation took the following form: $Outcome_{Time2} = \beta_0 + \beta_1 Pre_{Time1} + \beta_2 Gen + \beta_3 Age + \beta_4 Hours + \beta_5 BFI + \beta_6 BFI{*}Hours + \epsilon$.

45. Writing and math learning, which played a much smaller role in the software design, did not show significant gains, although subsequent analyses showed that older OSY participants (defined as 11 years and older) had larger gains than younger OSY in writing and math. Further research should look more closely at age-related differences among youth and young adults.

46. The present study was conducted while the program software was still under development, where the number of hours of instructional intervention was still small, and where the tests themselves had some ceiling effects (as noted earlier) that could depress the scores of the better learners. More suitable conditions for these factors would have, we believe, resulted in stronger gain scores in the treatment condition.

47. Recent research has shown that young children in poor (especially rural) schools have a slow trajectory in learning to read in primary school (Crouch et al., 2005; Greaney et al., 1999; Wagner, 2010).

Table 1c. Study 1: Results from Regression Analyses for Math.

CAI vs. non-CAI Math Growth Rate Regression Analysis				
Parameter	**Estimate**	**Std Err**	**t Value**	**Prob**
Intercept	−0.17	1.38	−0.12	0.90
CAI	−1.46	1.23	−1.19	0.24
Hours	0.00	0.01	−0.46	0.64
CAI*Hours	0.02	0.02	1.48	0.14
Male	−0.69	0.42	−1.64	0.10
Age	0.19	0.09	2.04	0.04

Note: N = 103 for CAI and N = 35 for non-CAI
R-Square = .07

Table 2. Study 2: Results from Repeated Measures Analyses.

	Dependent variable		
	Reading	**Writing**	**Math**
N (matched pairs)	74	74	64
Scale length	18	14	14
CAI treatment	−1.54	−0.58	−0.14
Hours	0.58	1.19*	1.53*
CAI*Hours	1.25*	0.32	0.06
Male	0.01	0.38	0.62
Age	0.79	0.55	0.65*

*Note: The variable "Time" refers to the assessment interval (pretest, posttest, follow-up); * < 0.05*

indicating that the rate of growth varies by treatment and favors the CAI treatment group, as in Study 1. There were no treatment effects for writing and math in which both groups showed an increase in scores between pre- and posttests.

The results of Study 1 and Study 2 show that a relatively low[48] number of hours (about 40) of CAI-based literacy experience, spread over a period of weeks (up to three or four months), had a modest (marginally significant) impact on the reading skills of both young children and youth/young adults who had no prior experience with computers. In Study 1, gains were quicker (rate of learning to read per hour) in the CAI mode than in the regular classroom learning experience. In Study 2, first and second grade children, in a very poor rural setting, were able to improve their reading scores using the CAI at a rate faster than children in a control group that did not have the benefit of the CAI input. These results, it must be reiterated, are only barely significant from a statistical perspective. This modest impact could be due to the limited sample size in Study 1, the young age of learners in Study 2, limited time on task, or other factors in data collection and measurement. Alternatively, as with other reports on the limits of ICT-supported learning (e.g., Cuban, 2003), substantive gains may be found only when intense inputs have been made in focused areas. Some evidence for this conclusion may be seen in the limited impact only occurring in reading scores. ICTs, in the present research, do not provide a broad "magic bullet" for learning, wherein a light bulb illuminates the entire learning process.

Nonetheless, in both studies, the design provided

48. There are no firm data on the number of hours of time on task required for effective learning the range, since the content of what is learned can vary enormously. Nonetheless, the BFI design, when fully implemented (after these studies were completed) was for each learner to have a minimum of 150 hours of instruction, a typical number in such educational interventions.

an opportunity to ascertain whether such learners, with little or no teacher support or prior technology experience, could engage in substantive learning in a technology-based environment. In Study 1, research allowed an investigation into the impact of time on task (learning rate) due to the substantial variation in hours that were available to the OSY learners. In Study 2, where all children had about the same hours of CAI learning time, the CAI-supported children learned more literacy skills than an equivalent control group. Our interpretation of these findings is that ICT can make a difference, even if limited, among the poorest communities that have received ICT-supported instruction, and with a near-zero amount of teacher-supported assistance. With further inputs, both in time on task and relevant teacher support, we believe the findings would be more compelling.

