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Reaching the Most Disadvantaged with ICT: What Works?

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Introduction

This paper is about the use of information and communication technologies to reach the most disadvantaged learners. Reaching the most disadvantaged has become a national and international educational priority, as articulated in such policy statements as *No Child Left Behind* (NCLB) (United States Department of Education, 2002), *Investing in Competencies for All* (OECD, 2002b), and *Education for All* (UNESCO, 2000). An important goal of the NCLB legislation is to ensure that even the most disadvantaged students succeed in their education (United States Department of Education, 2002). Education Ministers from OECD countries have committed themselves to the goal of tackling the long-standing educational inequities related to socioeconomic background, community, gender, and ethnic and other disadvantages (OECD, 2002b). And the United Nations and UNESCO have extended this goal to reaching every citizen in every nation (United Nations, 2000; UNESCO, 2000).

This issue raises a fundamental question: "Who are the most disadvantaged"? A strong case could be made that the most disadvantaged are those disabled by severe physical or mental handicaps, or those with little or no schooling from the lowest economic rungs within a country or around the world. However, in this paper, the focus is mainly on OECD countries and on programmes for those who have dropped out of school. We make the case that there is no clearer sign that a national education system or international policy has failed to educate all as when large numbers of youth - including those who are disabled or economically disadvantaged - enter school but leave before they complete their education. For example, in the United States, recent reports have established that 11% of the population between 16 and 24 did not complete four years of high school education, with percentages more than three times higher than this for urban minority populations (National Center for Educational Statistics, 2002); and approximately 15% of the population aged 25 or older did not complete high school (United States Census Bureau, 2003). A recent OECD report (2002a) found that among 16 of the countries participating in the study, 11 had a national secondary school dropout rate of higher than 10%.

While in economically advanced countries secondary school dropouts are only 10% or so of the youth population, they disproportionately suffer from and account for a number of social

problems. Studies in the United States (National Center for Educational Statistics, 2002, Kaestle, et al., 2001; Coley, 1995; Schwartz, 1995; Rumberger, 1987) indicate that high school dropouts are more likely to be unemployed than those who complete high school, they are more likely to go on public assistance, and they earn less money when they are employed, usually in low-level jobs. In 1992, high school dropouts earned on average about one-third less than high school graduates. High school dropouts are also more likely to have health problems, to engage in criminal activities, and to become more dependent on government programmes than are high school graduates (Rumberger, 1987). Dropouts comprise nearly half of the heads of households on welfare, and a similar percentage of the prison population. Dropouts are more likely to be to have babies and/or to be married by the age of 18. Unsurprisingly, the highest rate of adult illiteracy is for those who have dropped out of high school, and dropouts are the least likely to engage in literacy activities (Kaestle, et al., 2001). Further, United States employers reported providing approximately 7% of their employees with training in basic skills, such as reading, writing, arithmetic, and English language skills (United States Bureau of Labor Statistics, 1996). Only small number of dropouts, about 15%, report returning to complete secondary schooling later in life.

The main question addressed by the paper is: Can ICT be used to reach this important group of very disadvantaged people, and if so, how? The paper begins with an analysis of the characteristics of the most disadvantaged students and of the causes of high school dropout, particularly the academic, social, and linguistic issues related to dropout. It provides an analysis of how ICT might be used to address the academic, social, and linguistic needs of disadvantaged, out-of-school youth and of adults – with a focus on the United States and OECD countries more generally. In analyzing these applications, specific projects and programmes will be cited. However, it should be noted that ICT is still not in wide-spread use for out-of-school youth and disadvantaged adults. Consequently, some examples are drawn from in-school programmes for younger students and other projects that seem to have implications for youth dropouts and adults. Finally, the implications that these analyses have for educational policy and future research will be discussed. Specifically, policies will be considered that relate to ICT access for the disadvantaged and those that relate to integration of ICT applications with other educational interventions. In this review, we also raise the need for a revised definition of what works, and for a more rigorous approach to research that will allow practice to build on accumulating scientific evidence.

Causes and characteristics of disadvantaged students

In order to understand the potential that ICT may have to reach disadvantaged learners, we must first understand who these youth are and why they drop out of high school. In a comprehensive review of United States research on high school dropouts, Rumberger (2001) identified two types of causes of young people dropping out of school: those related to individual students; and those associated with context - the students' families, schools, communities, and peers. At the individual level, Rumberger contends that student disengagement and withdrawal from school is a long-term process that can be influenced by students' early school experiences. Numerous studies reviewed by Rumberger and others (Jimerson, Egeland, Sroufe, and Carlson, 2000; Coley, 1995; Schwartz, 1995; Simner and Barnes, 1991; Valverde, 1987) found that poor academic achievement is a strong predictor of dropping out. Almost one-fifth of dropouts had been held

back a grade and almost half had failed a course. However, dropping out is not simply a result of academic failure. Student disengagement can be both academic (for example students stopping doing their homework) and social (for example students not getting along with their peers), and is strongly associated with dropping out. Almost half of high school dropouts missed at least ten days of school during a school year; one-third of the dropouts were put on suspension or probation. Dropouts were twice as likely as school completers to have run away from home.

