uation of being alerted to articles in journals which should be available in their library but can no longer be afforded by the library because of the cost of the expensive new services.

A final matter related to library operations is the importance of fruitful personal interactions between an information specialist in the library or in an information center and the users who are constructing profiles. By far the best results are obtained from those institutions where a well-informed and imaginative librarian or information expert can work with a chemist in developing a profile and then help him follow through on improving it to the point where it really serves his intended purpose. Many users isolated in small departments or small companies where face-to-face contact with an information expert is impossible gradually get poorer and poorer results until they are alienated from the entire system. As is true with many other services, there is often a direct relationship between the initial effort of developing a good profile and the amount of value that is received from it later.

Notes

1. The University of Pittsburgh has an IBM 360/50 computer; the University of Georgia, an IBM 360/65.
2. I acknowledge support through NSF grant GN 738 and Pennsylvania Science and Engineering Foundation contract No. 60 for the development of the information systems described.

Education beyond the Horizon

Uses of communications satellites for education in developing nations are considered.

Lawrence P. Grayson

Communications satellites are not going to solve the world's problems. No technology can. Human understanding, an awareness of the problems that exist, and a desire to help are needed. However, satellites can be a mechanism for promoting understanding, for providing high-quality education to people in remote and underdeveloped parts of the world, and for assisting nations less developed than ours to advance. A satellite offers a country that lacks ground communications a system that can cover a geographic area of a million or more square kilometers. It can broadcast to the entire region or beam its presentations selectively to specific areas for particular users. It can reach isolated, mobile, and dispersed populations with an ease and total cost equal to that involved in reaching dense groupings of people. Unobstructed by mountains and rivers and "impassable" terrain, it offers easy access to regions that would be extremely difficult or very expensive to reach by ground systems. Truly, satellites are a man-made resource having a potential to reach and affect everyone.

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The Division of Nations

Social evolution has divided the nations of our world into two broad categories, which may be classified as the rich and the poor, the developed and the less developed, those that are technologically advanced and those that depend on intensive manual labor. One of the chief bases for classification in one or the other of these two groups is the average level of formal education of the nation's population. In a country with a high level of technological development, such as the United States, most of the population receives some form of post-secondary school education. On the other hand, in many nations of the world not more than 10 percent of the people are literate and perhaps less than 1 percent ever receive any secondary schooling.

The influence of Greek law, the adoption of a Judeo-Christian ethic, the founding of city-states and mercantile societies, the industrialization of the West, and the development of science and technology and their uses to improve the health of the people (*1*) have all been cited as factors that have led to this disparity between nations. Irrespective of the causes, however, the uneven distribution of wealth and the lack of opportunity in many nations are considered to be at the root of much of the national unrest and the international concern in the world today.

There is no simple way to reduce the gulf between nations and no rapid, easy way to bring the emerging countries on a par with countries that are more advanced. If this can ever be accomplished, it will be only through multifaceted developments. Agriculture must be modernized, industry must be expanded, outside capital must be brought in, and ways must be developed to effectively utilize resources existing in emerging countries. However, of all the needs, perhaps the most prevalent and urgent is the transformation of education. It has been suggested that from 50 to 60 percent of the gains in productivity in the West in the past half century can be attributed to education and the systematic application of knowledge. More specifically, it has been estimated that in the United States in the period 1929 to 1957, 21 percent of the growth of real national income per person employed is attributable to increased education of the labor force, while another 36 percent is attributable to the general advancement of knowledge (*2*). Yet, despite the importance of education for economic growth, developing countries have only the rudiments of a national educational system, and what does exist is often of doubtful quality.

How does one create an educational system to reach all the people in a country where teachers and educational materials are scarce, where the roads and mail systems are inadequate, where the transportation system is underdeveloped, and where school buildings and electricity are not widely available?

While there is no mix that will produce "instant education," we now have a potential capability to reach people, in a continuous, sustained, rapid manner,

in all parts of a country which may even lack a traditional infrastructure. Satellites provide that capability. They can be used to multiply the effectiveness of skilled teachers, to reach people living in remote areas, and to keep in touch with migrant populations. They can link various parts of a country together and can provide widespread communication services to nations which could not possibly otherwise obtain them, even through a decade or more of effort spent on the development of terrestrial systems.