Conclusion

It has been said that technology-based interventions often fail when they reach the "last mile" of connection with the target population. What is usually meant, in India or other countries with poor and rural populations, is that it is much easier to put power lines or telephone lines *near* a village than to get them *into* the village in terms of effective use. As we move into the 21st century, this situation has substantially changed—from access (to hardware or the Internet) to a concern with the "last few inches" of the cranium, the *internal* "last mile," so to speak. Installing PCs into a classroom has little overall merit if the software is in the wrong language or is of little interest or value to the learner. It is surprising, perhaps, but still the case, that many development projects end at the installation of infrastructure with relatively little known about the value added in learning. A greater focus on the quality of education has become more apparent with the advent of the EFA initiative to go beyond mere access to schooling (UNESCO, 2005). In a parallel way, ICT4D efforts must also cater to the unschooled, poorly schooled, or out-of-school learners, with quality learning approaches. The bottom line, we believe, is that ICT-based programs that do not pay sufficient attention to the language, cultural, and attitudinal needs of the individual are likely candidates for failure in the near term and for lack of sustainability in the longer term.

The present research began with a challenge: how to best address the difficulties associated with the use and effectiveness of ICT4D among poor and disadvantaged children and youth with no previous experience with technology who also have very low levels of literacy. India seemed an ideal place to carry out such a study for several reasons. First, India is a country closely associated with globalization and rapid economic growth, as well as a high-tech infrastructure and economy that is the envy of most developing nations. Second, India probably has the largest number of below-poverty level (less than US$2/day) inhabitants, as well as the largest number of illiterates (about 250 million). Finally, India is a country that is urgently experimenting with ways to address the education and technology issues, hence making for a positive environment in which to try out the present approach.

In a quasi-experimental intervention, results favored CAI-supported instruction in reading development (when compared to control groups), though differences were statistically modest. These findings provide some (limited) support for the view that not only can ICT4D be positive for skills development in such poor populations of children and youth, but that such inputs can overcome a lack of trained teachers. Perhaps just as importantly, programs like the BFI can motivate learners who drop out of school and get them to return to school. Indeed, the present research indicated strong learner interest in both young children and youth, impressive engagement in skill-learning with multimedia in mother-tongue Telugu, and substantial home and family support for ICT-based learning. As has been discussed elsewhere (Wagner, 2005b), the use of digital materials in support of local languages should not be underestimated. One of the most significant educational issues in developing countries is the choice of language of instruction. In India, the use of new ICTs has favored, to date, an increase in the use of English. By providing ICT-based support in Telugu, the current project may have found an important avenue for strengthening the use of local languages in basic education.[49] By providing local language digital resources for supporting basic skills,

49. It has often been pointed out that ICTs reinforce the educational use of international languages, since many indigenous languages have a relatively small footprint in global cyberspace (Wagner & Kozma, 2005). This fact tends to support ministers of education, who often insist on the use of languages like English or French in the classroom projects like this one support the argument that local language use in the classroom and in the computer lab can go hand in hand. These results lend support for future ICT4D interventions in India and elsewhere, and they bode well for national and international agencies concerned with meeting the Education for All goals in 2015 (UNESCO, 2008).

In addition, the study raises important questions about the methodological difficulties associated with demonstrating substantial impact in situations that are culturally complex and resource-poor. The learning outcomes impact of the present intervention, though in the positive direction in the key variable of reading development, was modest, even with the strong (self-perceived) motivation of learners. It is possible (and we think likely) that a longer intervention, in terms of hours per week of activity, as well as improved school-based record keeping and greater specificity of the control groups, could result in substantially greater learning gains and stronger statistical significance. Further efforts, using randomly assigned participants for experimental comparison where possible, will be required to demonstrate the kind of impact that technology supporters would like to see.

