Map No.			Channel	
106	Sacramento	KVIE	6	Central California Educational Television
107	Redding	KIXE	9	Northern California Educational Television
108	**OREGON**			
109	Corvallis	KOAC–TV	7	Oregon State Board of Higher Education
	Portland	KOAP–TV	10	
	WASHINGTON			
110	Pullman	KWSC–TV	10	Washington State University
111	Yakima	KYVE	47	Yakima County School District
112	Lakewood Center	KPEC–TV	56	Clover Park School District 400
113	Tacoma	KTPS	62	Tacoma School District 10
114	Seattle	KCTS–TV	9	The University of Washington
	HAWAII			
115	Wailuku	KMEB	10	University of Hawaii
116	Honolulu	KHET	11	
	PUERTO RICO			
117	Hato Rey (San Juan)	WIPR–TV	6	Department of Education of Puerto Rico
118	Mayaguez	WIPM–TV	3	

NOTE: In addition, KBZK operates in Pago Pago, American Samoa, and connects with six relay stations.

Supplementary Papers

The papers that follow were prepared for the use of the Commission, and are presented here for their general interest or reference value. Each is signed by its author. The views expressed are those of the authors, and not necessarily those of the Commission, whose own views and judgments are expressed solely in the Report of the Carnegie Commission on Educational Television, which precedes these papers. In addition to these essays, the supplement includes selected statistical material on educational television which was prepared by or for the Commission.*

**Dr. Licklider's paper was completed after the Commission had formulated its own conclusions.*

Frequency Use and Conservation

At the present time we have a completely filled VHF band and a rapidly filling UHF band. However, we note that the overwhelming majority of all man-hours of viewing are spent with sets tuned to the VHF band. It is therefore possible, at relatively small cost and dislocation, to reserve part of the UHF band for experimental purposes in research for better quality.

Although the gross national product continues to increase and items which require only more dollars for improvement can be anticipated with time, the use of the natural frequency spectrum is another matter. There is only so much of it, and any waste must be carefully prevented. It is true that there are underway applied research programs seeking to broadcast with a smaller portion of the spectrum while transmitting the same amount of video information. These developments are extraordinarily important but will not come to fruition for at least ten years and probably a great deal more.

It is to be hoped that the precious UHF spectrum can be allocated grudgingly to insure that the best possible use of television with improved quality of picture transmission is a firm requirement. The present standards must be tied to the VHF band in order to protect the interests of the public and of industry, but a part of the UHF band should be opened for experimentation and improvement.

While we may expect greater use of cables, it must be remembered that the broadcast receiver is the least expensive method of getting a television signal into the home and is the only method economically possible for a large fraction of television viewers.

Televistas: Looking Ahead Through Side Windows

by J. C. R. Licklider

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In planning to improve the use of television for educational purposes, most people have accepted the basic framework of conventional broadcast television.* That framework determines the basic structure of their thinking and in the process delimits it. For example, a person who thinks of educational television as a set of educational functions supported by the framework of conventional broadcast television is unlikely to think of television as a medium for two-way communication or as a way of transmitting the text of a book or the stimulus material for a course of programmed instruction.

The main purpose of this paper is to explore some of the possibilities that come to mind when one deliberately looks aside from the central line of thought about educational television and rejects the assumption that educational applications have to be built upon the framework of conventional broadcast television. It is not part of the purpose to argue that what is to be seen out the "side windows" is

*The term "broadcast," as I use it here, is not intended to imply that signals are necessarily radiated into space from an antenna. If a program were sent out to the public through coaxial cables, the program would be "broadcast."

more attractive than the view along the central path. The intention is merely to examine briefly a collection of ideas that seem interesting from a technical point of view and to consider how they might fit into the future of education supported by technology. It seems important to do this because the modern technology of information and communications is opening up a wide horizon of bright prospects, most of which seem to be technically achievable. These prospects should be held in mind, and brought into active interplay with pedagogical, psychological, economic, and philosophical factors, during this crucial period of planning and deciding the course of educational television.

"INTERACTIVE" AND "SELECTIVE" TELEVISION

The great simplifying characteristics of conventional broadcast television are that it is broadcast and that the broadcast stations transmit to viewers who do not transmit back. Under past technological constraints, those characteristics were a *sine qua non* for a wide-band medium. That is to say, to justify the use of a medium capable of carrying a very large amount of information each second, one had to reach a mass audience and therefore could not provide channels through which the many individual members of a large audience could talk back. In the future, technology will constrain less severely. We should therefore think about what educational television might do and what it might achieve if it could afford to present a much wider range of programs, direct its services to small and highly selected audiences, and even engage in two-way communication.

From an educator's point of view, the main intrinsic defects of broadcast television are that it offers everyone the same thing and does not give its viewers a direct way of participating in its programs or interacting with its program material. It is likely that advances in technological capability and changes in social perspective will multiply the channels available to educational television, making it possible for educational television to offer a wide variety of programs and services to meet diverse educational needs selectively and responsively. Indeed, it is possible that facilities will become available to educational television that will permit people to participate directly in educational programs and to interact directly with subject matter. These possibilities evoke concepts that I shall call "selective television" and "interactive television." Since interaction is such a strong factor in learning, let us consider it first.