Problems of Developing Nations

Education in emerging countries has been characterized by rote memorization rather than by critical thinking; by subject matter and curricula which often are outdated and irrelevant; by a shortage of skilled teachers; by a lack of instructional materials; by inadequate or nonexistent teacher training programs; and by student apathy. While these problems exist in varying degrees in the educational systems of all nations, they are much more acute in developing countries. Therefore, even if a child in an emerging nation is fortunate enough to go to school, his schooling is brief and inadequate. In many emerging nations, only from 5 to 40 percent of the children of primary school age actually go to school. Furthermore, rates of attrition are very high. For instance, in Dahomey one out of every four students drops out before the end of the first grade and less than half of the students who begin stay to complete the sixth grade. In Madagascar only 44 percent of the students who begin complete the sixth grade, while in the rural areas of Ceylon the figure is 51 percent, and in Argentina it is about 60 percent.

The dual problems of low enrollments and high attrition rates have no easy solution. Undoubtedly there are many contributing factors, including, but not restricted to, the irrelevance, imagined or actual, of education in underdeveloped countries. Other causes of underdevelopment, of a political, social, economic, and cultural nature, probably will continue to operate even if education becomes, and is viewed as, relevant. Therefore, these problems may persist for a time even after the educational system becomes more responsive to the people's needs.

In general, developed countries spend more per capita, by an order of magnitude, on education than the less developed countries do. They have a significantly higher student-to-population ratio and a significantly lower student-to-teacher ratio. A recent NASA-sponsored report (*3*) presented educational and economic statistics for 97 countries. If the division between developed and emerging countries is made on the overly simplified economic criterion of a gross domestic product of more or less than $750 per person (a comparison based on standard exchange rates, which does not relate the dollar value to local purchasing power or consider the barter market), then 26 of the 97 countries qualify as developed and 71 as less developed. It was found that, on the average, the developed countries spend $259 per student per year on education, as contrasted with $32 in the less developed countries; have a student population that is 21.5 percent of the total population, as compared with 15.6 percent in the less developed countries; and have a student-to-teacher ratio of 23, as contrasted with 36. These differences are even more striking when one compares expenditures on education by specific countries. For instance, the United States, with a gross national product per capita of $4280, spends $839 per year per elementary school and secondary school student (*4*), whereas Dahomey, with a gross national product per capita of $75, spends $42.50 per year per student (*5*). Furthermore, in the United States students make up 28.6 percent of the population and there is a student-to-teacher ratio of 22.9, whereas in Dahomey students make up only 5.9 percent of the population and there are, on the average, 38.2 students for every teacher. These sharp contrasts indicate the magnitude of the problem for developing countries and underscore their need.

If improvement of education were the nation's only problem, it could be dealt with in a variety of ways. But unfortunately it is only one of innumerable needs. The developed resources of the emerging countries are centralized and not well distributed. The roads and transportation systems are poor, the communication networks are inadequate, and their technologies are underdeveloped. Power often is not widely available, nor can it be widely distributed, and generally there is a lack of technical and production skills.

This all points to certain high-priority needs which exist in most developing nations. The literacy level of a majority of the people must be raised. This implies that formal education must be made available to a great number of people—children and adults—and that instruction must reach the people who are far from the population centers. Government and community services of all types (sanitation and health services, agricultural information services, and so on) must be increased. All the people must be aware of, and participate in, the governmental process, and officials must have a more complete knowledge of the changing needs and demographic characteristics of the country—a type of information necessary for developing an appropriate educational system. A satellite could provide the basis for a highly responsive data information system which could continually revise and refine demographic information.

In exploring a number of ideas for a communication and educational system capable of meeting these needs, various uses of satellites have been considered. These are discussed in the remainder of this article. The suggestions made are not proposed as a complete and viable model for any underdeveloped country. Rather, they illustrate a broad range of possibilities to be considered in designing a satellite-based educational system to meet the needs of a group of people having certain characteristics and capabilities.

The Promise of Satellites

A satellite can be used for radio and television broadcasts, two-way telephone service, facsimile transmission of hard-copy materials, or high-speed transfer of data from computer to computer. Each of these modes, in turn, can provide the basis for numerous educational applications, from individualized instruction to library information retrieval; from teleconferences (that is, conferences involving use of a telecommunications medium) to instructional broadcasts on a group basis; from remote computing to class management.