About a decade ago or so, when ICTs were becoming part of the mainstream in industrialized countries and were only beginning to be available in poor developing countries, a prominent African minister of education was quoted as saying: "How can we imagine an *information superhighway* [a term that referenced the Internet at that time] when we are still driving on dirt roads only a kilometer from my office!" That was then. The future of ICT4D seems especially bright, as more and more countries—even the poorest countries—are investing in new and many varied ICTs. The biggest challenge remains to reach the poorest populations, and to design content for their needs, including language diversity and socioeconomic realities. While increased access in terms of hardware and connectivity is essential, the digital divide will only be narrowed when content-based solutions are sensitive to the diversity of human skills and interests across the world. There is little question that such sensitivity in the use of ICTs will be one of the important growth areas in educational development, and particularly in reaching the poor. ■

Appendices

Table A1a. Study 1: Participant Characteristics for CAI and Non-CAI Schools.

	CAI	Non-CAI	Group Totals
N	103	35	138
Age			
<8	8.74%	5.71%	7.97%
9	15.53%	20.00%	16.67%
10	11.65%	25.71%	15.22%
11	9.71%	17.14%	11.59%
12	19.42%	22.86%	20.29%
13	12.62%	5.71%	10.87%
14	10.68%	0.00%	7.97%
15	5.83%	2.86%	5.07%
>16	5.83%	0.00%	15.79%
Grade			
0	5.83%	2.86%	5.07%
1	13.59%	17.14%	14.49%
2	17.48%	20.00%	18.12%
3	20.39%	20.00%	20.29%

(in Africa, for example), so that these languages can also be used on computers. However, by providing local language digital resources for supporting basic skills, projects like this one support the argument that local language use in the classroom and in the computer lab can go hand-in-hand.

Table A1a. (Continued)

	CAI	Non-CAI	Group Totals
4	24.27%	11.43%	21.01%
5	9.71%	8.57%	9.42%
6	7.77%	5.71%	7.25%
7	0.97%	14.29%	4.35%
Gender			
Male	55.34%	45.71%	52.90%

Table A1b. Study 2: Participant Characteristics for CAI and Non-CAI schools.

	CAI		Non-CAI			Group Totals		
	Srugavruk-sham	I. Bhimavaram	Elurupadu Main	Elurupadu Garvu	Pennada	CAI	Non-CAI	Full Sample
N	46	58	36	48	45	139	93	233
Age								
5	20.93%	17.86%	8.33%	11.11%	7.32%	16.30%	9.30%	13.57%
6	37.21%	30.36%	25.00%	31.11%	53.66%	31.11%	41.86%	35.29%
7	34.88%	42.86%	38.89%	46.67%	19.51%	39.26%	33.72%	37.10%
>7	6.98%	8.93%	27.78%	11.10%	19.51%	13.33%	15.12%	14.02%
Grade								
2	54.35%	56.14%	52.78%	—	55.65%	54.68%	55.56%	54.89%
3	45.65%	43.86%	47.22%	—	44.44%	45.32%	44.44%	45.11%
Gender								
Male	100.00%	42.86%	61.11%	44.68%	48.84%	66.67%	46.67%	58.77%

Table A2. Study 1: OSY Sample Participant Characteristics for CAI and Non-CAI samples.

		Mean	Std	Min	Max
CAI	Age	11.63	2.41	7	19
	Highest Grade	3.09	1.66	0	7
	Attendance (Days)	28.87	10.46	8	52
	Attendance (Hours)	43.31	15.69	12	78
++++++					
Non-CAI	Age	10.63	1.55	8	15
	Highest Grade	3.40	2.09	0	7
	Attendance (Days)	39.37	17.69	9	89
	Attendance (Hours)	177.17	79.62	40.5	400.5

Notes: CAI N = 103; Non-CAI N = 35

Table A3. Study 2: Sample Size and Average Scores Adjusted for Ceiling Effects and Matching Pairs.

	Full sample			Adjust for ceiling effects			Matching pairs		
	CAI	**Non-CAI**	**Total**	**CAI**	**Non-CAI**	**Total**	**CAI**	**Non-CAI**	**Total**
Reading									
N	139	93	232	49	40	89	37	37	74
Mean	15.0	14.8	15.0	8.7	9.5	9.0	9.5	9.5	9.5
Writing									
N	139	93	232	75	46	151	37	37	74
Mean	10.2	6.9	9.0	7.1	5.1	6.1	5.9	5.9	5.9
Math									
N	139	93	232	114	69	183	32	32	64
Mean	6.7	6.5	6.7	5.2	5.4	5.3	5.5	5.5	5.5

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