Information Technology and Education
Implications for Theory, Research, and Practice

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September 1987
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INFORMATION TECHNOLOGY AND EDUCATION:
Implications for Theory, Research, and Practice

by
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11 July 1987

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ACKNOWLEDGEMENTS

Work on this monograph was supported through a grant provided by the Social Sciences Division of the International Development Research Centre (IDRC), Ottawa, Canada. We would like to acknowledge Steven Klees for his critical reading of this paper. His extensive knowledge of economics, technology, and educational development was invaluable in the preparation of this final draft. A special thanks to Sande Milton for his intellectual contribution to various parts of the paper as well. We are also indebted to B. Bayrdo, Alpha Camara, and Suzanne Grant Lewis for granting permission to incorporate their annotated bibliography into our IDRC bibliography. We are especially indebted to IDRC's Sheldon Shaeffer and D. Morales-Gomez for their helpful comments on an earlier draft. The views expressed in this paper, of course, are those of the authors alone.
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INFORMATION TECHNOLOGY AND EDUCATION: AN INTRODUCTION

Information technology, particularly telecommunications and microcomputers, has cast a wide net and is being rapidly disseminated, although at greatly disparate rates, throughout North America, Western and Eastern Europe, Oceania and the Third World. Aptly called by Chen and Paisley (1985) the "second electronic revolution," this new electronic juggernaut comes on the heels of the previous revolution which led to the widespread diffusion of film, radio, television and satellite broadcasting. Together, these two "revolutions" have formed a pervasive influence on the content and context of cultural, social and technical relations within and across nations. In particular, they have raised strategic and substantive questions about how we educate our children worldwide.

This technology explosion comes during profoundly troubled times. There is a worldwide financial and economic squeeze; intractable, increasing worldwide unemployment; stagnating economic growth, still too high rates of population growth and intensified international competition. In the education sector, after almost thirty-five years of educational expansion, there is an increasing number of dropouts, underemployed or unemployed graduates and a consequent cry for radical educational reform. Moreover, these problems are occurring within the context of ever-
widening inequities within and among nations. These problems have contributed to a climate of "crisis," a crisis that cuts across the complex relations of North-South, the industrialized as well as the less-industrialized, technologically dependent world.

The primary purpose of this paper, then, is to broaden our understanding of information technology's impact on education and to identify policy and research issues that need to be addressed, if we are to deploy this new technology in ways that advance human development. The literature examined includes research that assesses the impact of computers on learning, on the organization and management of education, and on the social context of education. Assumptions underlying the various rationales used to promote information technology in education are also examined and discussed. In addition, computer literacy and its various programmatic meanings, are reviewed, analyzed and critically discussed, taking into account the vast differences between the industrialized and less-industrialized nations. Based on this analysis, we introduce a definition of computer literacy that takes into account the "reality of the South." Using this concept as a development metaphor, an approach is suggested for introducing and integrating information technology into the educational enterprise that limits technological dependency and promotes, we believe, technological self-reliance.
Implications of this literature for current and future educational policy, teaching and administrative practices and research agendas are discussed and a special effort is made to relate this discussion and analysis to Third World educational development. The importance of such an effort cannot be underestimated. The recent cries for educational reform and the calls for the introduction of new technology, especially information technology and microcomputers, as major solutions to educational problems are not limited to the industrialized world alone (Coombs, 1985; Simmons, 1980). In the final section a research agenda is proposed.

The introduction and application of microelectronic technology to computing and telecommunications and the subsequent convergence of these two technologies into what is now called information technology1, have launched an

1 For a complete discussion of the notion, information technology, see John Maddison (pp. 113-115, 1983). Maddison notes that the French word telematique conveys a similar meaning, the coming together of telecommunications and information. Scholars concerned with the dangers of technical determinism and the misuse of language warn us about neologisms that have metaphoric appeal but have an effect on our moral and intellectual outlook. For instance, Israel Scheffler, in his recent article "Computers at School?" (Scheffler, 1986, pp. 513-528), warns us of how the notion of information has metaphoric power and, from an educational point of view, is distorting and narrowing our conception of knowledge and understanding. In a similar vein, Manfrey Stanley (1978) who in his book, The Technological Conscience: Survival and Dignity in an Age of Expertise, explores the relationship between language, myth and ethics in technological society, contends that there is a new cultural phenomenon occurring driven by technicism, the metaphorical misapplication of some of the assumptions, imagery, and linguistic habits of science and technology, that leads to what my colleague Steve Klees calls "phony precision."
"information and computing power" revolution that has spread across the educational landscape, notably in the United States and Europe, but throughout other parts of the world as well (Microcomputers and Their Applications for Developing Countries, 1986; Duncan & Harris, 1985; D. Levin, 1984; Stover, 1984). Indeed, beyond education itself, the corporate world and governments have for some time taken the lead in the use and application of "computing power" and telecommunications. However, it was the introduction of microcomputers in the late 70's that has made the expression "Information Society" a popular and powerful metaphor in the public mind. Moreover, it is the desktop computer, with its promise of personal empowerment, easy access to information, increased productivity in the workplace and liberation in education from old and inefficient technologies, that has stimulated the growing belief that computers are the key to personal and societal revitalization.

J. David Bolter (1984) in his recent book, Turing's Man: Western Culture in the Computer Age, contends that the computer has emerged as the "defining technology" of our time and that this technology will serve as a metaphorical source for redefinition of self, of social relations and of the mind itself.2 What is of particular note here is not

2 Solomonides & Levidow (1985) remind us of the point made by Lewis Mumford in his classic work, Technics and Civilization (1934), that there is a sharp distinction between an enabling technology and a defining technology. While the former type of technology such as print may alter
electronic computing itself, since computing power has been around for some time.3 What is new is that the microcomputer, combined with telecommunications and appropriate software, promises not only a more productive person, a problem-solver and a life-long learner but also a better informed, rational and participative citizen; indeed, a modern "renaissance" person, living in the web and network of a worldwide electronic community. There seems to be no shortage of new categorizations and conceptualizations of the changes that are occurring and speculations as to the nature of the worldwide transformations brought about by the diffusion of information technology. William Paisley (1984) contends, for instance, that education and work, and everyday life, are becoming "algorithmic." This "age of algorithms," he notes, is "founded on process knowledge that derives from analytical science, technology, and the procedural analysis of experience" (p. 2). In a similar vein, Shirley Turkle (1985) concludes from her research that the microcomputer is as much a "subjective machine" as it is a technological device, a machine that creates opportunities and conditions that enable us not only to redefine and increase our individual technical capacity but also to

the way we do things, a defining technology such as the clock alters the way we experience ourselves and the world. 3 Maddison (1983) notes that the first commercial mainframe, UNIVAC I, was built for the American Bureau of the Census in 1951; in education, both PLATO, mainframe-based, and TICCIT, minicomputer-based, have been on the educational scene since the early 70s and represent the first systematic efforts at computer-assisted instruction.
rework our sense of self and the very social and cultural world in which we live.

Whether microelectronic processing and the personal computer have this type of impact on our lives or not remains to be seen. It is still unclear whether this is just the initial enthusiasm and optimism that have always accompanied new technologies, whether the "agonizing reappraisal" phase is just around the corner, or whether this is, indeed, a new era, an era of computerization. Nonetheless, it is clear that this technology is having a profound impact on the world of work: it has become a force that is accelerating the reorganization and restructuring of the workplace, creating new occupations and rendering others obsolete. It has provided new ways to manage and control work processes and has created new ways to access, manage, evaluate, analyze and share vast amounts of information. While at first glance these are welcome changes, the full impact of these changes on the technical and social relations in the workplace is not yet clearly understood. Issues of job loss, inadequate attention to loss of "microflow" activities and the downscaling of job complexity (the opposite of what was presumed), the emergence of "electronic sweatshops," and loss of job control are now being investigated (Grubb, 1984; Rumberger, 1984; "Home Computer

In the meantime, while these issues and their consequences have not gone unnoticed, educators, from teachers to educational policy makers, administrators and planners, have, for the most part, embraced the microcomputer and information technology, hailing them as major innovations for education that will transform the educational enterprise. Fogrow (1983) contends that unlike technologies that have been introduced into education in the past, computer technology in education has developed a substantial political constituency, strong parental support and a cadre of teachers who have spearheaded its introduction into the schools, at least in the United States. While Papert’s Mindstorms (1980), the book about “children, computers, and powerful ideas” and how children “teaching” the computer using the programming language LOGO develop new conceptual tools, is still controversial (for a thoughtful critique of this book, see Davy, 1984), it serves as the intellectual and theoretical rationale for the millions being spent on computer purchases for schools, the millions for teacher training (and retraining) and the even more millions spent on educational software development.

The computer promise has been so compelling that teachers in the United States (quite uncharacteristically)
have at least initially have been instrumental in the microcomputer's introduction into the schools (Hess & Miura, 1984; Becker, 1984). This is in contrast to the legacy of the past wherein the response by teachers to technological innovation has been fickle at best (Cuban, 1986; Papagiannis, Klees & Bickel, 1982). Indeed, it is remarkable how rapidly the microcomputer has been diffused into classrooms in the United States (Becker, 1983, 1984), in Europe (OECD, 1983) and, albeit to a lesser extent, in the Third World (UNESCO, 1986), and how quickly there has emerged a call for computer literacy. Of course, as Pogrow (1983) points out, the changes in the workplace, the fact that the microcomputer is a worldwide cultural phenomenon and the political-economic constituency that has developed on its behalf are important enabling factors. Yet, such widespread acceptance of this innovation as a major tool for educational improvement is unique in the history of education and technology (Maddison, 1983; Cuban, 1986; Papagiannis et al, 1982).

The fact that it has captured the imagination of people everywhere, and the fact that it has spread rapidly into all realms of our lives, particularly the workplace and the classroom, require that we stop and examine the full character of this "machine." Are we about to ignore Grubb's (1984) warning concerning the high-tech promise and hop on "the bandwagon once more," or do we, indeed, have a tool
that, unlike technologies of the recent past, will actually enhance and broaden our potential and capacity to learn, and will provide us with more meaningful jobs that lead to more self-reliant, productive lives?

An adequate and thorough study of microelectronic technology in education requires that we examine not only its effects on the process of learning and learning outcomes but also the rationales, philosophical and otherwise, for advancing it as an educational innovation. Moreover, the history of educational innovation suggests, both in the industrialized world and the Third World, that altering the educational enterprise in any fundamental way is difficult, often wrongheaded, and often done for the wrong reasons. This is not to say that microcomputers and information technology are merely passing fads and that we can expect them to pass from center stage as have prior technologies with their promise of educational transformation. It is an unalterable fact that the information society is here to stay and that it is having a profound effect on the structure of work, occupations and employment. It is also an unalterable fact that computing power is having an impact on education and is in the process of becoming part of the educational enterprise, here and abroad.

What is not clear, however, is the nature of this impact. Indeed, what remains problematic is how and for what
educational purpose microelectronic technology is being put to use. If, in fact, it is serving our educational goals, is this the most effective way to do so? How does it compare with other types of innovations or other conventional practices that if, properly implemented, would produce similar results? If microcomputers are not serving our goals, what goals are they serving? Finally, we will need to ask whether the current questions that drive educational research and evaluation on microcomputers are the only ones we should ask. What are some of the policy and research questions we ought to be asking? What kinds of information should we gather that would be helpful to policymakers and planners in their attempts to assess the "investment worth" of this new technology?

We begin to examine these issues by further elaborating on some of our introductory remarks concerning the broad context within which this information technology "revolution" in education is occurring. In the following section various theories, rationales and educational explanations are discussed that reformers of education draw upon to justify the introduction of microcomputers. The next section is a selective review of the research on computer-related educational efforts. This includes the research on its impact not only on cognitive learning, but also on the social, organizational and cultural aspects of education, as well as that attempting to assess to what
extent this technology contributes to or minimizes inequities in education. In the final section, the results of these research efforts are assessed and implications for educational policy and research are discussed.