At the contextual level, family background is widely recognized as the single most important contributor to success in school. Research cited by Rumberger (2001) and others (Valverde, 1987) has found consistently that socioeconomic status, most commonly measured by parental education and income, is a powerful predictor of school achievement and dropout behavior. Poorer, less educated, and single parent households tend to have less money, time, and parenting skills that they can contribute to their children's education. On the other hand, when parents monitor and regulate their children's activities, provide emotional support, encourage independent decision-making, and are generally more involved in their children's schooling, the students are less likely to drop out of school.

Further, Rumberger reports that the dropout rates of African American and Hispanic students are significantly higher than those of other racial groups. However, it is not clear from the research whether this is due to the socioeconomic conditions of high poverty and low parental education associated with these groups, or due to sociocultural factors, such as cultural differences in language, values, attitudes, and behaviors of communities, parents, and peers.

Communities and peer groups also influence students' withdrawal from school. Poor communities have fewer resources, over and above the influence of the school, to contribute to children's well-being (playgrounds, after-school programmes), and communities may influence parenting practices, beyond the direct influence of parental education and income. Students living in poor communities are more likely to have friends that are dropouts.

Finally, schools themselves exert a powerful influence on student achievement and dropout. Studies reviewed by Rumberger as well as others (Lee and Burkham, 2003), found that small school size and low pupil/teacher ratios have a positive and significant effect on high school and middle school dropout rates, even after controlling for a host of individual and contextual factors that might also influence dropout rates. Small school size also appears to have a positive influence on dropout rates, particularly for low SES schools. Teacher guidance and support are also significantly associated with lower dropout rates, especially for disadvantaged students (Croninger and Lee, 2001). Apparently these arrangements promote more student academic and social engagement. Schools may also have a positive influence on withdrawal through policies and practices designed to promote overall effectiveness of the school. Conversely, schools may have policies and practices that foster low grades, poor attendance, and misbehavior that can lead to suspensions, expulsions, or forced transfers and, hence, more dropouts.

The summary picture that is painted by the research in the United States is one in which the most disadvantaged youth come from homes in which parents, for a wide variety of reasons, are not able to support school success. Their community and peer values, attitudes, and behaviors may conflict with school success and their schools may not provide the necessary resources, programmes, or policies to afford success. As a result, after a lengthy history of disengagement

and academic failure, a large number of these American students - who are often Black or Hispanic - drop out of school. As adults, they have difficulty finding jobs and when they do, they have low-level jobs and lower incomes than high school graduates. They are more likely to be on government support and engage in criminal behavior. They have low levels of literacy and rarely engage in literacy activities. When they enroll in training, it is often to learn basic skills of reading, writing, numeracy, and the English language.

We display this rather bleak picture of the American condition of the most disadvantaged out-of-school youth and adults to provide a reality check which confronts any application of ICT for the disadvantaged. While this represents a statistical portrait of the contemporary United States, trends, evidence suggests similar portraits in other OECD countries (see other papers in this Volume). The mere use of ICT, however sophisticated, will not address the extensive, persistent, and interlocking personal and social factors that account for school dropout. Consequently, in this chapter, we do not just look at a range of hardware and software. Rather, we consider the application of ICT as it is integrated into systematic and comprehensive approaches that address the academic, social, and linguistic needs of the most disadvantaged.

ICT and the needs of the disadvantaged

Cognitive and social research and theory provide a number of insights into how programmes and policies can address the needs of the most disadvantaged students. And ICT can provide significant added value to these programmes and policies, if used appropriately. In this section, we first examine general principles of effective learning environments and then examine how ICT can contribute to these to meet specific needs of the disadvantaged.

Characteristics of effective learning environments

Significant strides have been made over the last several decades in developing a science of learning. Research and theory in cognitive psychology, social psychology, anthropology, education, and technology have converged to create body of knowledge that forms the science of learning and informs the practice of teaching (Bransford, Brown, and Cocking, 2000). This multi-disciplinary approach to educational research and theory is more likely than any single discipline to provide useful answers to the complex social problems of the sort we address here. Within this domain, researchers have examined the causes of school dropout, the needs of disadvantaged students, and programmes designed to reach disadvantaged learners (McPartland and Jordon, 2001; Means and Knapp; 1991; Rumberger, 2001; Slavin and Fashola, 1998). Given the extensive, persistent, and interlocking factors that account for school dropouts, effective learning environments need to comprehensively address the academic, linguistic, and social needs of disadvantaged students. Effective environments for the disadvantaged can be characterized as those that:

Address academic needs by:

Actively engaging students in challenging tasks. Effective environments involve disadvantaged students in sustained academic engagement that fosters deep understanding and application of important concepts and principles. Clear expectations are set for high standards

of achievement. Basic skills are learned in the context of complex, everyday problems and situations. Such tasks motivate the learning of basic skills and allow students to integrate basic skills with the higher-level skills needed to address complex problems.