A flexible, long-distance educational system could be established in developing nations by the following means: by setting up the facilities for voice and visual broadcasting to large geographic areas, with two-way voice communications between receiver and originator, and by providing keyboard-input and printer-output devices (such as typewriters or teletypes) and facsimile equipment for receivers in the larger

centers and in certain remote population centers. In this case "education" is considered in a very broad sense. Typical applications would include presentations and exchanges of generalized and specialized information; broadcasts of cultural events; telecommunications-assisted direct instruction; class management and school administration; uses of networks to increase the peoples' awareness of and ability to participate in governmental processes; teleconferences for special groups, such as physicians, lawyers, engineers, educators, and government officials; and communication of information to improve instructional, agricultural, and health services.

Television and Telephone Applications

Visual and voice transmissions can be used to improve the quality of direct classroom presentations in areas where there is a lack or shortage of qualified teachers. Conventional instructional presentations could be made to these locations. For instance, television broadcasts which originate at a school or university located in a central area, perhaps the capital or a major city, could be transmitted via satellite directly to classrooms or community centers throughout the country.

In the classroom of a school in a remote area there would be a teacher or teacher's aide who could formally conduct the class, elaborating on the presentation and answering elementary questions. If more detail about some point was wanted, or if the teacher could not answer a particular question, the aide could talk to an experienced teacher or resource person at the center by telephone. If classes were composed of about 40 students each and five classes were on a party line to the same resource-teacher, some 100,000 students in "small groups" could be reached by the lecturer with the assistance of 500 resource-teachers. The questions telephoned to the center could be sorted, and the lecturer could respond in his next telecast to the more common and significant ones. Without using any time-multiplexing or speech-compression techniques, the 500 person-to-person voice channels might use less than half the bandwidth of a single television channel. Since bandwidth for open-circuit broadcasting is extremely limited, the fact that audio channels require significantly less than television channels should encourage careful thinking about the goals of education and how they can best be satisfied (*6*).

In these ways the influence of qualified teachers can be magnified by enlarging the audience reached. One teacher could make a presentation to 100,000 students, yet do so as though he were instructing a group of only 40.

This system, moreover, could be used in programs of advanced professional education to enable a few specialists to reach a widely dispersed audience (*7*). For example, it might be highly desirable to teach an advanced course in the latest discoveries and practices in tropical medicine to doctors practicing in the field. There might be only 100 such doctors, working in widely separated regions. It might not be feasible to bring them together, or feasible for the country's one or two experts on the subject to visit each field location. The course could be taught via the satellite network. Similarly, the network could be used to bring teacher-training programs to teachers and teacher's aides in the field (*8*).

In addition, the system could provide the classroom teacher with a means for obtaining information needed by his particular class, assistance in diagnosing the difficulties of individual students or of the class as a whole, suggestions for remedial or additional work, and information concerning classroom management and school administration. These resource services might be provided on an "overnight" basis. Through use of the printers, typewriter-like and computer, in conjunction with the facsimile equipment located in the remote schools, a national center could accept requests from the teacher-administrator at the end of a school day, process them, and transmit printed matter, photographs, charts and drawings, and examination questions during the night, so that the material would be available to the local teachers the next morning (*9*). The ability to deliver standard examinations throughout the entire country at the same time could lead to the establishment of national educational norms.

National public awareness could be increased through television broadcasts. Events of immediate national interest (such as addresses by the President or major government officials), cultural events, disaster and health warnings, and events of international significance (such as deliberations of the United Nations or the Organization of American States, or sporting events such as the Olympic Games) could be broadcast to an entire nation. By bringing happenings of national interest to people in very remote locations, increased awareness and a sense of national commitment could be developed.

Small-group communications could be fostered through the use of telephone facilities in a teleconference mode. For instance, to provide short courses or seminars to specialized groups, lectures could be presented via two-way telephone channels. If the seminars were organized in advance, any necessary printed or visual material in the form of pictures, slides, or charts could be delivered by mail or by a facsimile system to the various locations prior to the lecture. Then at an appointed time all participants could be linked into a common telephone network so that they could converse with the lecturer or directly with each other (*10*). The advantage of this approach has already been demonstrated through the use of existing telephone facilities. As part of the normal educational activities, "teleclasses" have been conducted in Brooklyn, New York, and in Los Angeles, Oakland, and Downey, California, offering the regular school curricula to homebound students who are either permanently handicapped or temporarily disabled. This approach has been enthusiastically accepted by parents, teachers, and students alike (*11*).