NEW EDUCATIONAL TECHNOLOGIES IN CONTEXT

There are a number of aspects of our social, political, economic, and cultural context that need to be considered to understand the advent of the drive for microcomputers in education. This section explores some of the most salient.

The New Technology: Forgotten Lessons & New Promises

The availability of microelectronic-based information technology combined with a climate of crisis has sparked an unstudied receptivity for technological solutions, especially technologies that are couched in promises of employment generation, increased productivity, improved efficiency, and personal empowerment. While the history of technology in education is a history of unfulfilled expectations and false promises, the call for educational reform and the availability of new technologies make it difficult to take a cautious and thoughtful stance.4 This

4 The embracing of technological solutions to complex educational problems has a long history in the United States, as well as in the Third World, particularly as it has related to efforts at encouraging societal and national development and educational reform. While access to education has certainly increased through the expansion of schooling, efforts to alter or transform the quality of the educational enterprise through the introduction of new
is partly because "technology push" comes at a time when education is being strongly criticized in both the industrialized and less-industrialized world and because of a strong technological determinism in the ideology of modernism. The fact that North America and Europe have taken the lead and already have embraced computer-related information technology makes it even more difficult to ignore.

The incorporation of these new technologies, most notably in the private sector, but in the public sector as well, has begun to have a profound effect on the organization of work and the structure of occupations. The increasing centrality of computers and information in our everyday lives (whether we are aware of it or not), has already been heralded as the defining metaphor for the forthcoming "post-industrial society" (Provenzo, 1986; Bolter, 1984; Bell, 1973). While in the public mind, information technology appears to be a solution to many of our current problems and a symbol of societal progress, a growing number of critics have begun to question the all too simple acceptance of information technology as a solution to the many complex problems with which the world is faced today (Solomonides & Levidow, 1986). An editorial of a technology have been less than successful. For a comprehensive review and critical discussion of why efforts to reform and to modernize education through introduction of technical innovation tend to fail, see Papagiannis, Klees, and Bickel (1982) and more recently, Cuban (1986).
recent issue of *Development* (Elmandjra, 1985, p. 2) warns that,

Despite the sophistication and deeper understanding of the development reality, how easily we slip back into the development myths of the 1960's, as if nothing had happened in the meantime. Much of today's rhetoric about the "information revolution" seems to be echoing yesterday's rhetoric about industrialization, modernization, the "nuclear age," or the "green revolution": each of these technologies has been loudly hailed as a great leap towards the golden age. During the past twenty years, however, experience has taught us that technological breakthroughs have to be examined with attention and even suspicion--they never generate freedom, democracy or justice on their own. In fact they create a whole host of new problems.

While there is little doubt that information technology is here to stay, there is a growing need to begin to assess its outcomes and its side-effects. In one sense it is a truism that technology is neutral, but the purposeful use of technology always occurs in some historical-structural context with human agency and cultural significance (see Hansen, 1981). This requires that we examine this technology (or any technology for that matter) not only in terms of its promise and intended purpose but also in terms of its actual implementation and consequences and its actual uses and their side-effects and outcomes, in its social,
political, economic and cultural context, both national and international.

The Educational Connection

Computers and data management and transmission have been around for some time, in business, government and education. Mainframe computers and information management, computer-assisted instruction (CAI), and trans-national data transfer have, however, remained beyond everyday experience even though they have played a role in influencing the conditions of our collective lives. Instead, it is the microcomputer and its message of personal enhancement and productivity that have inspired images of societal transformation and socio-economic change. For instance, in North America, the United Kingdom and Europe, the rush to integrate the new "microelectronic" information technology into work, home and education has been phenomenal. Indeed, the notion "computer literacy" represents the recognition of the multiple dimensions of this planned integration. Computer literacy has been used to mean that we need to learn how to use this technology out of economic necessity as part of our preparation for the new computerized workplace. It means that we need to learn to use it to access information useful in our daily lives, enrich our children's education and manage our households. Computer literacy has also been used to highlight the need to use the
computer as a vehicle for developing higher order thinking skills and other types of learning. Perhaps most interestingly, it has been seen as the need to develop an understanding of the political, social, cultural and economic issues and problems that accompany the new information society (Papagiannis & Milton, 1987). Despite its surplus meaning, or perhaps because of it, computer literacy has become a major policy initiative as well as an educational goal.

The calls for "computer literacy" in turn have served as a special impetus for policy-makers and planners to begin the formulation of national policies to promote computer literacy among its citizenry. While in the United States, the vehicle for diffusion of microcomputers and information technology has been its commodification and the marketplace, other countries have relied on their national governments to develop information technology policies. Brazil, for instance, in an effort to manage and monitor the use of information and information technology, has developed comprehensive policies in the fields of telecommunications, informatics, telematics and transborder data flows.

5 William Paisley (Chen and Paisley, 1985, p. 21) points out that the perceived need to know about and to use computers has brought about a new demand for "print" literacy. Moreover, he contends that while the first electronic revolution of radio and television may have undermined literacy "as a foundation for learning..., the second electronic revolution of interactive media depends more upon literacy than do even traditional print media."

6 While only the small computer market in Brazil has been restricted to the local market, U.S. manufacturers have
policies include those governing the development of local manufacturing of mini and microcomputers and the development of a software industry as well (United Nations, 1982). In Europe, almost every government has developed a policy that has explicitly promoted universal computer literacy programs, both within and outside of the formal educational system (Papagiannis & Milton, 1987; OECD, 1983). And, while educational philosophies, strategies, and resources differ, educational leaders across the world have begun to introduce computing into the school curriculum, beginning as early as the elementary level in wealthier industrialized countries. Australia (Hammond, 1985), Israel (Barta, 1985), and Hong Kong (Tung 1985) are examples of other countries that have developed national policies for introducing computers and computer literacy into education. Moreover, while educators disagree over the notion of computer literacy and what implications it has for the curriculum (Papagiannis & Milton, forthcoming), it has not slowed the pace at which

cried "foul," reports Mac Margolies in a recent article in the Christian Science Monitor (March 26, 1987). These complaints of restraint of trade come despite the fact that both foreign and US manufacturers have increased their revenues. The issue seems to center around "market share." Margolies notes that, "The two (local and US manufacturers) are not in direct competition. In the last two years, though, Brazilians have caught and slightly passed foreigners in total revenues. Ten years ago, the multinationals controlled the entire industry; today, they own a smaller share of an ever growing pie" (p.17).
computers have been introduced into educational environments.

The Third World and Microcomputers

The Third World, despite its already limited resources and ongoing concern with technological dependence, has been plunged into the pursuit of computer literacy as well. Indeed, information technology and computers and cross-national data transfer are not new to Third World countries (United Nations, 1983; Nilsen, 1979). For many years now, mainframe computers have served multinational business and commercial interests. Even in the poorest countries, mainframe computing capability has been available in the public sector and at national universities. This increasing pervasiveness has given an old question a new form: "Does information technology promote or develop structures that stimulate development or does it encourage new forms of dependency such as information dependency?" For the past fifteen to twenty years this question has been debated in research and policy forums with respect to the mass media, particularly with respect to television transmission via direct broadcast satellites and news dissemination mechanisms (Richter, 1978; Guback, Varis, and Schiller, 1974). New technologies are now fueling these debates further. Telematics, the transmission of computer data across borders (Stover, 1984, p. 100), also involving issues
of national sovereignty, has only recently entered the public arena as a topic for debate. Most recently, the question of computing power serving as an agent for change or an agent for advancing technological dependency even further, stems from the introduction and popularization of the microcomputer. Whatever else the microcomputer may be, it is also a cultural phenomenon and, like jeans and coca cola, is finding its way into the cultural and educational fabric of every country in the world.

Already Third World policy-makers and planners are exploring, developing and implementing "computer literacy" policies (UNESCO, 1986). Informal reports indicate that almost every Third World country is examining, and in many cases already implementing, the use of microcomputers for development purposes (William, 1984; Moses, 1983; Weber, 1983). Moreover, even in countries where policies are still being formulated, microcomputers have already entered the social, political, economic and educational landscape. Used for some time in an "information handling" (Griffiths, 1981) role by business and government, they are even being used at the local level for such things as agricultural and health projects (Ingle, Berge, & Hamilton, 1983). Government and private schools are introducing microcomputers into their classrooms and business offices, although in private schools typically much sooner than in government schools; individual teachers, just as in the United States, introduce them;
universities, technical and vocational institutes also have begun to obtain them, often for both training and research purposes (UNESCO, 1986), sometimes with assistance from development agencies or foundations; national, regional and international conferences have already been held to share computer experiences (for instance, the BOSTID/ANLAC Symposium on Microcomputer Applications in Education and Training, held in Mexico, 1985); and the private sector, of course, has been using them for several years and, in many cases, provided the initial on-the-job training in the use of computers.

Microcomputers in Third World Schools: Some Dilemmas

The microcomputer as an instructional innovation comes at a time when Third World policy-makers and planners continue to grapple with basic problems of educational quality, access and relevance. While these problems have cried out for solution for a considerable time and yet remain unsolved, there is now a growing concern that Third World countries must also somehow prepare for the new age of computers or otherwise be left even further behind. Faced with limited, and in some cases, shrinking resources, the advent of the microcomputer as an educational device and its relatively high cost pose serious problems of direction and purpose. On the other hand, development agencies, both bilateral and multilateral, have begun to urge
experimentation with microelectronic devices for learning in Third World situations, hopefully, in part, as a way to grapple with the continuing problems of educational quality, access and relevance.

While such development assistance is laudable in its intent, it suffers from the same kind of "panacea" arguments that were assumed to support prior innovations such as television, programmed learning, vocationalization, and nonformal education. The usually quite limited or even negative effects of these past innovations did not reflect the actual intentions of development planners. Rather they reflected their neglect of the institutional context in which learning has traditionally occurred and the neglect of the larger context of economic, social, cultural and political constraints on the efficacy of technological innovation to bring about educational and societal improvement. In addition, it tended to reflect a narrow conception of how learning and teaching takes place. Factors such as school and classroom processes, indigenous teacher practices and administrative leadership now known to influence learning were ignored. Recent large-scale studies of educational innovation and reform in both industrialized and Third World educational settings have concluded that there has been little change in the basic instructional core, the use of technology, and the organizational structure of education management, access and performance.

With such a dismal record in the past and with such serious limitations on resources in education, what are the options for Third World countries when confronted with yet another "glamorous" technology? Is it doomed to be yet another failure or at best, as Kirst (1983) has suggested, an add-on such as driver's education or a school lunch program, or, worse yet, another expensive contraption to be locked up in the closet of "failed technologies?" It has not gone unnoticed by Third World observers that the promotion of microcomputers in education comes from the United States, a country seen by many as driven by "technological determinism," and whose culture persists in pointing us to "new technologies as the generators of economic and social progress" (Grubb, 1984, p. 429). Will this new technology really narrow the education gap within and across countries, or will it so distort the educational purpose and commitments in Third World countries that gaps that had diminished will now become so large that we will have inadvertently created a permanently stratified world educational system? Or is this new technology different from previous technology and, if properly used and implemented, can it surmount, perhaps even avoid, some of
the unyielding problems in Third World education, e.g., the lack of culturally relevant education/training, modest school financing, high dropout rates; inadequately prepared teachers, and inequitable access to quality education?

**Education, Technology and Culture**

Recently, Seymour Papert (1987) noted that in the assessment of technology, we have tended to focus on the technology itself, ignoring the cultural context within which it is implemented and the human agency required to carry it out. Similarly, Kenneth King (1985), in discussing new information technology for schools in Africa, points out that "like many technologies it already has a context and code built around it, and these reflect the present state of this technology in the West." (p. 26) He goes on to note, "...any Third World country buying into new information technology for schools has to be aware of this wider packaging..." (p. 26).