Focusing on individual learners' skills and needs. Students bring with them to the learning setting knowledge, skills, attitudes, and linguistic and cultural practices that affect their learning. Effective learning environments build on this base of skills, interests, and experiences and address students' individual needs. Goals and tasks are made challenging enough to maintain engagement but not so difficult as to lead to discouragement. Students are given the time needed to master the skills. Multiple approaches are used that acknowledge student differences. For example, students from one cultural background may be more comfortable working in group settings, while other students may be more oriented to independent learning environments.

Providing students with structure and support. Disadvantaged students need the guidance and support of a teacher or more knowledgeable peer as they attempt more challenging and complex tasks. Complex cognitive skills are explicitly displayed and modeled. Meta-cognitive skills are nurtured that allow students to monitor, structure, and begin to manage their own learning and continue this into the future. As the students become more skilled, this support is withdrawn so they can perform on their own and support the learning of others.

Presenting frequent assessment and feedback. In effective learning environments, students are regularly provided with opportunities to display, examine, revise, and improve their thinking. They receive constructive and detailed feedback on their efforts early and often along the way. Progress is recognized and rewarded.

Address social needs by:

Creating a supportive learning community. Effective learning environments develop group norms that value and support learning and success. The social atmosphere is supportive and non-threatening. Students collaborate in groups on joint projects. They help one another solve problems by building on each other's knowledge, asking questions to clarify explanations, and suggesting avenues that would move the group forward. Interpersonal problems are addressed and social problem solving skills are developed. Schools or programmes are small, as is the student-teacher ratio. Strong relationships are fostered with a teacher or other supportive adults.

Connecting with the outside community and resources. Positive classroom communities can be strengthened by the outside community. Effective environments build connections between classroom-based goals and values, and the participants' situations, tasks, and structures in the outside world in order to support success in learning. They develop the support and involvement of parents and other adults and enlist community resources and services. They also build on cultural experience and practices in the community. For example, cultural practices that encourage knowledge sharing within the community can become an effective model of cooperative learning and problem solving in the classroom.

Address linguistic needs by:

Building on current language skills and developing new ones. Disadvantaged students often have limited literacy skills in the dominant national language. Effective learning environments draw on current language skills and literacy practices to support learning. Equally important is the development of new literacy skills. A positive sociolinguistic context is especially important if students come from immigrant families, which is the case in many OECD countries.

A number of programmes for the most disadvantaged students have incorporated these principles (Rumberger, 2001; Slavin and Fashola, 1998). For example, the Coca-Cola Valued Youth Programme (described at http://www.youthdevelopment.coca-cola.com/ach_ccvy.html and reviewed in Slavin and Fashola, 1998) is a cross-age tutoring programme designed to increase the self-esteem and success of high school students at risk of dropping out by placing them in positions of responsibility as tutors of younger students. The programme was originally implemented in San Antonio, Texas, among predominantly Spanish speaking students but has since been wide replicated throughout the Southwest United States and elsewhere. In this program, students are required to enroll in a special tutoring class that develops their basic academic skills as well as their tutoring skills. Home-school partnerships are also developed. Slavin and Fashola (1998) report significant reductions in dropout rates for students in the programme, compared to matched students in a comparison group, and improved student scores on other academic and attitudinal measures.

In Europe, a pilot programme was instituted by the European Commission (2001) in which 13 "second chance" schools were set up in 11 countries to address the needs of students who had dropped out of secondary school. The programme is a partnership between local authorities, social services, associations and the private sector in which the latter offers possible training places and jobs to pupils. The teaching and counselling approach focuses on the needs and abilities of individual pupils. Students are actively engaged in learning modules that combine basic skills development such as numeracy, literacy and social skills with practical training in and by enterprises. There is a central role for the acquisition of skills in and through ICT. The initial evaluation of this programme documents its positive impact on school completion and dropout rate.

ICT in support of effective learning environments

Given the extensive, persistent, and interlocking personal and social factors that account for school dropout, how can the use of ICT reach the most disadvantaged out-of-school youth and adult learners? This can happen only if ICT is used in the context of comprehensive programmes that address the academic, social, and linguistic needs of these learners. ICT by itself will not make a difference. But the capabilities of ICT can be used to supplement, support, reinforce, and extend these programmes .