The same telephone channels could be used for conferences among professional people. For instance, doctors in the field could discuss new treatments or difficult cases with each other and with medical specialists at a major medical center, hospital, or college. In this way the practicing physician could obtain assistance in diagnosing and treating rare or difficult cases, and could also increase his professional competence (*12*). The same type of application can be envisioned for teachers who want assistance with special or difficult educational problems. Furthermore, the telephone channels would allow educators to collaborate on the planning of national educational studies, on data collection, and on a discussion of the results of those studies.

The telephone could connect the physician in a remote location or a central city with a national or even international taxonomic information center. Since it is impossible for every doctor to be fully aware of the symptoms and treatments for all poisons, particularly for those that are rare or

occur infrequently in his geographic area, telephone access to a taxonomic information center would be highly desirable and even mandatory to save the lives of individuals in certain cases.

Computer Applications

A satellite could be the mechanism for establishing a computer utility serving an entire country, or even several countries. This might be accomplished by placing computer terminals in all parts of the nation and providing them access to a computer in a central location, the data being transmitted in both directions via the satellite. For school use, remote batch terminals consisting of card readers capable of optically sensing hand-produced marks and printers could be set up in classrooms and laboratories to allow students to engage in problem-solving activities. This might be particularly useful in selected secondary schools and in colleges (when they exist) in remote areas. Students could be better prepared to move to a university for advanced study and to handle the nation's future data processing needs, which surely will increase as the nation develops.

It is also possible to use telephones as computer terminals for some applications. For instance, using the telephone dial as an input device, a student could program the computer to carry out numerical calculations, engage in arithmetic drill exercises, or respond to multiple choice questions, or he could request and hear audio tapes which were accessible through the computer (*13*).

Furthermore, students and faculty members in small colleges, whether in remote areas or in the nation's capital, could have available to them the power of the country's largest and most sophisticated computers for carrying out research, as well as for instructional projects. In this way, one or several computers could serve the needs of a large number of schools. Remote terminals also could provide school administrators with the current and past information necessary for improving school management, planning, scheduling, and other administrative services.

If specialized data bases were established on a national or even an international scale, queries could be addressed to them from remote areas. For instance, a doctor in the field who required the latest information about the symptoms, diagnosis, treatment, and preventive measures for a specific malady could place a request at a remote terminal. The computer would interrogate its files and provide the physician with the information. This information could be provided through the remote printer and facsimile equipment, or provided by having the computer ask a distribution service group at the center to make duplicate copies of the computer-located information, assemble them, and send them to the physician. If a system whereby the computer could provide an immediate audio response was desired, all possible messages could be prerecorded and stored on a random-access audio unit from which the computer could select the proper message (*14*).

Through the use of the satellite it would be possible and economically feasible to have a computer in the developing country communicate directly with a computer in a developed nation. For instance, the computerized records of the Library of Congress could be searched from the developing country or copied into the files of the remote computer. The data transfer could occur in both directions, so an information exchange could be established between the two countries.

The remote terminals could be a mechanism through which government officials could obtain demographic data about all the people of the nation. Thus, governmental decisions could be based on accurate up-to-date information. For instance, data on birth, death, and sickness could be entered daily at the remote terminals and immediately recorded at a national demographic information center. The data could be tabulated and correlated in various ways, and patterns and trends could be developed statistically. Government officials debating an issue would have available current information and statistics on the characteristics of the population, and even on the needs and desires of their constituencies.

Applications Less Suited to Developing Nations

The applications discussed above certainly are not the only possible uses of satellites in education. Rather, they are suggested as possible first uses of a national educational communication system for a country which does not now possess one. They are presented here because of their relative simplicity and their potential to benefit a large number of people while requiring less hardware and fewer supporting services than other uses. There are many other applications which, while highly innovative and imaginative, seem less likely to satisfy the stated needs of developing countries at this time.