To these warnings we would add that this technology is also burdened with not only socio-cultural baggage but with curricular and philosophical baggage as well. No technology is introduced separate or free from preferred educational practices. These practices in turn are influenced by questions and answers concerning their purpose and use, and reflect shared educational philosophies, which in today's
global ideological climate are dominated by technicist (Stanley, 1978) or technocentric (Papert, 1987) thinking. One only has to note the lack of debate among international development educators and their funders about how to use microcomputers in learning. The instructional technologist mentality, armed with "systems analysis tools" and behavioristic learning assumptions, although playing only a small role in U.S. education, dominates the large U.S. funded or inspired international educational development projects and legitimates the "curriculum as technology" ideology. While today the United States is experiencing a revival of critical discussion of curricular issues (Apple, 1982), little controversy or reexamination of educational philosophy and its relation to technology is occurring within international development agencies such as the United
States Agency for International Development (USAID) or the World Bank.7

The major point here, however, is that whether they be instructional technologists or subject-matter specialists who claim that the structure of knowledge determines teaching practices, or developmentalists who focus on student characteristics for determining curricular matters or experientialists who view the learning process as the basis for developing teaching practices, all apply information technology in a way consistent with their basic assumptions, whether they are aware of it or not. What this means is that when a technology is promulgated, it is done so within the context of the "wider packaging" of some curricular perspective, some set of assumptions, both implicit and explicit, that may reflect educational goals, activities, or even resources, not fully visible or

7 In a recent critical review of research, Richard E. Clark (1983, p.456) contends that there are no learning benefits to be gained from media-driven instruction. He suggests that we must return to the study of curriculum and methods of instruction. He concludes, "One might reasonably wonder why media are still advocated for their ability to increase learning when research clearly indicates that such benefits are not forthcoming. Of course such conclusions are disseminated slowly and must compete with the advertising budgets of the multimillion dollar industry which has a vested interest in selling these machines for instruction. In many ways the problem is analogous to one that occurs in the pharmaceutical industry. There we find arguments concerning the relative effectiveness of different media (tablets, capsules, liquid suspensions) and different brand names carrying the same generic drug to users." Similarly, international aid agencies are still dominated by media-driven instructional approaches and seem to be unaware of or impervious to the recent contributions to teaching and learning policy by such thinkers as Lee S. Shulman (1987).
It should also be noted that the conduct, direction and interpretation of research have the same character and flavor. While there is no longer any serious doubt among scholars that all social science research reflects implicit ideologies and assumptions, it is still important to remind ourselves that most of the research conducted, particularly in education, is from a positivistic perspective. Moreover, it should be noted that much of the research on learning and teaching and educational innovation draws on a psychological paradigm. While research is conducted everywhere, and from every perspective, it is in the United States that the methodological empiricist bias of both policy-makers (who provide the demand) and researchers (who supply the research) collaborate to produce most of the research on innovatory effectiveness and impact. This means that most of the research, at least the initial research on innovations, originates in the United States. Rarely is the researcher aware of how his or her thinking about a piece of research and the research itself may be affected by implicit social or cultural factors. After all, the positivist scientific mentality itself is a cultural product wherein ecological validity is assumed. While the comparative education literature is full of studies that warn of this danger (See Mukweso, Papagiannis & Milton, 1982; Farrell,
1979), development agencies often rely on this type of research to support their development initiatives in Third World countries.

Michael Huberman (1987), in a recent and timely article, describes the dangers of this type of "carpetbagged" research. He points out the dangers of carpetbagging concepts, constructs, treatments, instruments, and results obtained in research work in the United States to other countries and reminds us of the extent that research, while often based on well-established theory, is also comprised of made-at-home assumptions, both implicit and explicit. This comment is in the form of a warning since much of the research and commentary available on microcomputers, even the critiques, come from the West. In the analysis of this literature at the end of the paper, we will attempt to take these biases and their implications into account.

THE MICROELECTRONIC PROMISE IN EDUCATION

Most innovations are accompanied by a wide range of promises and rationales. The introduction of microcomputers into education has been no different. While there is a variety of ideas that drive the introduction and promotion
of microcomputers, most of these can be organized into six categories. They are as follows:

- The First Round: Computer-Assisted Instruction (CAI)
- The Mindstorms Rationale
- The Evocative Motivator Rationale
- The Relevancy in the Workplace Rationale
- The Cost-Effectiveness Rationale
- The Liberation and Empowerment Rationale

The First Round: Computer-Assisted Instruction (CAI)

As mentioned above, use of computing power in education began much before the relatively recent introduction of microcomputers, in the form of computer-assisted instruction (Suppes, 1966), and so did the research on its utilization and impact, even its unintended impact (Brod, 1972). Studies are available of the impact of earlier CAI efforts on achievement, including the two best known systems, TICCIT (a mini-computer system) and Plato (mainframe-based) (Maddison, 1983; Roblyer, 1985). There is also a study on

8 For a summary of the similarities and differences of PLATO and TICCIT systems, see John Maddison’s (1983) concise description. He quotes from a study by D. L. Alterman et al: “Evaluations of the educational impact of each project revealed that neither CAI system had reached the potential so long claimed for this form of instructional technology. The PLATO system met with favorable reactions from teachers and students, but it had no significant impact on student achievement. The TICCIT program did result in improved student achievement. However, the completion rate for
the problems and issues of introducing these systems into schools (House, 1974), and even several analyses of whether they are cost-effective when compared to other innovations such as reducing class size, increasing the length of the school day and tutoring (for instance, see Levin, Glass, & Meister, 1984; see also Glass, 1984).

At the time that computer-assisted instruction was being developed and implemented, so was Skinner's philosophy of teaching and learning. Indeed, this philosophy's educational partner, programmed learning, was in its heyday (Maddison, 1983, p. 38). This may have profoundly influenced the nature of CAI, and, more importantly, may be the legacy that that continues to influence how microcomputers are used in education. It is not surprising, then, that electronic page-turning, programmed learning, and drill and practice type uses still capture, and perhaps limit, the imagination of some of the advocates of microcomputers in education and still may be the main feature of computer usage in schools today. However, it is the rise of cognitive and

courses under the TICCIT was lower than the completion rate for the same courses under a lecture-discussion format."
(Maddison, 1983, p. 167)
9 Rowntree (1982, p. 16) comments that, "conceiving of the learner as an object to be worked on rather than as a social being whose purposes and strategies are influenced by what he perceives about the people around him and the demands of the institutional setting in which he is operating..." is a simplistic conception of classroom realities. This is not only a criticism of these particular practices. Rather, we want to note how what we do with computers is influenced by our educational and curricular commitments. There are many places and situations wherein these curricular tactics may be most appropriate. Maddison (1983) quotes Richard Hooper,
developmental perspectives (Maddison, 1983, pp. 40-41), most notably of Piaget, that has provided a more recent rationale for the use of microcomputers in education.

Mindstorms

Indeed, the "Mindstorms" rationale is probably the single most important intellectual justification for the use of computers in education. The idea that through playfulness with computers and the creation of a learning environment wherein children and youth "teach" the computer through the use of a specially-designed programming language, LOGO, finds its full expression and justification in the book by Papert (1980). The idea of teaching "thinking" through LOGO programming has had a profound impact on teachers and has led to the wide-spread use of computers in schools around the world for this purpose. Papert contends that children, by directing their turtle-like sprite on the screen to form simple to complex patterns, are enabled to directly master LOGO-talk and LOGO-thinking. This prepares them, through the creation of

the director of the National Development Programme in Computer Assisted Learning: "Many people equate computer assisted learning with programmed learning and with the provision of cost-effective teaching through reduction of labour costs (i.e. fewer teachers). This image of CAL (Computer Assisted Learning), largely inherited from North America, must be put to one side if the National Programme, and this final report, is [sic] to be understood. Computer assisted learning and its twin, computer managed learning, as defined and developed by the Programme, are characterized by a versatility of applications, some of which have nothing to do with programmed learning at all."
"Microworlds," to directly experience, not only intellectually but qualitatively, "formal" ideas and "formal" intellectual structures (such as Newton's Three Laws of Motion). The significant idea here is that children can, through this approach, begin to appreciate "official" physics through the initial use of their own "baby-talk" dialects, i.e., LOGO, in their microworld of learning and experimentation. (Papert, 1980, p.126) In this sense, Papert's approach is designed not only to promote ways of thinking but also, perhaps even more importantly, to promote an appreciation of formal ideas and concepts. Key to Papert's ideas are attention to the cognitive and developmental implications of this use of computers and programming, the commitment to cognitive and developmental models of learning, and the philosophical focus on instrumental reason as an important educational aim (see Davy, 1984 for an interesting critique).

The Evocative Motivator

It is, however, Shirley Turkle (1984) who underscores the powerful social, cultural and psychological dimension of the microcomputer. In her naturalistic and ethnographic study of children working in "microworlds," she finds that the computer is a "subjective machine" that "evokes" more than just an intellectual response from pupils. She documents how the relationship of children and
microcomputers evolves and how this relationship affects the identity of the children. She notes how the computer (and LOGO) seem to "evoke" thinking rather than determine thinking. She also documents how different personality styles can be expressed through the use of the computers, highlighting some differences that may be gender-linked, whether social or biological in origin. The implications of her work, while they are varied and need to be subject to further analysis, are clear on one point: microcomputers are motivating and have the potential for holding pupils attention. In light of the competing attractions of today, e.g., radio, television, etc., microcomputers as a major tool for learning may be the only electronic device that can successfully compete for students' attention.

The Information-Oriented Workplace

Among the rationales for promoting the use of computers in education, there are several that are rooted in the changes occurring in the workplace. In the public mind, for instance, it is now commonly believed that there is a rapid

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10 Her work provides research support that the computer may be serving as a defining technology (see also Bolter, 1983). Drawing on a naturalistic perspective, Turkle provides "grounded" evidence of a three-stage process that the children undergo as they experience and interact with the computer. Briefly, the process is comprised of, first, a metaphysical phase wherein the children experience the similarities, and eventually the differences, of the computers' characteristics in comparison with the children's own. The second phase is characterized by working out identities and the third phase is one of mastery over the computer and its power.
transformation occurring that is pushing societies toward
the long-heralded information society. This is due, in
part, to the exponentially growing amount of information
becoming available and the need to restructure the workplace
to be more productive and more efficient in information
gathering, analysis and use. Indeed, the rapid diffusion of
computing power throughout the work-world has been
phenomenal. Looking at it from the point of view of the
U.S. data processing industry, for example, the value of the
industry's computer product shipments from 1978 to 1984 has
increased from $17.6 billion (U.S) to $53.2 billion, with
1988 output estimated at $104.6 billion. (Information
Processing in the United States, 1985, p.3). Moreover, the
fastest growth is to be found among the personal computer
segment of the market. From 1978 to 1984 world shipments of
personal computers increased in value from .77 billion to
16.8 billion! (p. 3). While the growth of sales of large-
scale, medium-scale, and small-scale computer systems
continues, microcomputer sales showed a growth rate of 2,082
per cent between 1978 and 1984 (p. 3). It should also be
noted that it is estimated that by 1988 shipments overseas
will be a little more than one-third of the U.S.
manufacturers' total (p.3). Moreover, the total computer
labor force is expected to increase from 1.15 million in
1982 to 1.78 million by 1995, a 64.6 per cent increase (p.
4). As far as preparing people for work in the computer
field, it is reported that in the academic year 1981-82,
over 20,000 students graduated with a bachelor's in the computer field, a 34 per cent increase over the previous year (p.5).