A number of articles and reports have reviewed the research and theory on the use of ICT with disadvantaged youth and adult learners (Kozma and Croninger, 1992; Office of Technology Assessment, 1993; Wagner, 2001; Haddad and Jurich, 2002; Stites, in press). The interactive capabilities of ICT can engage learners in the extended consideration of important concepts and principles while providing extensive assessment and feedback. The processing capabilities of

computers can individualize learning and customize instruction to specific learners. Various productivity tools can be used by students to create significant intellectual products. Multimedia capabilities can provide multiple approaches to learning, can visualize difficult concepts, and connect school learning to real world situations. Simulations and models allow for the deep exploration of complex systems. And the networking capabilities of ICT can connect students to a range of informational and social resources outside of the classroom.

There are two fundamentally different but potentially reinforcing approaches to the use of ICT in support of the learning goals of disadvantaged learners. These can be referred to as the instructive and the constructive approaches. With the instructive approach - often typified by computer-assisted instruction (CAI) - computers and other technologies are used to provide students with direct instruction on some subject matter topic. Often the skills acquired in this way are relatively basic in nature. With the constructive approach, computer tools and other technology resources support students as they solve some problem or produce some product and in so doing acquire higher-level skills. Such skills can include the ability to search for information, reason with models, analyze data, and communicate ideas. In the analysis below we examine both approaches. In the following section we discuss the ways ICT can be - and is being - used to address the academic, social, and linguistic needs of the disadvantaged.

ICT and the academic needs of disadvantaged learners

Instructive applications of technology - or CAI - support engagement in learning by providing students with frequent opportunities to respond to instruction. With these applications, subject matter is broken down into small segments or chunks, with each chunk of information followed by an opportunity to respond to or apply this information. Students progress through these chunks at their own pace, determined by their performance. Early success allows students to quickly progress to more challenging work; early failures quickly result in additional support and opportunities to respond. CAI focuses on individual learners' skills and needs by providing them with instruction specifically tailored to the type of errors or misunderstanding that they display in their responses. Instructive applications of ICT provide students with support and structure by giving explicit instruction, examples and models of desired performance and procedures. In addition to providing frequent opportunities to respond to instruction, CAI applications also provide frequent feedback to students. In this way, students can chart their progress as they acquire basic skills. A variety of media is often used in CAI. Recent applications of CAI often incorporate animations, and digital video and audio and these media can provide reinforcing messages that increase students' understanding and transfer of learning (Mayer, 2001). These additional presentational forms also compensate for students' limited text literacy. Recent applications of artificial intelligence (Graesser, Person, and Harter, 2001; Koedinger, Anderson, Hadley and Mark, 1995) have made CAI programmes much more sophisticated in their assessment of students' knowledge and in tailoring the subsequent guidance so as to be appropriate to the students' problems.

Several recent reviews of research studies that examine the impact of CAI on student learning have established the effectiveness of this approach (Fletcher, 1996; Murphy, et al., 2002). One example of one of these effective programmes which illustrates the capabilities of this approach is the *Algebra I Cognitive Tutor* (Anderson and Lebiere, 1998; Corbett, et al., 1999). Cognitive

Tutor uses artificial intelligence technology to monitor and model students' problem solving activity and uses this information to provide the student with customized step-by-step advice, specific to the kind of problem the student is working on and the nature of the student's difficulty.

An alternative approach to the use of ICT is the constructive approach. Unlike CAI, constructivist approaches support student academic engagement through the use of complex, real-world tasks. In these tasks students use a variety of ICT tools to produce a range of academic products, such as research reports, designs, solutions to complex problems, and group presentations. Many of the tools are common productivity applications, such as Internet browsers, word processors, presentation software, and multimedia and Web-based authoring tools that learners would otherwise encounter in the work world. In the context of a complex, meaningful task, students use these tools to access information on the Web, to organize and analyze the information, and to create some product, such as a multimedia presentation or Web page.

With constructive approaches, learning is individualized around the specific tasks and issues that motivate students' work. However, the primary responsibility for structuring and guiding student work remains that of the teacher. The teacher plays an important role in structuring and managing the learning experiences to fit individual student needs. Database management applications of ICT can help teachers keep track of individual goals and of the problems of the various students in their charge. Frequent feedback is also an important component of the constructive approach to education for the disadvantaged. With this approach, ICT is often used as a way of sharing students' work to obtain feedback from others. Students may give PowerPoint presentations in class or post their work on an intra-net or on the Internet, often in electronic portfolios. Feedback may be provided by the teacher, by other students, or by a wider public. Since the frequency of this feedback is important, students often present or post initial drafts or partial products, specifically requesting reactions that can be used for revisions and refinement. To maintain engagement and motivation, it is crucial that this feedback be structured around learning goals - particularly the students' own learning goals - and that the feedback be constructive and support revision and further learning.

In the constructive approach, multimedia may also be used for expressive purposes. That is, students often use video, audio, animations, and multimedia software to create presentations and productions that convey their understanding of what they have learned, as illustrated in case studies below. In addition, computer-based simulations and models are occasionally used to allow students to build, explore, and reason with systems that make underlying concepts and principles visible and concrete. Further, ICT can be used to connect learning to real world contexts, for example by the use of video case studies in which students apply skills that they have learned in reading, math, or science to solve a life-like problem as presented in an interactive video case study. Finally, as more and more of the "real world" is moving online, students can use the Internet to access libraries, museums, databases, subject matter experts, and potential employers.