For instance, one approach to education which currently is receiving a great deal of attention in the United States is individualized instruction—that is, patterning the presentations to fit the needs of individual students. In computer-assisted-instruction (CAI) approaches this can be done by having each student interact with a computer through a remote terminal on a real-time dialogue-like basis. It can also be done (i) through various classroom management techniques, such as having students take frequent tests which are analyzed and used, in conjunction with the student's history and the goals of the course, as a basis for prescribing special instructions, or (ii) through interactive and selective television, as when entire programmed lessons are presented via TV. In the latter example, if the combination television receiver and student-response terminal has a storage capability and the image on the screen is changed only once every 10 seconds, then standard television, which transmits 30 images per second, may be able to broadcast 300 images or frames of programmed instruction in the 10-second period. If the terminal is able to select the appropriate image from among those broadcast and to do so on the basis of the student's response, then the student can proceed to study at a rate independent of that of the learners at other receivers. Moreover, his path through the material will be patterned by his responses and can branch elaborately. Used in this way, the television terminal acts as a video version of a textbook in programmed instruction format (*15*).

However, while such applications have great potential, they may be more beneficial for nations that already have extensive educational systems than for those that do not. It does not appear feasible to make the first systems for long-distance instruction in developing nations responsive to the needs of individual students. Rather, the magnitude of the problem and the necessity for wide availability of instruction to raise the literacy, health, and economic standards of the countries in question point toward instruction patterned to

fit the abilities and needs of a group as the best initial approach. It must be remembered, however, that every group is a group of individuals, and that any approach, to be effective, must relate to, and account for, differences between individual students.

Can It Work?

Although at this preliminary stage it is not possible to answer the question "Can it work?" with certainty, it is clear that the success of any technology-based system will depend on several factors. These include the ability of people to learn with the aid of technology; the cost, complexity, and reliability of the hardware; the appropriateness of the materials presented; the cultural and historical background and the needs of the country; and the degree to which the system is accepted, from both the political and the personal points of view. Most of these factors are critical, so that failure in any of these areas can negate success in others and minimize the effectiveness of the total system. To understand the problems more fully, let us explore each of the factors in turn.

Technology *can* be used for teaching. Numerous studies have been made which deal with the effectiveness of existing instructional media, including instructional television, computer-assisted instruction, language laboratories, radio broadcasts, and films, and with the attitudes of teachers and students toward such media. These studies have shown that students can learn by means of any instructional medium, and that, in general, they learn at least as well through technological means as they do through conventional classroom presentations. While this discovery of "no difference" in the effectiveness of the two approaches may not be regarded as justification for introducing a new technology into an existing high-quality educational system, it can mean significant improvement for people in developing countries, who currently have very poor educational opportunities or none at all. It means that instruction as good as that now provided by the best traditional methods can be brought to countless people who now receive substandard education.

Technology can also provide motivation. In several recent studies of the use of computer-assisted instruction in the United States, the attrition rate of students taught in this way was significantly lower than the rate for students taught by more conventional methods (*16*). In a related finding, Chu and Schramm (*17*), after examining numerous reports of the effects of television, stated that, under suitable conditions, television can provide high motivation for learning in developing regions. This factor of motivation can be of extreme importance in any attempt to improve education in countries in which, in the past, nearly half of the students have dropped out of elementary school.

Another advantage of visual technologies, such as television, is that they can be used for making dynamic pictorial presentations. They can be used to teach by showing familiar scenes and situations to people who have little experience in learning from printed materials, in countries where illiteracy is widespread. While television viewers must learn certain pictorial conventions, the evidence suggests that these conventions are easily learned even by people who are not literate.

A second critical factor to be considered is the hardware. Although the satellite can be designed, built, and launched by a developed nation, responsibility for building, operating, and maintaining the ground terminals will rest with the developing country. This can be a major problem. For instance, present-day television receivers have been designed for ordinary household use in countries, such as the United States, where the viewers are accustomed to using sophisticated electronic equipment. Familiarity with such equipment is not universal. Furthermore, the terminals will have to be maintained by local personnel, who, in many countries, are not highly trained. Therefore, the terminals must be easy to operate, simple to maintain, and reliable.

Another consideration is the cost of an individual terminal. While the costs of constructing and launching the satellite are significant, it is the investment in terminals that will dominate the total cost of the system when hundreds of thousands of terminals are served by a single satellite. Therefore, the cost of a terminal must be low if the system is to be economically feasible. Finally, in considering the delivery, operation, and maintenance of the terminals, it must be remembered that in many regions an infrastructure is just being developed—that transportation is often very poor and electricity may not be widely available. These conditions may necessitate the development of special antennae systems and the use of battery-operated television and radio receivers.