From another perspective, Stanley Pogrow (1983) highlights the rate of diffusion of information technology in the workplace. In extensive detail, he points out the growing use of robots, telecommunications, office automation, data bases, information services and utilities such as Compuserve and Dialog. Pogrow argues that, "...the two basic forces promoting adoption of the new technologies are (a) the need to be competitive in a worldwide economy and (b) the general desire to increase living standards" (p.43). Given these changes and the reasons for them, Pogrow calls for a grand reform of education that would be responsive to these changes and at the same time improve the quality of education. He warns that if we are unable to incorporate the new technologies into our educational goals and into the instructional core, then public education may suffer "environmental collapse."11 The rest of his book is devoted to the critical discussion of appropriate local,

11 Pogrow defines environmental collapse as..." a process wherein dissatisfied constituents do not try to change an organization. Instead, they abandon it for an alternative, economically compelling service or product made possible by a fundamentally new technology" (p.93).
state and federal polices for integrating the new technology into the educational system.

It should be noted that not all analysts are convinced that computer use in the workplace is a rationale for computer use in education. For example, Levin and Rumberger (1983) argue that in the U.S. there will be relatively few new jobs created by hi-tech industries in the near future in comparison with the vast number of unskilled jobs that will be created in the service sector. Furthermore, their examination of past transformations of industry indicate that new technologies develop in such a way that less skilled workers are needed (the idea of "deskilling") and so even those jobs that are created in hi-tech industries may not demand better educated workers (even so, Levin and Rumberger argue for much greater use of microcomputers in schools, but for reasons other than the workplace rationale). Regardless of whether or not analyses like Levin and Rumberger are correct, the point we wish to make here is that computerization of the workplace has created a belief among many and a sense of urgency that computer technology and other microelectronic technologies must be introduced into education as well. There are several reasons for this: first, because information and computers are becoming pervasive in shaping today's world of work and it is therefore thought that youth need to trained in their use; second, because it is believed that properly deployed,
it can increase "educational productivity," just as it purportedly has improved economic productivity in the world of work.

Cost-Effectiveness

One of the key selling points for information technology has been that it can assist in the modernization of education. Education, as an industry, has been seen by economists as stagnant, making little, if any, progress in increasing productivity due to its unchanging labor-intensive nature (Baumol, 1967). Twenty years ago, Phillip Coombs (1968) put it simply: "education's technology, by and large, has made surprisingly little progress beyond the handicraft stage." For the past two decades there has been the oft-expressed hope by economists and others that new technologies could lower costs and increase effectiveness in the way that some capital-intensive technologies have increased productivity in other sectors of the economy.

The cost-effectiveness rationale was a principal promoter of the considerable experimentation over the past two decades with using the previous technological revolution, i.e., mass media like radio and television, in educational systems. In Third World nations this push has been, and continues to be, especially strong, based on the belief that intensive use of mass media in schools can
provide better instruction than the poorly trained teachers generally available and that, furthermore, this can be done much more cheaply than by upgrading teacher training and consequently having to pay higher teacher salaries. The evidence on the success of the many educational radio and television projects that have been tried is mixed (Carnoy & Levin, 1975; Schramm, 1975; Wells, 1976; Spain, Jamison and McAnany, 1977; Klees & Wells, 1983; Wagner and Kemmerer, 1986). What is clear is that the promises that these mass media technologies would rapidly transform the educational enterprise have not been realized. In rich countries like the United States, televisions sit in storerooms, and few Third World countries have been willing to make the major structural changes required to adopt such technologies on a widespread scale.

The cost-effectiveness rationale applied to the promise of microcomputers in education basically follows one similar to that applied to the mass media "revolution." The use of microcomputers, it is hoped, will enable teachers to restructure their role and become more managers of the instructional process. With the aid of this technology, more students can be reached by fewer teachers, thus reducing the overall costs of instruction. In addition, the quality of education will also improve since the software to be developed will be prepared by experts and will embody the best available pedagogy. Equally important, teachers will
be able to devote more attention to students with special needs since the individualized instruction through a microcomputer "teaching" the other students will not require a teacher's continuous intervention.

While to many these promises seem as unrealistic as those of the previous era, others point out that there are significant differences between the two revolutions. Chief among these differences is that instructional radio and television, in essence, have tried to get around the teacher quality problem by taking control of the educational process. Also, at a systemic level, adopting these mass technologies almost requires a nation-wide restructuring of the educational system to a lock-step process where all children are learning the same thing at the same time. Microcomputers, however, require and build considerable teacher skills, and their use can be implemented gradually, with a wide variance in their application determined by locally made decisions. Whether such differences will alter what eventually happens to microcomputer use in education is unclear. While the cost-effectiveness rationale is increasingly being employed to promote new information technology use in education, it is only now that studies are
being conducted of actual uses to evaluate the extent to which this rationale can be justified.

Empowerment

Among the various reasons for incorporating "computing power" into education, one of the most exciting is the possibility it has for extending what Stewart Brand (1984) calls empowerment of individuals. This line of thought stems from the two different sources: one from concern that, with all the data transmission occurring on in business and government, the control and access of information needs to be seen as a policy issue rather than as a technical issue. The other source of this "liberating" notion comes from the "aid to communication" and "aid to solving and posing problems" promise of personal computers. This view is similar to the view held by some in the Third World that this technology may have the potential to contribute to self-reliance and independence.12

A major implication of this incredibly large confluence of rationales and the concomitant diffusion of these new technologies in education is that computers, their potential

12 Another factor here is that personal computers have, to some extent, served to demystify the computing power of the mainframe computing systems. The mainframe system of operators and consultants, and its perceived lack of interactiveness (real or imagined), made the mainframe seem more remote to the everyday potential user. The fact that one can control and interact with his or her own computer has a liberating flavor.
as well as their danger, need to be studied and understood in a variety of ways—not only in how they manage to do some tasks well, but also in how they may reinforce old problems (Reinecke, 1984; Solomonides and Levidow, 1985; Siegal and Markoff, 1985; see also Masuda, 1980, for a futuristic analysis of the information society and its possible benefits). Research in this area is a burgeoning academic industry (see Papagiannis, for a bibliographic database of over 1,700 citations and abstracts on microcomputer commentary and research, 1986) and, although still in its initial phases and undertaken mostly in industrialized countries, already has offered some interesting results.

THE RESEARCH: SOME PRELIMINARY FINDINGS

In the United States, since the first Apple microcomputer was introduced into the Cupertino school district in California in 1977, there has been a phenomenal spread and diffusion of information technology into schools (Becker, 1983; 1984). Today, few U.S. schools are without at least one microcomputer and many have at least five or more. Such a rapid introduction of microcomputers into the schools is a phenomenon in itself, especially when one

13 Although we are concerned with Third World uses of microcomputers in education, the vast majority of existing studies come from the United States and other industrialized nations. We focus our review on this research in part because it is more broadly relevant, but with the warnings mentioned earlier, and also because, like the technology itself, it is exported to the Third World and often has great influence on educational agendas there.
compares their level of diffusion with the level of penetration of prior innovations such as educational TV, programmed learning, film, and radio. 14

It has been a decade since the microcomputer first entered a U.S. classroom (keeping in mind, however, that PLATO, the mainframe computer learning system, arrived much earlier but was never widely implemented), and the research on its impact has begun. A national survey (Becker, 1983) of 1,082 computer-using schools in the U.S. has already been carried out to assess the level and kind of use of microcomputers in schools. Concurrently, there have been efforts to assess to what extent microcomputers have been integrated into the core curriculum (Meister, 1984) and what effects they have had on the quality of education (Sheingold, Kane, Endreweit, 1983). Some effort has also been made to assess to what extent computer-based instruction (CAI) is cost-effective compared to other innovations (Levin, Glass & Meister, 1984). There have been studies to assess the impact of microcomputers on achievement, which include studies of CAI based on the mainframe and minicomputer (Roblyer, 1985) as well as the

14 Chen and Paisley (1985) describe this earlier period of innovation as the first electronic revolution and the recent period of computers as the second revolution. Of particular importance here is their crucial but paradoxical observation that the second revolution brings with it a new demand for text literacy (pp. 21-22). They also distinguish the second electronic revolution from the first by the strong interactive quality of computers, a quality missing from the technologies of the first revolution.
microcomputer. Other studies have focused on equity of access and type of usage questions: to what extent is there differential access based on diffuse status characteristics such as race, gender and class; to what extent do microcomputer curricular strategies differ across these characteristics; to what extent are there other unintended consequences or side-effects, positive or negative? There is also a rapidly growing literature of actual descriptions of techniques, approaches and strategies involving the pedagogic use of microcomputers in the classroom.15 Systematic evaluation of these materials or the activities they describe, including "horror stories" such as unused

15 In addition to the countless books on computers in education that have been published recently, there have also emerged several journals such as Computers in the Schools, Computers & Education and Education & Computing, to name a few, that encourage the publication of articles on practice, theory and applied research. Philosophical works discussing the implications of computers for curricular reform, and, more specifically, philosophical analyses focusing on the implications of the emergent "information society," telecommunications, and computing for educational aims and goals have also been published. Then there is a genre of publications that focuses on the pitfalls and dangers of computers for society, education and human freedom. While the concerns expressed in this type of critical literature go beyond the immediate topic of this article, many of the issues raised have implications for the how and why of microcomputers in education. This type of literature, or these types of questions, usually trouble and perplex U.S. educators, accustomed to viewing education and curriculum as a strictly technical and professional activity rather than as a complex and dynamic human and social process, influenced by assumptions of values, economics and politics. Most of the U.S. literature was, and continues to be, promotional. The conditions in the larger societal context and the public’s ready and almost uncritical acceptance of the microcomputer as a possible cure for many of our educational ills promise a steady market for this type of literature.
computers in school storerooms, are becoming available but they are usually anecdotal (Tucker, 1985; Hatch, nd.) 16

Impact on Achievement

Based on the studies that have been undertaken to date, the impact of computer use in schools on achievement is problematic. Using several review approaches, including meta-analysis, on sets of CAI studies, Roblyer (1985) found mixed results. For instance, she found that effect sizes on achievement for computer-based learning, compared to more traditional approaches, were high at the elementary level. At secondary levels, the effect sizes were low to moderate. Supplemental computer-based instruction produced higher effects than "replacement" CAI. In general, math study benefited more than reading/language arts. Lower ability students seemed to learn comparatively better from drill while high ability students seemed to do better using tutorial type CAI (p. 20). Roblyer also reports that several researchers found other non-computer learning strategies such as instructional television or improved reading/study skills more effective (See also Tucker, 1985). It should also be noted that the results of her review of studies that did not lend themselves to meta-analysis found

16 Interestingly, Giaquinta and Ely (1986) in their study, A Longitudinal Study of Children's Educational Microcomputing at Home, found that on the whole, children who had microcomputers in the home did not use them for academic or learning purposes. Game-playing was the dominant use.
no significant difference between computer and non-computer treatments. One final finding was that there was a clear reduction in learning time using the computer but that traditional learning contributed to better retention. In a more recent synthesis effort (Samson, Niemiec, Weinstein & Walberg, 1985), findings were reported from 43 studies conducted in natural settings which indicated, on the average, small but significant improvements in achievement scores due to computer use. However, clear causal connections may be confounded, the authors suggest, since most of the studies suffered methodological shortcomings, and therefore the achievement gains may be as much the result of the instructional method, novelty effect, or content differences (p. 8).