Interactive Participation

Viewers do, in a sense, participate in conventional television programs. If the program material is dramatic and matched to a viewer's motivations, the viewer may sit on the edge of his chair, empathize overtly, and utter words of encouragement. That kind of participation fails, however, to qualify as *inter*active participation, since the actual course of a broadcast television program depends in no way upon the concurrent behavior of its viewers. The criterion for what is here called "interaction" is that both the program and the viewer be capable of influencing each other.

From a psychologist's point of view, there is an important difference between interactive and noninteractive participation which is crucial to the development, as distinguished from the exploitation, of motivation. Noninteractive participation stems from previously established drives, but it does not contribute effectively to the development or augmentation of motivation. Interactive participation, on the other hand, is regenerative. It stems from already established motivation and may in turn strengthen and even restructure that motivation.

It is obvious enough how viewers can react to a television program, but how can a television program react to its viewers? If it is a set piece, it can do nothing that is not set into it. If it is a contingent program, on the other hand, it can in principle adapt itself to its audience as a lecturer adapts himself to his. Indeed, if the "program" is an array of contingent programs – a "multiple-track" program, in the

parlance of programmed instruction — it can adjust itself simultaneously in different ways to achieve and maintain resonance with each of several or many sectors of its overall audience. The trouble, of course, is that the difficulty of selective adjustment increases with the size of the audience. Obviously, there is an essential incompatibility between viewer-program interaction and mass media.

Participating by Selecting

For a viewer of educational television, the next best thing to having the program itself react to him may be to select from an ensemble of transmitted alternatives the one that is most appropriate to his needs or interests. The viewer of conventional television can, of course, select a channel and change his selection whenever he likes. That is good as far as it goes, but it does not go far enough to give the viewer any sense of participation in a program. The idea of "participating by selecting" involves the assumption that broader and more systematically organized sets of options can be offered to the viewer and that more convenient and more sophisticated ways of selecting among the options can be provided.

On *a priori* grounds, to augment the selectability of program material seems less likely to open significant new opportunities than does the establishment of true interaction between the viewer and the program itself. However, selectability does not suffer as severely the essential incompatibility with mass-audience broadcasting that handicaps interaction, since the entire process of selecting can be carried out at the receiver and no feedback channel from the home to the television station is required. Let us, therefore, consider a few approaches that involve selection by the viewer — approaches that might achieve some of the same advantages as interaction without giving up mass audiences.

SELECTIVE BROADCAST TELEVISION

The approach to improving the effectiveness of educational television that requires the least modification of the framework of conventional broadcast television is one that takes advantage of increased availability of television channels to broadcast a large amount of carefully scheduled and coordinated material, from which individual viewers can select what meets their needs and interests. Each broadcast program, for example, could be an array of subprograms, from which each viewer could select one. From time to time, either at specified points in the program or at moments of his own choosing, the viewer could switch from one subprogram to another. A few of the ways in which this general method could be applied are suggested by the following ideas:

1. Several cameras are used to cover a group discussion, a play, or a football game. All the signals are broadcast and received by the television receiver. Associated with each receiving set is a control by means of which the viewer selects the camera through which he wishes to watch.

2. The picture of a work of art or of a scene on a large stage is transmitted in such a way as to preserve very fine detail. A control on the receiver permits the viewer to select whatever part he likes of the overall picture for display upon his screen. Having mastered the control arrangement, the viewer can let his eyes explore a painting almost as though he were before it in the gallery or follow spontaneously the action of a dynamic scene.

3. The news broadcast has two main parts. First there is a summary in which the essence of each item is presented very briefly. During this presentation, the viewer presses a button each time he sees or hears something he wants to learn more about. Then, during the second part of the broadcast, when fuller and more penetrating accounts are given of the various developments, his receiver selects for

him and presents to him a program custom tailored to his interests.

4. Instead of broadcasting a "moving picture" – a succession of still pictures, each minutely different from its predecessor – the transmitter sends out a sequence of still pictures in which one is quite independent of the next. The still pictures, coming at a rate of thirty per second, constitute a vast informational resource from which each receiver can select. The receivers are designed to pick out certain images and to hold each one for view until its selected successor arrives. Thus the viewer sees a succession of still pictures, each selected from a large set of alternatives.

The first two schemes would be interesting only if means were developed through which viewers could control the selection and display of received images very conveniently and very naturally, almost as a part of the act of viewing. The third scheme does not appear to involve any problems of adjustment by the viewer that would require the development of sophisticated means, but it does invite development of sophisticated arrangements for controlling the selection of program elements on the basis of the viewer's pattern of interests and preferences. The basic idea, suggested in terms of an augmented newscast, was to offer a variety of program elements, transmitting them in several parallel sequences so that each viewer's receiving set could make its own selection. If the entire schedule of offerings were preannounced, each viewer might of course piece together his own news program by operating a simple channel selector. To make the scheme practicable, however, it would be necessary to provide, for each receiver, a programmable selection controller. This notion, which tends to develop itself into a concept that might be called the "control subsystem" of the home information system, will be pertinent also to other ideas to be introduced later.