Important as the hardware problems are, they may not be the most difficult to solve. More serious can be the development of appropriate and effective educational presentations which satisfy the national needs and appeal to the people; obtaining the support and cooperation of the political units in the country, the existing school administrations, and the teachers; and organizing and training people to use the technology effectively. These problems are not unique to satellite-based systems but, in varying degrees, face all of modern educational technology.

The development of effective instructional material is time-consuming and expensive. The economic appeal of educational technology in general, and of satellites in particular, is that they can be used by large groups of people, perhaps in several countries. Yet, the material must be relevant to local needs and even to the needs of the individual student, and this creates a dichotomous situation. In each such application, therefore, a compromise will have to be reached between general and local relevancy, and this compromise will be based on considerations of cost and on the degree of homogeneity of the prospective audience.

If satellites are to be shared by several countries, a number of political problems come to the fore (*18*). For instance, a country will have to decide whether it will allow material that has been produced by, and broadcast from, another nation to reach its people. Furthermore, a country will have to be willing to establish a national educational and communications system that is based on a satellite facility over which it does not have total control. It is clear that this will require a high degree of cooperation among the nations involved.

Furthermore, the introduction and successful exploitation of an advanced technology requires a serious commitment to educational improvement from a country's political and educational hierarchies. If this is not forthcoming, any program will be severely hampered and will probably be viewed as a frill or an experiment. This apparently was the case in Nigeria when it first introduced a major educational tele-

vision project in 1965 (*3*). Because it lacked the proper commitments, the project encountered serious programming and operating difficulties, did not receive the enthusiastic support of the nation's teachers, and, as a result, was not able to meet its objective of significantly improving the quality of instruction in the school system and of providing effective teacher-training programs.

The amount of organizational activity and precision necessary to establish and operate a national, satellite-based educational system will surely tax the capabilities of any nation and will demand a strong desire and commitment on the part of the country in question if it is to succeed. Programs for training operating and maintenance personnel must be established; terminals must be manufactured and distributed throughout the country and maintained in local areas; programs must be produced and must appear on schedule; operating and broadcasting schedules must be widely known; supporting materials must be available in every area where they are required at appointed times; communications between remote users and the central facility must be reliable, with few interruptions of service; and there must be coordination between the teachers in the field and the resource personnel. All of this requires the cooperation and administration of a large number of specialists dispersed over a wide geographic area, often in remote regions. Therefore, it demands a high degree of organizational efficiency, which unfortunately is not found in most countries.

There are many problems to be overcome, and a satellite-based national educational system can succeed only if it is carefully planned, is wisely implemented, and receives a strong national commitment. While the effort and commitment required are great, the potential benefits for the entire nation can be truly significant.

Concluding Remarks

Most of the nations of this world have not realized their potential for economic and social improvement. There is no doubt about the magnitude and gravity of the problem this presents. These nations must be given the same opportunity to advance that the more developed countries have had. This will require development along many lines—improvements in agriculture, expansion of industry, and the building of an extensive infrastructure. Perhaps the most necessary and far-reaching change of all will be the development of a high-quality national educational system aimed at raising the levels of literacy and skill of the people of the entire country (*19*).

It is in this last area that satellites hold great promise. They offer a country a means of rapidly implementing an educational system capable of reaching all of the people, no matter how remotely situated they may be. Satellites can make centrally located educational resources available throughout the country, can magnify the influence of high-quality teachers, and can reduce the number of scarce and expensive items of equipment, such as large-scale computers, that are needed. Satellites also provide a means of exchanging information through audio or audiovisual presentations, rather than through the written word. Thus, they may even allow a country to temporarily bypass the literacy stage in order to effect certain immediate improvements, such as improvements in nutrition or health practices.

Yet, despite the need for a satellite-centered educational system and the advantages such a system offers, extreme caution must be exercised in introducing it in an emerging country. This is true not only for a satellite-based system but for any technology that promises to radically alter the existing ways of the people involved. Before any technological system is devised and implemented for a developing nation, a very careful and complete study of the impacts and implications of that system for the nation should be carried out. This study should be a joint effort between the nation in question and developed countries. The system devised must not be technologically too advanced for the environment for which it is intended. There is no reason to believe that a technology which would be effective in the United States or even in one emerging nation would be effective in a second emerging nation. In fact, too often the evidence points just the other way (*20*).