Like previous research of media impact on learning, the results have been mixed. Clark (1983, p. 457), who conducted a major critical review of the impact of media on learning research (which includes research on the impact of computers on learning as well), concludes, "that all current reviews of media comparison studies suggest that we will not find learning differences that can be unambiguously attributed to any medium of instruction. It seems that existing research is vulnerable to rival hypotheses"
concerning the uncontrolled effects of instructional method and novelty."17

Impact on Cognitive Development

Mixed and ambiguous findings also characterize the study of the microcomputer on cognitive development. Pea and Kurland (1983) found that LOGO programming did not have an effect on problem solving skills. Indeed, they found that after a year, students did not even have a full command of programming skills. Studying the effect of LOGO on generalizability, Pea (1983) found little evidence that what was learned in LOGO (or BASIC) could be generalized to other content areas. Fogrow (1985), in his study to determine whether LOGO could enhance higher order learning skills, found that it did under certain conditions. He argued that, because LOGO lacks "concrete links" between subject matter and the LOGO process, teachers must develop lessons that integrate the two. Cramer (1984), Al-Orainy (1984), and Pea & Knowland (1983) all found evidence in their respective studies that there are skills which must be developed prior to learning programming in order to derive significant benefits. In other LOGO related studies (Emihovich, 1986; Heap, 1985), mixed findings concerning the power of LOGO to enhance learning-related skills such as peer collaboration

17 Noteworthy is Clark's (p. 457) recommendation "that researchers refrain from producing additional studies exploring the relationship between media and learning unless a novel theory is suggested."
are the norm. Whether LOGO-based activities contribute to writing ability, peer collaboration, planning, and procedural or higher order thinking remains problematic.18

**On Cost-Effectiveness**

One area of interest in the emerging research on microcomputers is that of its cost-effectiveness. If the use of CAI or other computer-based teaching-learning strategies improves, or at least maintains, learning at acceptable levels but at reduced cost, then the microcomputer can be heralded as an innovation that delivers instruction more efficiently. This could allow teachers to do other important teaching or remedial work often left undone. Moreover, students would have additional time to participate in enrichment activities or to pursue their studies in greater depth. At the very least, educational budgets could be stabilized, and more efficient allocation of both funds and human resources would result. This certainly has been one of the promises of technology in education, and most recently, of the computer, whether it be mainframe, mini or microcomputer. Levin and Meister (1985)

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18 Papert (1987) criticizes this genre of LOGO research and contends that researchers and educators alike have misconstrued LOGO's purpose and therefore how and what ought to be studied. His discussion of technocentric thinking in education is discussed later in this paper.
summarize the arguments that advocates of computers routinely make:

Microcomputers promise to be the most cost-effective and adaptable instructional vehicles. They are highly flexible in use and configuration. They can be operated singly or in a network; they can employ both visual and audio stimuli and they can integrate interactive videocassettes or videodisc components. They can be used for a wide variety of instructional applications, subjects, and approaches including games, simulations, drill and practice, topics within a course, or a complete course. Students can learn by following prescribed routines or be challenged with written, artistic, or mathematical assignments or problems in which the computer provides an individualized response and assistance to the learner. (p. 5)

Unfortunately, little research has yet been undertaken that assesses the cost-effectiveness of microcomputers. In one study using the tools of meta-analysis and cost-effectiveness analysis (Levin, Glass & Meister, 1984) to compare four educational interventions, peer and adult tutoring approaches were found to be more cost-effective than reducing class size, increasing the length of the school day, or using computer-assisted instruction. Moreover, the research on new educational innovations in the past has almost always shown that costs were underestimated. All too often in the early phases of a new technology, the focus has been on the cost of the hardware, not on the actual cost of software development or implementation, or on the opportunity costs. This past history of new technology
cost assessment and the one study above suggests caution in accepting the cost-effectiveness promise of microcomputers (Levin & Meister, 1985).

Access and Equity

For the United States, some quite interesting findings regarding access to this new technology are presented in a massive survey (Becker, 1983) undertaken of microcomputer use in schools. Despite the fact that almost 15 million students and 500,000 teachers in the U.S. use computers, the ratio of students to computers remains high. Becker points out, for instance, that the ratio of students enrolled to computers available in K-6 was 60-1; in middle-junior high school, it was 41-1. He says, "to provide even 30 minutes of computer time per day to all students enrolled, a school would need to have one computer for every 12 students—and that assumes that the computers are in constant use" (CREMS, 1986, p. 3). On the other hand, when compared to previous educational innovations such as instructional TV, film and radio, the level of diffusion is impressive. As noted by Cuban (1986), there has only been very modest acceptance of these previous innovations and they were rarely ever integrated into the core curriculum.

Another important finding of this survey was that the major use of microcomputers in elementary schools involved
working with drill-and-practice type learning programs. Only about 12% of student time was spent on writing LOGO or BASIC computer programs. While microcomputers can be located in the classroom, the library or a special laboratory, the middle schools in the study had led the way in having "mobilized" them into laboratories. This is important since the study shows that computers located in a laboratory setting are more likely to be used (Becker, 1986).

This diffusion of microcomputers in the United States has tended to favor the better-off schools, schools in which groups of teachers strive for improvement, and where the financing of microcomputers is generous and community driven. Moreover, how the microcomputers were introduced, how they are organized for use in schools, what role teachers and administrators play in their implementation and whether they are at the primary or secondary level determine, in part, who among the students have access to them. For instance, Becker (1984) found that when only one or two teachers introduced or implemented a computer strategy, there was a tendency for only the very bright
students to get exposure. If more were involved, more students across the school were likely to have access.

While access to computers at the primary level showed little or no gender bias, at the secondary level, access and use by male students was much higher than for females. This parallels the predominant use of microcomputers in math and science, where gender bias has long been entrenched. Another quite interesting observation is that minority children was more likely to be exposed to "electronic page-turning" type software while dominant culture children were more likely to be exposed to LOGO programming, justifying the term applied several years ago to microcomputers use in schools by the Wall Street Journal, "The Class Machine". Other studies (Miura, 1986; Ascher, 1984; Hess & Miura, 1984; Lockheed, Nielson, & Stone, 1983) show further differences in access, interest and use as determined by diffuse status characteristics such as race, gender and class, again with males using it more, particularly in math and science, and students from well-off schools doing more LOGO type work and students from less well-off schools doing much more drill and practice. How a school district generally views innovation and change seems to play a role as well, suggesting that organizational factors, educational philosophy, and community resources and attitudes enhance or
mitigate the possible inequities of the innovation (Sheingold, Kane & Endreweit, 1983).

While there is much more research being conducted and more developmental work with computers being done, the results of this first phase of research are fairly clear. Computers may be in schools but the promised revolution has yet to take place (Tucker, 1985). The diffusion of computing power into schools has certainly taken hold, unlike previous innovations. Nevertheless, the preliminary information on who uses them and how they are used, what the impact has been on achievement or other valued educational goals, and their presumed cost-savings compared to other teaching-learning strategies, can only suggest that the "decisive influence" of computers on education has yet to occur.

INFORMATION TECHNOLOGY AND EDUCATIONAL DEVELOPMENT: ANALYSIS AND DISCUSSION

Given the lack of clear evidence for the effectiveness of computers in education, why then have they so successfully entered the schools? First, external factors supporting their introduction have been powerful, particularly the fact that they are a cultural phenomenon (Pogrow, 1985; Turkle, 1984). This is, in our estimation,
the critical difference between innovations of the past and this one. It explains, in part, why earlier technological innovations, computer-based or otherwise, while fully integrated into other societal institutions, were never widely diffused throughout the educational systems of the United States (Cuban, 1986). Despite the fact that some of these earlier innovations had public support, they were not rooted in perceived changes in the workplace nor did they have the cultural pervasiveness of the microcomputer. Rather, while seen by their advocates as improving the quality of education and the efficiency of instructional delivery, they were also seen by the ultimate users, the teachers, as "irrelevant to their practice; that [they]...increase[d] their burdens without adding benefits to their students' learning, or ...weaken[ed] their control of the classroom." (Cuban, 1986, p. 71)19

The relatively successful diffusion and acceptance in the U.S. and other industrialized countries of microcomputers in education, despite some negative side

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19 Apple (1982) argues that efforts to produce instructional approaches that separate execution and control of the instructional materials, so-called teacher proof materials, have the potential to de-skill our teachers and to shift control of the learning process in the classroom away from the teacher (a deprofessionalization process), and work against broad-aimed democratic educational goals. Therefore teachers often resist these types of innovations, even though the implications of these types of "reforms" may not be fully understood. Contrast this with Cuban's (1986) argument that teachers tend to resist innovations that are not "organizationally realistic" or are not attentive to organizational development issues.
effects and, thus far, limited benefits, may be seen also as a result of an explicit cultural ideology of personal use and empowerment: their obvious interactive capability and their implicit promise of revitalizing the role of teachers and the restructuring of the learning environment within the school. It is this cultural metaphor, more than formal or informal philosophies of educating, that has played a key enabling role in the rapid expansion of microcomputers in education. We contend that Papert's vision of LOGO and learning, its current salience to educators, is partly the result of this metaphor, even though teachers' actual practice may not reflect it. If our contention is correct, microcomputers have more potential to serve as a stimulus for the reexamination of our educational methods and ends than they have as electronic mediums for more effective techniques in the classroom. Indeed, as the empirical research in previous chapters would suggest, many of the assumptions about the use of computers (and other media as well) and their influence on learning are unsubstantiated and have come under question (Clark, 1983).

The key to the successful use of "computing power" in the educational process will depend on the extent to which it is able to demonstrate its educational worth. Coupled with this will be the extent to which it assists the teacher in the classroom, or in whatever the appropriate learning environment will be, to carry out the educator work in the
teaching-learning nexus. In this sense, our attempts to
assess the microcomputer's impact on, say, achievement,
while important to policy-makers, parents, and educators
alike, may not be the only question that we should be
asking. Even the current questions concerning the impact of
programming, or other specific uses of microcomputers, on
the cognitive development of children and youth, fall short
of adding up to the multiple aims we have established for
education. "Teaching the microcomputer" (programming),
being taught by it (CAI and CMI), and using it for
"productivity" purposes (word-processing, data-management,
both quantitative and qualitative, spreadsheeting, etc.),
may all have some role in "educating" our children and
youth, but we have not looked at whether these specific
tactical uses of "computing power" contribute to the overall
quality of the educational process. Indeed, most of the
current criteria of educational or learning success may
distort the questions and issues that we ought to be asking.

What have we learned from this first phase and the
preliminary research that has been conducted? First, we may
have learned that we allowed old innovatory metaphors, such
as programmed learning, to dominate our thinking about how
computers could best serve teaching and learning. (Note that
the key word here is dominate. Programmed learning and
drill and practice for many learning activities are not only
appropriate but desirable. However, it should not be the
guiding principle in education. Second, in our efforts to break away from older approaches, we may have embraced too quickly approaches such as LOGO without carefully assessing their assumptions about the learning process. Thirdly, we may have rushed too quickly toward computers as a panacea when other, less glamorous and less costly innovations were available. Fourthly, we may have overlooked some of the lessons learned from past attempts at implementation of innovatory technologies. And finally, in our haste to implement this innovation, we may have forgotten how complex the educational enterprise is and how social, economic and organizational factors can overwhelm spirited efforts at reform and innovation (Kirst & Meister, 1984). Indeed, in our efforts to implement a microcomputer strategy in education and to assess its impact on education, we may have relied too much on the narrow goals and questions of cost-efficiency and achievement to guide its development and its evaluation, when in fact the computer's value in education may lie elsewhere. As once said by a sage colleague, "the right answer to the wrong question is still the wrong answer to the right question". Now, with the first phase of computer penetration into education coming to an end in the industrialized countries while, at the same time, just beginning in Third World countries, it is time to rethink
our goals and questions concerning computing power and education.