The constructive approach to the use of ICT is, as yet, seldom seen in programmes for out-of-school youth and disadvantaged adult learners, although Stites (in press) makes a strong case for why it should be. On the other hand, it is used quite extensively in formal primary and secondary education around the world. A recent international study (Kozma, 2003) conducted in 28 countries identified 174 case reports of highly-selected, innovative classroom practices using technology. Many used ICT in constructive ways. Of the 174 cases, nine were targeted at

secondary school students at risk of failure or at ethnic or language minorities. For example, at a French upper secondary school near Paris, students participated in a year-long, multidisciplinary media project in conjunction with taking an international trip to Italy. The subject areas of French and history were addressed through searching the Internet, watching Italian films, analyzing images, and writing the scenario for a short film that focuses on the end of the Roman Empire. During the trip, students collected documents and made daily entries in a trip diary. The teachers guided their students in finding information that was relevant to their scenarios. Students collaborated with one another, providing assistance to each other and giving each other assessment feedback. Students used ICT to retrieve information, to write documents (such as a journey diary or a scenario), and to produce products (such as making and assembling a film, creating web sites inserted into the school site, or creating a CD-ROM)

Another case that illustrates the constructive approach is a project in Norway in which students created and built an authentic bathroom with all the ingredients. The project consisted of three main phases. The first phase was when the whole work process was planned and all the details were worked out about what the bathroom which each group would build would look like. The second was the practical phase, where each group worked on their bathroom. The third phase was presentation and documentation of the results. ICT was an integrated element in all three phases. Each group set up a daily schedule and at the end of the day each student wrote what they did that day in their logbook. The students used Excel to make budget calculations for the project. They had to use email and the Web to order materials. And as part of their project the students had to write a report for Norwegian and English classes.

Instructive and constructive applications of computers may be used together, as students find that they need specific basic skills in order to move forward with their project. For example, the *Higher-Order Thinking Skills* programme is a technology-supported curriculum that makes use of popular discrete educational software programmes, such as the Learning Company's Oregon Trail, as a means to motivate and engage children in teacher-supported learning activities. The goal is to develop high order thinking skills as well as basic skills in reading and writing (Pogrow, 1999).

ICT and the social needs of disadvantaged learners

As mentioned earlier, many the most pressing needs and problems of disadvantaged learners are social. Dropping out is often the result of social disengagement from school, as well as of academic disengagement from learning. Often disadvantaged students have had motivational or behavioral problems that have affected their relationships with adults and with peers in school. Conversely, the values, beliefs, and behaviors of adults or peers at home or in the community may have worked against continued effort in school. All of the effective programmes for the disadvantaged cited by Rumberger (2001) and Slavin and Fashola (1998) had a significant social component. The emphasis was on providing positive adult role models and relationships, and creating strong positive relationships among peers that reinforce success and continued effort.

This has two important implications for the use of ICT with the most disadvantaged. First, ICT should be used in group situations to support social engagement with learning. Often, this is accomplished by collaborative, project-based learning in which pairs or groups of students use a

variety of ICT tools and resources to work on a project of shared interest (Brown, 1997). Students in these groups may divide up components of the task based on specific interests or complementary skills. Much learning goes on in the course of student interaction around these join projects, as students seek to understand and to explain their various contributions. Feedback is a natural product of this discussion. The instructor plays an essential role in these group interactions, both in structuring the activities to accommodate the goals and skills of group members, and in structuring the social interaction to assure that it is constructive and contributes to success. Such projects and social interactions may take place in a formal school setting.

Another case from our international project (Kozma, 2003) illustrates this kind of group interaction. In a French upper secondary school near Paris, disadvantaged students participated in a year-long, multidisciplinary media project in conjunction with taking a trip together to Italy. In preparation for the trip, students searched the Internet, watched Italian films, analyzed images, and wrote scenarios for a short film that focused on the end of the Roman Empire. During the trip, students collected documents and made daily entries in a trip diary. The teachers guided their students to find information that was relevant to their project. Students also collaborated, providing assistance to each other and giving each other assessment feedback. Students used ICT to retrieve information, write documents (journey diary, scenario), and produce products (like making and assembling a film, creating web sites inserted into the school site, creating a CD-ROM, etc.)

The use of ICT by groups of students can occur outside of school. Increasingly, work-based or community-based technology centres (CTCs) have been set up both to provide access to technology and the supportive academic and social environment that is needed by disadvantaged out-of-school youths and adult learners (Michalchik and Penuel, 2003; United States Department of Housing and Urban Development, 1999). For example, the Seattle Community Technology Alliance (reported in Michalchik and Penuel, 2003) supports community technology centres that provide after-school activities, adult and family literacy programmes, career development and job preparation services, and small business support to low-income areas across Seattle. It provides funding, technical support, leadership, professional development, and opportunities for communication and collaboration to the seven CTCs it currently supports.