Despite the commonality of their problems, there are great contrasts among the developing nations. For instance, a nation may have an abundance of natural resources, such as iron, timber, oil, and minerals, as Bolivia has, or, like Dahomey, it may not. Its climate may be tropical or frigid. It may be rich in life forms or relatively barren. The nation, like those in Latin America, may have an old, highly developed culture with a wealth of archeological treasures and documentary evidence of its past, or only its recent history may be recorded, as is the case in southern Africa. It may once have been the focus of large migrations and subsequent ethnic incursions, or it may have been isolated and thus have remained fairly homogeneous, culturally and genetically. There may be a common national tongue, as in Central and South America, where in most areas Spanish is virtually a universal language, or there may be a multitude of tongues, as in India, where 15 official and over 800 recognized languages are spoken.

These wide disparities only point to the fact that there is no universal solution to the educational problems of emerging nations. No technology—and this includes a satellite-based technology—can be effectively applied in the same way to every situation. Rather, a technology must be adapted and used in ways which satisfy particular needs. In this regard, satellites are very promising, since they provide a flexible communications medium which can be used in a variety of modes for numerous educational applications.

Finally, it must be remembered that many of the developing nations are not industrialized but are agriculturally oriented. Therefore, a technology that depends on highly sophisticated skills cannot be immediately effective in these countries. Moreover, the degree of sophistication must be based on the background of the receiving nation and not measured against the level of skills of people in the United States. In the planning of any technological system, its effects on the sociological, historical, legal, economic, political, and cultural aspects of the receiving society should be carefully weighed.

The range of applications discussed in this article is not intended to comprise a viable model for any developing country. Rather, it is meant to represent a spectrum of ways in which satellites can serve education. For any particular country, the needs of the people and the goals to be achieved must be clearly defined. Then a satellite-based educational system, with all of its supporting components, including the development of instructional materials,

teacher training, maintenance of equipment, and so forth, can be designed within the social and political constraints.

The potential of satellite-based communications systems for the education of people in developing nations should be fully investigated (*21*). Although satellites will not solve the world's problems, they can help raise the literacy level of all people and their ability to communicate with one another, and thus better prepare them to cope with the problems that they face.