Another reason for reexamining our questions is that we have too often formed our research and evaluation questions based on simplistic notions of the goals of education, focusing in particular on measurable cognitive achievement. We have substituted these for complex and thorny "policy questions" about our broad-aimed educational goals that we must continually address if we are to continue to improve our educational enterprise and have it contribute to the improvement of our lives in general, not just in a particular occupation or in the workplace. With our focus on learning outcomes of computing, we may underplay or miss entirely other kinds of impacts as suggested in several recent studies. We suggest, for instance, that we have given all too little attention to the "qualitative" aspects of this microelectronic device, the observations that social context and interaction (both the interactiveness of user and computer and interaction among the users, pupils with pupils, pupils with teachers) are key mediating factors in the learning process. Those who advocate the introduction of the microcomputer but don't take these facts into account may doom the technology to failure, despite its promise and potential in realms not yet fully explored (Emihovich, 1986;
Lockheed, 1985; Anderson, Welch & Harris, 1984; Turkle, 1984; Sheingold, Kane & Endreweit, 1983).

As a preliminary research agenda, then, we need to pose questions that do not focus on achievement outcomes alone but rather on current uses of computers in schools and in the workplace, to see how they might be used more effectively. Concurrently, we need to examine in context how those current experiments in education that focus on computers as productivity tools, generic programs for word-processing, spreadsheeting, data-management, etc., are used by teachers in classroom applications. Such studies are already beginning to be conducted (see for instance, Levin, Riel, Rowe & Boruta, 1984). Drawing on naturalistic and ethnographic approaches, we should examine to what extent these productivity tools stimulate the development of learning experiences that contribute to problem-posing/problem-solving and critical understanding. In this regard, it is our contention that if teachers can design lessons that embody these goals, the use of microcomputer productivity tools will enhance the learning of those skills. On the other hand, if lessons are not developed that embody these goals or ideas, computers will not make a difference either. No innovation, regardless of its potential, can substitute for the thoughtful, critically thinking, well-prepared, well-educated teacher. Therefore, we need to study how teachers work, under what conditions
and how they understand the curricular development process in practice.

Building and using educational telecommunications networks and/or using software such as MINISIS (developed by the International Development Research Centre in Canada) in nation-wide or regional information systems for the support of learning and teaching is another avenue that needs to be implemented and researched. Note that the capacity to access and analyze large amounts of information could mean that the emphasis in the curriculum would be increasingly on problem-posing and problem-solving, knowledge creation, management, analysis, synthesis and evaluation of information, and understanding. In such a scenario the curriculum would need to undergo considerable change and even the purpose of textbooks would change. This suggested strategy, however, would require a more thorough examination of the curriculum and the reorganization of the structures and culture of the learning place itself. Conditions would need to be created that enabled teachers to continue to play a leadership role in the development of a new curriculum and the organizational setting to support this reform.

Given this perspective, then, we need to study the impact of using computers in the educational context, on the attitudes of teachers toward their work, and on the student attitudes toward education and learning. Here the argument
is that if computers can make the workplace a better place to be, if computers and their effective use in the learning process help teachers regain their sense of professional efficacy and restore students' appreciation of learning as synthesis and analysis rather than as information transmission and memorization, then we will have taken a major step toward accomplishing our goal of preparing students for lifelong learning in the information society. Finally, we need to do the type of policy research that examines what kinds of organizational environments are required to facilitate this kind of curricular activity and how many and what kind of computers and software are needed, and how they can be financed.

Interestingly enough, support for this approach can be found in Papert (1983) who early in his book speaks to the issue and problem of innovation in education, the role of the teacher and educational purpose. Papert (p. 32) observes that "the educator must be an anthropologist," if the teacher is to understand what cultural materials and societal trends may contribute to intellectual development. We add that the teacher as anthropologist must also understand how these new cultural artifacts are being used and what they mean in the environments where they are already being used. Papert as educator may not be altogether right about LOGO 's power to transform one's mind, but Papert's insightful advocacy of educational reform
is absolutely correct. This means beginning to understand microcomputers as productivity tools, as electronic assistants, not, as Tucker (1985) warns us, as electronic teachers administering instruction (p. 19). This approach is much more consistent with what is possible in education. Training teachers to use generic application programs within their subject matter specialization is much easier than teaching them to program or to use authoring systems and immediately opens up opportunities for the teacher and the student to establish telecommunication networks, to have access to new data-bases and bibliographic sources, and to practice using tools designed to input, manage, analyze and evaluate information.20 Again, if we return to Papert, we note that he views the ultimate value of the microcomputer as a "cultural machine" in its role as revitalizer or enabler of change. He says, "Today what is offered in the education market is largely determined by what is acceptable to a sluggish and conservative system. But this is where the computer presence is in the process of creating an environment for change." (p. 37).

As a confirmation of this notion, in a recent article Papert (1987) reiterates this in his criticism of the "technocentric thinking" of both the users of LOGO and the researchers of its effectiveness. This brings us back to

20 Already universities have paved the way for defining the use of microcomputers in this way. Tucker (1985) notes with irony how few professors use the microcomputer as part of their instructional delivery system.
our earlier comments on the enduring goals of education. We maintain that the link between these goals and what can be practiced using the various data-base management programs, word and concept-processing (outlining) programs, spreadsheeting, quantitative and qualitative data-management programs, within the various subject-area specialties, are precisely the skills we urge our teachers to prepare students in. In other words, our traditional educational aims of improving problem-solving, problem-posing and critical understanding through the use of productivity tools and creative programs in the subject-areas could become a reality in practice, especially if we realize the "maieutic" potential of the computer and interactive applications software programs.

At first glance, much of the discussion in this section may be seen as principally applicable to the policy and research questions posed by new information technologies for the industrialized world. Clearly, this is where most of the experience with microcomputers in education has been to date, and it is this experience upon which we have reflected here. However, it should be noted that we have focused not only on the research conducted and its results but also on

21 Maieutics refers to the educational process and practice of the dialectical or "...Socratic mode of teaching, a mode of teaching called maieutic because it helps the student bring ideas to birth. It is teaching by asking questions, by leading discussions, by helping to raise their minds up from a state of understanding or appreciating less to a state of understanding or appreciating more." (Adler, 1982, p.29).
why the technology is used in the way it is and on the kinds of research questions asked. These approaches, we contend, are linked to the politics, economics and culture of the United States and the way education is conducted there. By making explicit the "wider package" of microcomputer application in schools in the United States and highlighting how our technocentric approach to curriculum also influences the kind of research we do, we are able to illustrate the importance of context in the application and study of technological innovations, whether it be in an industrialized nation or a Third World country. Therefore, we would argue that most of the ideas we have raised in this section should also be important in framing policy issues and research questions in Third World settings. To conclude this paper we try to extend our analysis explicitly to such settings, first by considering how the different concepts of computer literacy might give direction to Third

22 It should be stressed, however, that while this research and commentary can inform policy and research in other settings, every effort needs to be made to make explicit the fact that technologies cannot be separated from their institutional frameworks. This is the point that Winner (1986) makes in his book, The Whale and the Reactor: a Search for Limits in an Age of High Technology. Tom Athanasiou (1987), in his review of this book, underscores the point that technology has structuring effects and that their form and consequences must be understood socially. Avoiding narrow determinism, Winner adds that some technologies lend themselves to various constructions and that some technologies are political and some are not. We take this to mean that computers and computing power and their possible role as a development tool must be rethought anew in the Third World situation.
World policy initiatives and, finally, by considering the implications of these directions for needed research.

IMPLICATIONS FOR THE THIRD WORLD: COMPUTER LITERACY AS A DEVELOPMENT POLICY METAPHOR

While in one sense, the computer as a metaphor symbolizes the fact that we are being inundated with masses of new information, that our lives are being constrained by galloping standardization, routinization and over-bureaucratization, in another sense, if used thoughtfully, it is part of the solution to this problem and, if used educationally, can be liberating. The microcomputer may be the very instrument to spearhead the breaking down of traditional ways of organizing work and knowledge and to actually increase our awareness of the need to be mindful of the distinctions between information, knowledge and critical understanding and the skills necessary to teach them to our youth. These are, after all, the educational goals for which educators strive but have rarely accomplished.

Quoting Marc S. Tucker's (1985, p. 22) summary of the possible future of computers in education:

The key to the future use of the computer in education...lies not in its history in schools as an instructional delivery system but in its evolving use in the society at large, as a tool to
get work done—not as an extension of the teacher but as an intellectual companion for the student.

In the last several years information technology has become an important policy issue in the Third World. In a recent survey by UNESCO (1986), a majority of Third World countries reported either existing policies or blueprints for the introduction of computer literacy into their educational system. However, the term computer literacy has "surplus meaning" and how it has been used and defined for advancing the new information technology into the public mind and into formal and informal educational process has been greatly influenced by a specific context—in particular, what King (1985) refers to as the "wider package" of context and code of the West. This analysis demonstrates how the context plays a role in the shaping of information technology policy.

Computer literacy has taken on essentially three meanings. In the United States, computer literacy has been defined primarily as employment preparation (i.e., technical familiarity, at least at the early schooling levels), while at the higher levels, it has included a strong emphasis on technical competence in computer

23 The following discussion and analysis of computer literacy is taken from a recent earlier article prepared for Prospects, by George Papagiannis and Sande Milton, (1987, no. 3).
programming. This technical bias is not surprising. Grubb's (1984) analysis that technological determinism suffuses United States culture is especially apt. He contends that in the U.S., there is a tendency to translate problems into technological challenges, and to search for technical solutions, even if the problem is decidedly social, cultural, economic or political.

In Europe, while there is considerable overlap with U.S. definitions, there are examples of expanded notions of computer literacy which can be attributed to a greater emphasis in European education (not to mention in the society at large) on the importance of the socio-political analysis of everyday life, as contrasted to the U.S. bias towards psychologism. What this means is that Europeans tend to define issues such as the introduction of a new technology in social policy terms, while Americans tend almost exclusively to frame these questions from the point of view of the effects on individuals, i.e., individual

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24 It should be noted that formal definitions of computer literacy in the United States do include a broader set of goals than we are claiming here. However, in practice, the non-technical curricular components are rarely implemented. See Levin (1983) for a discussion of the Minnesota Educational Computing Center (MECC) definition of computer literacy and Watt's definition, both of which include each of the conceptions discussed here. Also, see Paisley (1985) and Culbertson's (1986) "Whither Computer Literacy?".
productivity, preparation of job skills, and individualized learning.

In addition, educational decision-making tends to be more centralized in Europe, and therefore the introduction of computers in education has been seen as a "societal" decision. In other words, the public-sector has served to mitigate the strong business and industrial influences which led to the more strictly consumer-oriented or vocationally-driven approach taken in the U.S. The concept of informatics, at least as we conceive of it, broadens the scope of study to include the role of computers in society, even though it has been frequently used in Europe in the narrower sense just as in the United States. Further, while not ignoring the vocational effects, informatics puts a greater stress on the effects, both negative and positive, which the computerized society will have on individuals.

The perspective which we elaborated above flourished in the presence of an emergent informal learning network, one which did not require state intervention. Indeed, this is because of some important preconditions under which this process flourished. Pogrow (1983) points out that, in the United States, computing and information technology are cultural phenomena; that is, there is a strong belief that society is moving away from an industrial-based society toward an automated, information-oriented world, with the
computer benignly leading the way. Second, microelectronic technology has already rapidly transformed the workplace, thus serving to underscore its cultural presence. And finally, the computer hardware and software industries have taken an aggressive stance in promoting this vision. Other conditions which have facilitated the growth of this informal learning network in the United States, England, and to a lesser extent Europe include the relatively low cost of computers and software, the low cost of formal and informal training, the already high level of education in the general population, and the existence of software which is written in the native language.