A second implication drawn from the social needs of disadvantaged learners is that ICT can be used to create social environments and opportunities for academic interactions for disadvantaged learners. That is, networked computers can allow learners within a group to store, share, and build off of each other's contributions. For example, *Computer-Supported Intentional Learning Environment* (CSILE) allows a group of students to study a specific area of mutual interest over an extended period of weeks and months and to create shared knowledge. The intent is to support the building of a literate community - to provide students with an ongoing, shared, knowledge-building capability. This is in someways similar to how scholars and other professional communities create knowledge by sharing the products of their intellectual efforts for a common purpose (Scardamalia and Bereiter, 1999). In CSILE, students create written, online note cards that contain information about what they have learned, what they think, what they are trying to learn, or what they have found in their research. The knowledge base is developed as other students respond to questions, elaborate on statements, give examples, agree or disagree with conclusions, and so on. As students' responses and contributions accrue and become increasingly

interconnected, the group collaboratively creates knowledge - sometimes convergent, sometimes divergent - related to their shared topic.

Alternatively, networked computers may allow learners to communicate with people who they would not otherwise be able to contact. This might include supportive adults within the community, distant experts, and students in other communities with similar interests. For example, a project in Chile from our international study (Kozma, 2003), entitled Mi Lugar (*My Homeland*; http://es.geocities.com/milugar_muermos/), had students conduct research on local traditions, on historical events, and on artistic and cultural manifestations of their communities. They used tools such as word processors, spreadsheets and presentation software, and then shared the results with students doing similar projects in schools from other countries. ,using e-mail and a web site specially created for the project.

The social engagement of disadvantaged learners has, perhaps, a third implication for the use of ICT - or rather for its inappropriate use. Distance learning, or virtual schools, is a growing phenomenon in post-graduate, higher, and even secondary education (Tabs, 2003; Zucker and Kozma, 2003). Within distance learning, one approach involves giving the student access to online instructional materials. Students then progress through these materials on their own. Online tutors may be available if students encounter difficulties (Zucker and Kozma, 2003). A second approach looks more like an actual classroom. It involves a teacher, a syllabus, online assignments, and regular meetings - either synchronous or asynchronous - in which the teacher and students do things such as discuss topics and share assignments. The advantage of this approach is that distance learning provides students with access to courses that might not otherwise be available, and their learning is often not dependent on time and place. This advantage can be considerable for adult learners faced with many constraints and competing demands. And it may be an advantage to secondary school students when it gives them access to otherwise limited educational opportunities.

However, there are a number of factors that make this approach ill-advised for the most disadvantaged learners. First, disadvantaged learners are least likely to have access to the technology in their homes that would be needed to participate in these programmes (United States Census Bureau, 2001). Secondly - and most importantly - this approach does not provide disadvantaged learners with the social support that they need to maintain their engagement in learning. Zucker and Kozma (2003) found that in one virtual school that used online discussions, the interactions between students and teachers and among students were not as frequent or as rich as those in a comparable face-to-face class. Other versions of online schools do not provide even this much social interaction, as students work independently in their home. This may be the reason that there is such a high dropout rate reported for virtual schools (Bigbie and McCarroll, 2000; Hittelman, 2001). All of this indicates that virtual schools may not effectively meet the social needs of the most disadvantaged learners.

ICT and the linguistic needs of disadvantaged learners

The most disadvantaged learners often have serious problems as a result of limited literacy skills. They may also have problems because the language that they speak at home is not the dominant language of the formal education system or of their work situation. Effective learning

environments accommodate these linguistic and cultural issues by building on current linguistic skills and supporting the acquisition of new skills.

A variety of CAI programmes have been developed that specifically focus on the needs of literacy students. Over that last several years the power of these applications has increased considerably: digital video and audio have been integrated with them, and artificial intelligence technology applications have been incorporated. Literacy tutorials can use the interactive capabilities of computers to help learners build their cognitive skills of decoding and comprehension. Tutorials focusing on decoding skills can be used to teach word recognition, phonetics, pronunciation, grammar, word usage, and vocabulary. These tutorials are often delivered on a disk or CD-ROM. They typically present information on a target skill - such as a description of a decoding strategy. They then give some examples of the use of the strategy, and problems or exercises in which the learner applies the strategy.