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6. Another bandwith reduction scheme is being investigated by the International Development Technology Center at Washington University, St. Louis. They have proposed still-picture video with continuous audio transmission. In this application, a single video channel can be used to transmit a large number of time-multiplexed pictures, from which appropriate ones can be selectively received by a given audience.
7. Several similar, but very limited, versions of this system, involving terrestrial communications only, are already in operation or are being planned. One of the most successful, in the area of graduate engineering education, is GENESYS, operated by the University of Florida; see M. E. Forsman, in *1968 IEEE International Convention Digest* (Institute of Electrical and Electronics Engineers, New York, 1968). Southern Methodist University is offering some 60 graduate engineering courses, via television with two-way voice channels, to more than 800 industrial employees working for advanced degrees in over 30 receiving classrooms in 11 industrial sites in eight cities within a 60-mile radius of Dallas. Stanford University is using a similar system to teach graduate courses at remote locations in its geographic area.
8. A recent National Academy of Sciences' study committee strongly recommended as a matter of high priority the development of a multichannel system for a "teleclub" type of educational, instructional, and informational television for special groups, such as physicians, lawyers, engineers, and educators; see "Useful Applications of Earth-Oriented Satellites, Report of the Central Review Committee" (National Academy of Sciences, Washington, D.C., 1969).
9. A limited attempt at providing "overnight" services is now in operation in St. Paul, Minnesota. The "Computer Assisted Dial Access Video Retrieval System" (CADVRS) allows a teacher to call a participating educational television station and select a film from a catalog of available materials. During the evening the requested material is transmitted, after a station's normal sign-off, and is received at the school on a signal-activated video tape recorder, so the program is available for use by the teacher the next morning; see *JCET News* **2**, No. 1 (Jan. 1970), published by the Joint Council on Educational Telecommunications, Washington, D.C.
10. For continuing professional education, similar systems have already been implemented in the medical area. The Albany Medical College has conducted courses for physicians at 60 hospitals in seven New England States by means of two-way radio; the University of Wisconsin has conducted similar courses in its area.
11. A. H. Malcolm, "Disabled attend school by phone," *New York Times* (30 Nov. 1969). This type of application should become even more widespread with the advent of the Picturephone, a telephone with the capability to transmit images as well as voice; see *Bell Lab. Rec.* (May/June 1969). It has been predicted that about 1 million Picturephones will be installed in the United States by the mid-1970's.
12. As a first step toward establishing a permanent satellite communication and educational network, Alaska has initiated a major educational experiment based on use of the NASA-operated ATS-1 satellite. The complete experiment has two major objectives—education of the native population, particularly in remote regions, and medical communications. As a first step, voice communications were established, in April 1970, between the University of Alaska, the University of Wisconsin, Stanford University, and the National Institutes of Health in Bethesda, Maryland. In the future the system will be modified to allow television broadcasts. See Senator Mike Gravel, *Congressional Rec.* **115**, No. 172 (22 Oct. 1969), and B. W. Poirier, "A Turning Point in Alaska Communications," paper presented at the Satellite Communications Conference, Anchorage, Alaska, 28 August 1969.
13. An experimental system called Dial-a-Drill, now being studied by the New York City Board of Education, can drill 2000 students in the fundamentals of arithmetic and maintain a record of each student's level of achievement. In another telephone application, developed by the Oak Park and River Forest High School in Illinois, a student in a high school carrel or in his own home can dial a computer and obtain random access to, and then hear, any one of 224 taped lectures in numerous subject areas. See R. R. Campbell and G. H. Honnold, "Teaching by telephone," *Bell Lab. Rec.* **1970**, 23 (Jan. 1970).
14. Computer-selected audio response systems are already operational. For instance, IBM has used one to provide its customer engineers with the latest information on computer maintenance. A customer engineer can use any Touch-Tone telephone in the country, dial a computer located in Poughkeepsie, N.Y., key in his request in coded form, and hear a computer-related voice response giving him the needed information. In the United States, applications of digital inquiry and voice-response systems are expanding so rapidly that these systems are becoming almost commonplace. For a discussion of these systems see "Machines at your fingertips," *Bell Tel. Rec.* (June 1969).
15. J. C. R. Licklider, in *Public Television, A Program for Action* (Bantam, New York, 1967), pp. 201–225.
16. In a course in Russian at Sanford University, 73 percent of the CAI students completed the three academic quarters, while only 32 percent of the students in the regular course finished the year; see P. Suppes and M. Morningstar, *Science* **166**, 343 (1969). In a course in German offered at the State University of New York, Stony Brook, 77 percent of the CAI students completed and passed the year's work, as compared with 60 percent of the students in the audiolingual sections; see H. W. Morrison and E. N. Adams, *Mod. Language J.* **L2**, No. 5 (1968).
17. G. C. Chu and W. Schramm, *Learning from Television, What the Research Says* (Stanford Univ. Press, Stanford, Calif., 1968).
18. "Final Report, President's Task Force on Communications Policy," Eugene V. Rostow, chairman (Government Printing Office, Washington, D.C., 1968).
19. In effecting any large-scale change, a clear distinction must be made between the goals and the means for achieving those goals. As pointed out by Merton R. Barry and C. A. Wedemeyer of the University of Wisconsin, in a private correspondence, literacy is not an end in itself but, rather, is a means toward attaining other goals. In the short-term development of a country, literacy may not be necessary and, in fact, may only delay progress toward specific improvements, such as in agricultural production, health and sanitation practices, and the like. This is not to say that literacy is without value, but to say, rather, that literacy may not be the only means for achieving these types of desirable change. Over the long run, however, as certain basic and immediate changes are being made, literacy is essential, because some goals, such as setting up a national judiciary system or a structure for procuring, distributing, and selling various man-made goods, require literacy as a means to their achievement.
20. H. E. Hoelscher, *Science* **166**, 68 (1969).
21. At the Second Hemispheric Conference, held in Santiago, Chile, in April 1969, it was proposed that an international institute be established to study the financial, educational, research programming, and legal aspects of the use of satellites and to prepare 50 hours of demonstration programming for satellite transmission throughout Latin America [see N. Hurley, *Mensaje* **1969**, No. 178 (1969)].