The purpose of the above discussion has been an attempt to elaborate the evolution of information technology policies, both stated and informal, in the North. It is our contention that the role of the social, political, economic and educational context has strongly influenced formal as well as popular conceptions of computer literacy and the actual course followed in the diffusion of knowledge and use of microcomputers. This leads us directly to the question of how the concept "computer literacy," broadly defined, can be thoughtfully discussed in the radically different context of the Third World, given its cumulative experience and insights about overly facile and Western-initiated
"technicist" solutions to the complex problems of development.

Toward a Theory of Appropriate Computer Literacy

Third World educators have been cautious in implementing information technology into the educational system. For instance, universal primary school familiarization with microcomputers has not been generally embraced in the Third World. Limited resources, questions of educational worth, issues of technological dependence, mixed results with prior technologies designed to "transform education," and fears concerning its impact on employment have made policy-makers and planners reluctant to promote such universal computer literacy strategies.

Many Third World policy-makers and planners, educational researchers and communications specialists have begun to put these issues related to information technology, microcomputers and new technology into a larger development perspective (Carnoy and Loop, 1986; Papagiannis, 1985; King, 1985b; Rada, 1980; Wad, 1982; Rogers, 1983). Most of the developed world has defined the needs of the Third World as the need for more technology, while Third World policy-makers focus on development as a complex process of which technology, its development, transfer and adaptation, represent but one part. In this sense, information technology for development, much less for education, is not
straightforward, but quite problematic (Schware & Trembour, 1985).

The persistent problems of developing countries, coupled with the recent history of the failures and mixed results of the introduction of "quick-fix" technologies for the advancement of development, have forearmed Third World policy-makers with critical questions which challenge facile acceptance of North American and European definitions of computer literacy, especially in light of recent calls for reappraisal of approaches used in American schools. (See, for instance, Lockheed, 1986). Consequently, the limited concept of "computer literacy," as it has been used in the United States, needs to be further broadened and transformed into a conceptual framework that denotes how microcomputers can contribute to development, one which needs to include notions of microcomputers contributing to organizational and institutional emancipation, of microcomputers for advancing self-reliance, and of improved access to information, and of advancing local knowledge production (Cutazar, 1985; King, 1985a). The role of microcomputers in education can only be determined when these other questions have been addressed.

Having discussed the importance of linking the introduction of information technology to the needs of the development context, we can now turn to an analysis of the three conceptions of computer literacy which have been
utilized in the United States and Europe--preparation for computer-related occupations, informatics, and computer use for personal and organizational productivity--and to the question of the extent of their applicability in the context of the Third World.

Computer Literacy as Employment Preparation

The need for indigenous programmers and technicians in the Third World is acute. If the microelectronic revolution is not to lead to further economic subordination (Rogers, 1983), then less-industrialized countries will need to develop policies that will result in a pool of indigenous technicians who will maintain hardware and programmers who will be able to adapt and translate existing software and to develop new forms of software which are consistent with Third World needs. For example, Clayson (1981) points out that in industrialized countries, software is geared towards large and complex industrial problems, while in the Third World what may be needed are computer-based problem-solving techniques targeted to small-scale public and private enterprises. This, perhaps, is also the type of human infrastructure required for the development of Third World "silicon valley" type industries, including "clone" manufacturers and retailers, which can offset the
oligopolistic marketing practices of multinational computer manufacturing companies (Nilsen, 1979).

However, the need for nationally-based technical training programs should not be misconstrued as a universal educational program. Even in the United States, as we have argued above, the labor market need for computer technicians and programmers has been grossly overestimated (Rumberger and Levin, 1984). Furthermore, given the limited resources available for basic educational needs, such as books, trained teachers, and physical plant, a plan to increase computers throughout a national educational system would border on folly. Instead, governments may want to target resources for technical training, but these programs should remain limited in size and kept at the upper secondary level. In addition, it is at this level that partnership with local enterprise can either defray the cost of such training in a school system, or absorb the costs entirely, the latter perhaps being appropriate in cases where it is the private sector which is the chief benefactor.

Computer Literacy as Informatics

Computer literacy as informatics stresses the need to understand the social, economic, political and cultural issues related to information technology. In this regard, the central issue for informatics in the Third World is how
can it be applied so as to advance economic and social development with the goal of strengthening self-reliance. Informatics reminds us that microcomputer technology, like other technologies, is not politically or economically benign; in resource-limited countries already suffering from dependency relationships, an informatics approach necessarily requires the formulation of policies. Otherwise, the continued diffusion of information technology and its accompanying infrastructures through existing systems of technology transfer, such as the market system (Rogers, 1983), is likely to worsen existing inequalities between and within countries.

One issue of concern is the direction, flow and control of information. There are already indications that imbalances in transborder data flow are likely to be worsening the dependency status of Third World countries. International data communication systems currently originate from industrialized nations, and are mostly controlled by multinationals. Third World persons who have access to such information tend to be located only in the "modern" sector. This use of computer power, as Schiller (1981) has said, "facilitate[s] an economic order which is inherently exploitative and wasteful of human and natural resources."

Even within developing countries, the availability and control of information and communications systems are
limited, typically, to capital cities, a situation which may be further widening the resource gap between rural and urban areas. For example, management information systems for national institutions such as education, health, agriculture, and even cultural affairs, remain centralized. The consequences for the periphery are not only the lack of access to information upon which decisions affecting resource allocation are made, but also a lack of capacity for creating and defining the kinds of information which are collected.

Such issues create the need for national policies concerning information technology and microcomputers, and they also suggest that the study of informatics may well be the cornerstone of an educational policy on computer literacy (for a summary of Brazil's promising efforts to develop policies in telecommunications, informatics and transborder data flows, see United Nations, 1982). In order to develop national policies which will serve the development process for all groups in a nation, the education of a broad range of persons about these issues is a necessary precondition. If such explicit dissemination of these issues and the social approaches necessary to address them does not take place, this technology will be transferred in the usual laissez-faire way, much as we have seen in the United States. The consequence will be that a technology which might have served an important function in
development will work against it: groups which are already resource-poor will now become information-poor.

If we accept the broad notion of informatics as a key ingredient of "computer literacy," there are many possible ways such a program could be incorporated into an educational agenda. For instance, Buttedahl (1986) argues that it will be imperative to develop an adult education program which exposes all citizens to the current status of information technology and the issues and significance of this new technology and its possible roles (both positive and negative) in national development. In conjunction with such a program, she suggests ways that must be developed through which adults have greater access to information and information technology that may be relevant to development problems, including centralized national library systems (as are being developed in China), regional data exchange networks for the exchange of information and for computer-based conferencing (Balson, 1982), and local computer centers where microcomputers are made available for use by persons who would otherwise not have access to them.

In schools, while microcomputers are not likely to be widely available for classroom use, the inclusion of an informatics-based computer literacy component into the curriculum is still a distinct possibility. Such a curricular component might best be located in the social
studies area, particularly when the issues of national development are addressed, and would prevent students from being unrealistic about occupational prospects in the computer industry, while making them more knowledgeable about the possibilities and the limitations of the microcomputer revolution in development.

**Computer Literacy as Productivity Enhancement**

The version of computer literacy as productivity enhancement relates to learning to use computers in order to improve non-computer related activities. In the North, this has tended to mean personal productivity (especially word-processing skills), and business productivity (including spreadsheeting, data-based management, and text and graphics reporting techniques). While it can be argued that the increases in personal and business productivity which have resulted from the use of microcomputers have led to an increase in societal productivity overall, it is unclear whether the social and economic consequences have been equally salutary across all groups. In the Third World, we argue, the need for all groups to share in development is crucial, and therefore any adaptation of information
technology must be done in such a way that this principle is central.

The use of productivity software has been the single greatest factor in the computer literacy movement in the North. However, the self-learning and informal learning networks which have developed there could only have done so under the following conditions: computers and software are low-cost commodities; the technology is already entrenched in the workplace; the population is already highly literate; and the microcomputer has become a cultural phenomenon which is congruent with Western cultural forms, i.e., it is individualized, rationalized, and technical. In the Third World, it is unlikely that the computer as productivity enhancement will or should follow the same course as in the North. First, there will be fewer individuals willing or able to invest time and money into the essentially speculative activity of buying and learning to use microcomputers to enhance their own productivity or to improve their chances in the labor market. The relative cost of the technology will remain high, even if a local industry develops. Moreover, since microcomputers are not yet being widely used in the workplace, the payoffs to individuals are not clear. Nor has the technology yet become the cultural phenomenon that it is in the North, which has been due in large part to massive advertising and
the consumer-orientation in highly developed capitalist market economies.

We need to be attentive to the fact that, in order to take advantage of productivity tools, the skills that these tools were developed to enhance must already be in place. This means that our traditional goals of education—developing problem-solving skills, analytical capacity, and critical understanding—become increasingly salient (Levin & Rumberger, 1986; Schware & Trembour, 1985). In other words, the microcomputer and information technology in general are no substitute for the basic skills required for development activities.25 This means that the current educational agenda of Third World countries needs to be reaffirmed, and that it should be made explicit that

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25 In their review of two attempts to implement a computer strategy for information management in an Egyptian and a Tunisian development project, Schware and Trembour (1985) conclude that there are major guidelines to keep in mind: the particular problems of the organizational structure and administrative environment in each setting must be taken into account; the technology itself should not distract from the need to develop the skills needed to handle information; too much or too sophisticated technology should not be introduced too soon. Sophisticated equipment can always be added later, after sufficient training and experience have been obtained; and finally both the informal and formal information systems of the organization need to be understood and analyzed before plans for hardware are prepared.
computers will not enable one to "leap-frog" stages of development (Wad, 1982; Schiller, 1981).26

What may be needed in the Third World are policies that create conditions and opportunities for the use of the