For example, in developing a phonetic decoding strategy in English, the software programme might present several words with the same phonetic base both as text and sound and note the similarity in the graphemes (i.e., letter groups) and phonemes (i.e., sounds) of these words. The tutorial might then present additional words with the same phonetic base and students would be asked to apply the decoding rule to read these words. The computer could analyze the student's response, comparing it to the right answer and various phonetic errors that students typically make. It would then provide feedback based on this analysis. Extensive practice can build speed and fluency, so tutorials could provide many similar exercises in which the rules and strategies are applied. Tutorials that emphasize comprehension could provide students with text passages of increasing length and complexity. The presentation of pictures along with the text can help students use their knowledge of the text topic to support both comprehension and decoding (Mayer, 2001). The software could ask students for responses that show their understanding of the meaning of the text. The computer could, in turn, provide feedback. For some examples of the use of CAI with the disadvantaged in developing countries in the work of Wagner and colleagues in South India, in the Telugu language (see Wagner and Kozma, (2003) or the website www.bridgestothefuture.org).

Applications of artificial intelligence (AI) allow the computer to understand the students' responses. They allow the computer to adjust the instruction in order to further challenge students or to accommodate specific errors or misunderstandings. Initial applications of AI could accommodate only fairly simple responses from students, such as multiple-choice or a well-anticipated, simple, constructed response. Current AI technology accommodates lengthy responses of relatively unexpected content, although this technology is still not widely available. Recently, AI technology has been combined with new speech recognition technology. This has important implications for first and second language learners (Mostow, et al., 2001). With speech recognition technology, the user speaks a word or phrase into a microphone hooked to a soundboard in the computer, and the computer matches the sound to a model sound pattern in its memory. In this way, the computer can determine if the response matches a correct speech pattern or perhaps one of several standard errors in pronunciation, word choice, verb ending and so on. The software can then make the next instructional move to accommodate the specific response of a learner, perhaps using digital audio. This technology is already being used in some simple ways that are useful for students with limited language skills. This technology is used to help students build relatively simple speaking skills such as word pronunciation, or verb declension. Speech

recognition technology is also beginning to be used for children's learning of literacy decoding skills. An example is *Let's Go Read* (Edmark, Novato, CA). Speech recognition technology is also being used in commercially available second language tutorial software, such as the *Learn to Speak* series (Broderbund; Novato, CA). With these packages, the student can read a word or respond to a question with a simple spoken response.

Text-to-speech technology can read aloud from emails, web pages, or typed text. This can be a big help in giving learners with limited reading skills access to the growing body of digital text on the web and elsewhere. For example, *CoolSpeaking* (Peach Seed Software, Powder Springs, GA) can read text from emails, web pages, or typed text. Advances have also been made in machine translation. There are also now products, such as *Systran* that are plug-ins for Microsoft Office and that automatically translate Word, PowerPoint, or Excel documents for common European and Asian languages. And there are a number of web-based services, such as *Babelfish* (http://babelfish.altavista.com/) or *FreeTranslation* (http://www.freetranslation.com/web.htm) that allow the automated translation of text materials found on the Web. In certain situations this technology can help learners with limited skills in the dominant language. For example, native Spanish-speaking students in the U.S. who are still learning English can use these services to translate difficult English passages on a Web page into Spanish and thus both receive help in building their English vocabulary and gain access to information on the Web that may not otherwise be available to them.

Finally, applications of ICT can also support the needs of the most disadvantaged by providing them with a new set of literacy skills. Certainly, the operation of a variety of hardware and software applications is becoming increasingly important in everyday life, and using these applications in the educational environment will prepare students for there use elsewhere. But regular use of technology in the ways that we have discussed can foster a more complex and important set of skills that are often referred to as "information literacy". From this perspective, literacy is defined as a broader set of text and technological skills that includes not only the decoding and comprehension of text but the ability to access, analyze, evaluate, communicate, and use information to solve problems and create new knowledge (Partnership for 21st Century Skills, 2003; Quellmalz and Kozma, 2003; Wagner and Kozma, 2003; Educational Testing Service, 2002; 21st Century Workforce Commission, 2000; OECD, 2000; International Society for Technology in Education, 1998). Consequently, ICT is not just a means for delivering literacy skills but is an integral part of an information-literate society (European Commission, 2000). From this perspective, participation in society not only involves text literacy skills but the skills to use technology to access, disseminate and create new information and knowledge for the benefit of the individual and society. As more and more resources and work opportunities appear online, disadvantaged people – whether in school or out – will need to be prepared to participate in such an information-driven society.

Implications for policy and research

ICT can play an important supporting role in addressing the academic, social, and linguistic needs of the most disadvantaged out-of-school youth and adults. This has important implications for policies targeted at this special group of students. There are also implications for the kind of

research that is needed to establish and validate the applications of ICT that work best for these students.