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26 One of the dangers of uncritically adopting information technology for schools in the Third World is that the "how" to use computers and the software developed for them is determined by many context-specific factors. For instance in the United States, there is a strong technocentric or technicist approach toward technology. The focus of innovatory efforts tends to be on the technology itself rather than on the curricular goals, activities and processes that comprise the educational context and content within which the innovation is to be implemented. Technological determinism is part of U.S. culture and it colors how most social problems and issues are viewed. It makes U.S. educators less attentive to the social and cultural context and more focused on the rational, the technical and the psychological aspects of the educative process. Moreover, the technological "fix" as an innovatory approach has not been successful in remedying the serious problems found in U.S. education. Despite this criticism, it should be noted that within the informal learning system, a great deal of computer learning has taken place in the United States, Canada and the United Kingdom. It has occurred outside the formal educational system because of many unique characteristics of these nations. First, the computer is a cultural phenomena that has drawn large numbers to it in much the same way that automobiles attracted the previous generation. The relatively high wealth and high level of literacy of the population, the low-cost of microcomputers and their availability, the commercial promotion and support, their ubiquitous presence in the workplace and the elaborate informal user-group networks (special learning systems) have made computers commonplace, even though their success as educational devices remain problematic. What this suggests is that any attempt to evolve a strategy for use of information technology in Third World countries (quite frankly, it is an argument that should be made in the United States as well) needs to sort out curricular objectives and educational purpose, what can be learned by its adult citizenry through informal and nonformal approaches and what needs to be learned by its youth through formal schooling. In addition, any Third World strategy must take into account the modest resources it has and how a few computers might make a difference in the educational process. Moreover, it must judge the educational worth of computers and their
possibilities in light of the "lesser" technologies such as improved teacher training and increased availability of quality textbooks and, perhaps more importantly, it must be judged as a possible vehicle for bringing other types of changes in education. For instance, Peretti (1986) suggests that we need to bring about new ways to organize learning, to further broaden forms and approaches to teaching, to find ways to reintroduce formative evaluation into the testing and assessment process, to revitalize the in-service teacher training process and to restructure the way researchers and practitioners inform each other's work. Hurst (1986) points out the need to do similarly in the area of educational management, planning and administration. In both cases, we have a call for the improvement of the quality of education wherein the microcomputer could play a role since technology usually facilitates reorganization of work relations and practices. This approach requires that we not accept, uncritically, the way computers are being used in education in the industrialized nations or accept the ways that innovation is routinely evaluated by them. (See Papert's 1987 article, pp. 25-26 for an analysis of two reports, one experimental and the other qualitative, of the impact of LOGO on cognition). In our discussions, and criticisms and proposed agendas for research above, we have, in effect, been talking about another kind of computer literacy—one for educational policy-makers and planners themselves. The "curriculum" we propose for computer literacy is one which draws upon all the conceptions we have discussed above (Papagiannis & Milton, forthcoming, 1987). Moreover, in the final analysis, it is clear that the introduction and diffusion of information technology do not eliminate the need for drawing on our enduring understandings of the dilemmas of development, and the social, political, and economic constraints on the role of information technology in the development process. The dependency relationship in which Third World countries find themselves, the perennial problem of scarce resources, and the need to continually work towards self-reliance all require a meticulous assessment of the consequences of the introduction of new technology, both intended and unintended. Critical assessment implies critical thinking, and this is one of our primary educational aims. Indeed, the conception of computer literacy as productivity enhancement in education may well be one from which Northern countries will profit from as well. In addition, a technology which offers access to and management of vast amounts of information offers not the slightest guarantee of an iota of added knowledge or critical understanding if we lose sight of the fact that we must still educate and train our youth to the skills of reading and writing, and problem-solving, analysis and synthesis. Computers may aid teachers in the teaching of these skills or they may not— the evidence is not yet in. But no further research is needed to understand that using
microcomputer and appropriate software as a productivity tool for the goals of national development. This means, for example, that productivity hardware and software might best be introduced first in demonstration projects dealing with the management of health-related information, nutritional programs, rural development activities and organizations (such as community cooperatives), as is being done in some countries. As another example, in order to further promote decentralized research and development activities, the concept of the locally controlled microcomputer-based "research station" can be developed. Since indigenous computers productively requires prior education and some hands-on training (Levin & Rumberger, 1986). By doing a good job of educating and by providing a good understanding of the new computer-oriented world, its possibilities for development and its dangers, the Third World may be able to construct strategies for using information technology that advance development of the country as a whole, rather than the interests (international or domestic) of a few. Finally, in this age of proliferating technology, policymakers and planners need to be not only computer literate but "technology literate." They should be armed with a set of questions which they ask of any technology. Third World scholars are already aware of this concept and policy-makers are already good at doing this. Perhaps, then, in the spirit of Paisley's (1985) notion of the "new literacy," it is these kinds of questions with which we should arm today's youth to prepare them for tomorrow's questions. In other words, we must develop strategies that prepare everyone for "computer and information citizenship."

27 Currently there is a large microcomputers in schools project in Kenya, sponsored by the Aga Khan Foundation with additional assistance from the International Development Research Centre and the Rockefeller Foundation. This development effort has a large research component, designed to document the implementation and impact of the project. George Papagiannis serves as a consultant on the research project and, in collaboration with the local research team, developed a desktop computer-based research station for the research staff to use in the following areas: data storage, management, and analysis of quantitative and qualitative data, word-processing and report writing, and project management. All the software used were commercially
information generation and analysis have been serious shortcomings in most development efforts, and given the relatively low cost of local data collection, management, and analysis, microcomputer-based research stations could enhance decision-making capacity at the local level, as well as improve efficiency for the central government. The existence of project management and budgetary analysis software programs, similarly, could improve the efficient management and administration of development projects where scarce resources have prevented many experiments from achieving their goals or even reaching the implementation phase. For instance, in education, the clearest advantage of microcomputers may be in planning and management applications (Hurst, 1986).

RESEARCH IMPLICATIONS FOR THE THIRD WORLD

Earlier we warned against the acceptance, uncritically, of carpetbagged research constructs and research results. In addition, we tried to point out how often educators introduce a new technology for implementation without distinguishing between practices that are inherent in the technology itself and practices (the wider package) that originate in the context in which they were implemented and tested. Further, we noted that it was important to make developed and did not require any extensive training. This "station" enables the research staff to be completely independent regarding all aspects of the project.
explicit how information technology was being used and for what purpose in the public and private sector, and at what state the local information technology industry was. If information technology is to be thought of as appropriate technology, then the question of who controls it and how it is used at the national level becomes important in the development of national policies for its use in education, both formally and informally. Even modest application of this technology in education requires the development of, if not a hardware industry, at least a software industry. This requires the formation of national policies designed to create structures and conditions for local development such as those already established in Brazil. Therefore, in the specification of initial research directions, it should be kept in mind that the above concerns serve as assumptions that guide the selection of the questions and issues to be addressed.

We believe that there are thirteen areas of interest that might produce information that would inform the

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28 Even here the development of a "clone" industry would serve to keep the multinational corporations who promote and sell information technology hardware somewhat honest. These corporations have a history of selling outdated equipment to Third World countries at prohibitive prices (Nilsen, 1979)
decisions that policy-makers and planners need to make in this area:

1. First and foremost, we recommend that a national survey be conducted that identifies the uses of information technology in both the public and private sector. The technology has entered almost every country in the world, both formally and informally. How is it being used? Who has it? Are there concentrations? For education, both the private and public educational systems need to be surveyed. How did these systems originally plan to use microcomputers and how are they actually being used? How are they being financed? One benefit of this type of study is to identify local, ongoing experiments that might serve as models for further dissemination and developing local expertise in the use of microcomputers for educational purposes. Another benefit would be to identify projects that could be studied more closely from an ethnographic or naturalistic perspective. Some preliminary assessments might be possible in regards to their potential for improving the quality of education. Identification of alternative ways to finance information technology would be another important finding useful to planners.

2. In order to assess the impact of information technology on the educative process, we recommend that studies be conducted in educational environments from an
ethnographic and naturalistic perspective. This perspective allows for casting the net wide in order to learn about what is happening in the educational process, both anticipated and unanticipated, negative as well as positive. If one looks only for "cognitive" development, without examining other possible outcomes, then one is likely to miss the real potential of this technology. For instance, as in the United States, do student experts emerge who play a special role in furthering the informal training of teachers? Do teachers begin to rethink how they teach? Do they broaden their range of ways of teaching? Does a pattern of usage among pupils emerge that reflects the dominant diffuse status characteristics, thus reinforcing long-standing inequities of that culture? While achievement questions cannot be ignored, especially in test-driven educational systems, there are theoretical and methodological problems with trying to assess the impact of a technology medium such as the microcomputer on achievement.

3. There should be research conducted on the impact of this technology on teachers and how it affects their work. Moreover, attempts should be made to assess whether teachers' view their roles changing as the result of introducing microcomputers into the classroom. And if so, how and in what way and does it alter their conception of education? Indeed, it may be more important to assess to what extent the deployment of microcomputers in schools
inspires new teaching methods or leads to experiments in classroom organization that are more conducive to carrying out effective teaching.

4. Research on the role of the microcomputer as a revitalization device should be conducted. While it may be useful to assess the impact of microcomputers on specific learning outcomes, it is equally important to assess whether they are having an impact on how learning is organized and whether they are contributing to further differentiation of teacher roles.

5. In education, who has access to computers? This question has several parts: first, in comparing use and access across private and public schools, where is the higher concentration? Note that it is important to have a clear historical understanding of how schools became what they are in order to make sense of these findings. Of relevance, for example, is that the role of private and public schools varies by nation. Second, within schools is there a pattern of usage that is not random? What role does the subject play as to where computers are likely to be used? Are there other prior patterns of course-taking that are reinforced or undermined by the introduction of microcomputers into that subject area? Are there differences in use and access between all-boy and all-girl schools? Between co-educational schools and all-boy or all-
girl schools? Finally, is there a difference in use and access found in boarding schools?

6. To what extent does involvement with information technology, and in particular with the "evocative microcomputer," contribute to restructuring concepts of self? In other words, to what extent has the microcomputer become a defining technology (as opposed to an enabling technology)? Assessing information technology's impact on language would be one way to begin to assess its impact on the "culture" of those exposed to it.

7. As with most technologies, there are cost issues of maintenance, repairs, downtime, and implementation. Furthermore, there are the so-called opportunity costs that need to be assessed. Research on cost-effectiveness is a critical line of inquiry that should be pursued. Comparisons with other technologies are particularly worthwhile types of research to carry out.

8. Another dimension of this question that needs to be explored is to what extent prior practices and older technologies get used. Are they discarded? Or are new ways discovered to use them? New technologies often make older technologies worthwhile. This is an important question that
is part of the side-effects questions that researchers should be addressing in their work.

9. If technology dependency is to be minimized, then feasibility studies ought to be carried out in order to determine the best way to encourage the development of a local software industry. In addition, research needs to be carried out in order to determine the best way to develop a "clone" industry. What kind of training is necessary for preparing local entrepreneurs for this type of business? What role can adult vocational education play in advancing this activity? What role can the university play in developing local versions of hardware that would be cheaper and yet meet the required standards of the technology?

10. Research needs to be conducted to assess the nation's capacity for networking. Information handling and exchange should be a part of any information technology development blueprint so strategies to create the infrastructure for this development need to be developed, if they haven't been already. Equally important, policy studies need to be conducted to investigate how networking and information access should be encouraged to develop. Should the "market" determine this? Or should the government develop approaches that would enable the public
to access and use information, say, through a public library facility?

11. While local knowledge should be developed concerning this topic, it is also important to put that information into comparative perspective. Studies should be conducted across countries, across regions and between countries in terms of computer usage, in all educational as well as non-educational settings. One important aspect of these types of studies is to examine closely the trans-border data transfer activities between countries. Information of this sort is important for the formulation of national policies regarding information control, use and abuse. Information is a resource and should be treated as one would treat any natural resource.

12. Workplace research is important to conduct if we are to better understand the impact that information technology may be having on the nature of jobs and the occupational structure, and work relations within the workplace. The technology and the role it purports to play in deskillling need to be examined in context. Surveys of actual and forecasted employer use should be conducted. This type of research is particularly important since the promotional literature is such that it suggests that "everyone" will be working with computers in the near future. To implement an educational strategy based on that
assumption when it may not be true would lead to a poor allocation of scarce resources.

13. With the use of microcomputers, via processing or networking, are there ways to "leapfrog" over older technologies? Are the educational and human resource development demands of development such that leapfrogging is not likely?

While there are many more types of questions that can be asked, we think it may be more important to stress the need to draw on research paradigms that allow an openness to discovering what is actually occurring in the use of this innovation. In this sense we advocate a greater use of ethnographic and naturalistic approaches. At the same time, it will be important to critically examine the literature already developed by Third World researchers who are addressing the structural and historical questions concerning innovation and its usages. Donald A. Hansen (1981, p. 109), in proposing new research directions for study of families and the new media, i.e., information technology such as microcomputers, said:

...what is required is a careful and sensitive structural analysis of the historically-situated meanings of the varied uses of the media for diverse social categories and social positions, particularly those of race and SES. Without such analyses, we are (to borrow Walter Lippmann's apt phrase) but cats looking at kings: even though we may carefully identify patterns of current media use within clear social categories, we will be unable to interpret their
contemporary meaning, or discern their implications for the uses of the media even in the near future.

In conclusion, then, from a researcher's point of view, we advocate a shift away from the conventional questions that educators routinely ask when assessing a new technology and urge the posing of questions the answers to which may contribute to the increasing of technology independence and an improvement in the quality of education. At the same time we suggest that this type of research should take into account information about the larger context, both within the country itself as well as in its relations with other countries. As Hansen's quote suggests, it is the union of grounded interactional and phenomenological research with structural and historical study that will provide the conceptual framework for conducting policy-relevant research on this subject. This is the type of research that needs to be conducted if we are not to succumb to technocentric or technicist thinking.
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