Implications for policy

Two policy implications are clear from this review. First, the use of ICT to reach the most disadvantaged learners must be part of a comprehensive programme to address the academic, social, and linguistic roots of school failure. Technology alone, however advanced, will not address these needs. Dropping out of school is not simply the result of academic failure, and it cannot be addressed merely by developing more advanced technology or more effective educational software. The social and cultural roots of school dropout require coordinated policies and programmes. These policies and programmes involve not only ministries of education, but those of labour, welfare, and cultural and community services. Such comprehensive programmes must involve multiple layers of the social system - national, state or provincial, and local governments. Programmes must provide academic offerings and job training customized to the needs of school dropouts and disadvantaged adults. These must be combined with programmes that develop home and community environments that value and support school success. If governments expect to bring disadvantaged citizens into the global economy in their respective societies, there is little doubt that education and technological literacy will need to be a core component, and that ICT tools will provide an important scaffold for new and nascent skills. When integrated into a comprehensive programme designed to meet the academic, social, and linguistic needs of disadvantaged learners, appropriate uses of ICT can engage students in sustained academic work, build and support learning communities, and compensate for and develop linguistic and literacy skills. However, it must be noted that the inappropriate use of ICT can isolate disadvantaged learners from teachers, fellow students, and community members that could otherwise support their learning and success.

A second implication has to do with the access to the computer and network resources that are necessary if ICT is to reach these learners. At both the national and international levels, significant investments have been made to put computers in schools and connect them to the Internet (Anderson and Ronnkvist, 1999; Pelgrum and Anderson, 1999). But only a very small fraction of this investment has been made for out-of-school and at-risk youth or for poor adults (Wagner and Kozma, 2003). While discussions of the digital divide most often contrast ICT resources in the developed and less-developed countries (United Nations Development Programme, 1999), there are also digital divides within countries and these parallel the "advantaged-disadvantaged" fault lines. A recent National Center for Educational Statistics report (2003) indicates that approximately 65% of Black and Hispanic students have access to computers in their schools, compared to 79% of non-Hispanic white students. On the other hand, Black and Hispanic students are far less likely to have home use of computers: approximately 30% compared to 60% for non-Hispanic whites. Consequently, dropping out of school eliminates the primary source of access to ICT for Black or Hispanic students and reduces the prospect that ICT can be used to address their needs. Any programme that attempts to use ICT to reach the most disadvantaged students will need to draw these learners back into schools or invest heavily in out-of-school computer access. Alternatively, investment in community technology centres might be the best way to provide access, particularly if such centers also house the co-ordinated academic and social services that would support improved learning in disadvantaged youth and adults.

Implications for research on what works

Both policy makers and practitioners seek to know what works in all areas of education, and especially so in the relatively expensive world of ICT. While there are some examples of programmes that assist youth and adults, most of these are as yet inadequately investigated by researchers. Often reviews that consider ICT programmes for out-of-school youth and adults, such as ours and those of others (Office of Technology Assessment, 1993; Stites, in press), must rely on studies conducted in formal school settings and on software packages designed for much younger learners. More research needs to be conducted (and, for that matter, more programmes need to be developed) that focus on the use of ICT that is specifically designed and structured for out-of-school youths and adults.

Not only is there a need both for more research and for better research. Too often a claim that something works relies only on case studies or self-reports by programme staff. These studies often examine programme implementation rather than measure outcomes. Or, claims of improvement are based only on pre-post measures, rather than on comparisons with alternative approaches or current practices. What is needed, we believe, are new approaches to determining what works when ICT is used in education. This would apply, in particular, to the most disadvantaged - those who come the learning situation with the greatest diversity of home and social backgrounds. Slavin and Fashola (1998) call for more rigorous research in education generally, and Murphy (Murphy et al., 2002) directs this challenge at ICT research more specifically. We reiterate this call. To establish what works for ICT and the most disadvantaged out-of-school youth and adults, research is needed that uses experimental designs. In such designs, well-defined programmes are compared to alternative approaches or current practices that are equally well defined. Control or comparison groups must be matched for background characteristics of the participants, particularly age, ethnicity, literacy skill, previous academic success, and school and community characteristics. Standard outcome measures need to be used along with new measures that are designed to assess information literacy skills (Quellmalz and Kozma, 2003) and any measures that are specifically designed for the program. Standard approaches must be used to analyse the data for individual studies and to aggregate the results across multiple studies. At the same time, in order to understand the social and linguistic dimensions of success and failure as discussed earlier, qualitative and ethnographic studies are crucial in assuring that the data collected from standardized measures are appropriately gathered upfront and interpreted downstream (Wagner, 2004).

These efforts would be greatly facilitated, especially in the ability to aggregate studies across countries, if researchers from international organizations such as the Organization for Economic Cooperation and Development and the International Association for the Evaluation of Educational Achievement could agree on a common definition for the most disadvantaged out-of-school youth and adults, a common taxonomy for describing programmes(including ICT-based programmes) that address the needs of these students, a common set of standards and instruments for measuring the outcomes of these programmes, and a common approach to the analysis of the data.

Clearly this renewed approach to determining what works requires significant policy and budgetary commitments. But such commitments are also required for the comprehensive services needed by out-of-school youths and adults. Until these commitments are made and acted upon, we

will not know with confidence how it is that ICT can reach the most disadvantaged learners and exactly what it is that works.

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