Assuming a sophisticated control subsystem, one can envisage application of "custom tailoring" to other things than news. It would be especially appropriate for announcements of forthcoming events and, indeed, for any subject matter that naturally divides itself into elements of which some are likely to be of interest to one viewer and others to another. Inasmuch as materials and services offered for sale to the public constitute precisely such a subject matter – and the development of sophisticated control subsystems would open new fields of advertising for commercial television – one can look forward to the actual appearance in the home of such selective means as we have been envisioning.

In the fourth scheme, many sequences can be carried by a single television channel of normal bandwidth because they are sequences of images separated by seconds of time rather than by milliseconds. The basic idea – not very appealing on first thought – is to give up the motion-picture quality of conventional television in order to make room for the many alternatives demanded for certain applications of selective television. If for each viewer there were one image every ten seconds, on the average, instead of thirty images every second as in conventional television, the same channel that carries a conventional moving television picture could carry three hundred entirely different sequences of images. Selecting from those three hundred sequences, each home television receiver could assemble its own unique program.

If the images had to be selected deliberately by the viewer, through some explicit control action taken each time he wanted to see a new picture, the idea of trading the dynamic motion-picture quality of conventional television for the high degree of selectability under discussion probably would not seem attractive for any purpose. However, if we recall and extend the concept of a control subsystem introduced earlier, we see that the viewer need not concern himself with the individual selections. The procedure governing the selections can be programmed into the control subsystem and, what is most important, the procedure can be made contingent upon relations between the viewer's responses and criteria transmitted along with the sequences of pictures. This notion of making the selection of the next

picture contingent upon the viewer's responses to preceding pictures – responses he might make by pointing to part of the picture with a stylus or by pressing buttons on a portable response unit – can, in effect, convert television into a radically different and very interesting new medium.

The new medium would be especially appropriate for programmed instruction. Each receiving set would be equipped with a "light pointer" (a stylus connected to the receiver in such a way as to communicate the viewer's responses to the control subsystem), and scoring criteria would be transmitted along with the picture and sound of each "frame" of instruction. The result would be an extremely sophisticated teaching machine capable of presenting self-scoring multi-track instructional programs with automatic path selection. With such a medium, and with the aid of sophisticated programming, one should be able to involve each individual "telestudent" in an active participation that would verge upon true interaction with the program material.

Any scheme that requires the television receiver to hold an image for several seconds requires a receiver somewhat different from conventional receivers that use short-persistence picture tubes and embody no other means for storing the image than is inherent in the luminous phosphor of the display screen. However, devices and techniques now under development offer hope that receivers of the kind we have been discussing will be technically and economically feasible within a few years. Several different "buffer storage" devices have been tested successfully, and storage tubes are available that will hold their images until deliberately erased. An early development version of a "meshless" storage tube capable of displaying pictures with high resolution (i.e., the reproduction of fine detail) was demonstrated recently.

The dynamic – or, to put it more precisely, the kinematic – quality of moving pictures and conventional television is so obviously valuable that the thought of sacrificing it to achieve some other quality, such as the selectability just discussed, is likely to require a considerable amount

of urging, even though assurance be given that the idea is to supplement rather to replace the standard medium. But it is important to keep the mind open to periodic reassessment of the values and costs of various ways of using the resources available to television. It is important to face the fact that the cost of the kinematic quality is high. Another costly quality is what we might call the "full-pictorial" quality of the conventional television image. Conventional television does not provide very high resolution, but it does reproduce more or less faithfully the hue, the saturation, and the brightness of each small area of the scene before the camera. Typically, there is a large amount of information in a detailed picture, and it takes a wide channel to transmit such a picture in a short time. With the facilities required to transmit one image of full-pictorial quality, one could transmit many pages of letters and numbers or many line diagrams, graphs, and sketches. Text and line drawings can of course be transmitted, received, and displayed either with motion or without.

Recorded Television

The development of low-cost video recorders and recordings adds important new dimensions to educational television. The impact of these components will depend upon the quality and reliability of their performance, upon their cost, upon the merit of the programs available to and through them, and upon the effectiveness of the program distribution systems. The potential seems very great, for it includes both a marked increase in the number of programs from which viewers may select and freedom from the constraint of having to synchronize the viewers' schedules with the broadcasters'.

"Hard-Copy" Television

Although we are used to thinking of the output of a television set as ephemeral pictures ("soft copy") and sound, it is interesting to consider also some of the possibilities and problems suggested by the phrase "hard-copy television." The change of domain from soft copy to hard requires that

we make a corresponding change in the range of functions considered. Perhaps the most appropriate functions for hard-copy television overlap the functions now served by newspapers and magazines.

The concept of the newspaper delivered by wire has been discussed widely enough to need no elaboration here, but it may be worthwhile to relate it to ideas presented earlier about selection of program material by the viewer. The essential things are to give the viewer a way of specifying what he wants to have put into his newspaper and to incorporate into his receiver the means for selecting and recording, and later playing back upon demand, the appropriate items. Those requirements can be met by a blend of "ordering from menu" (as suggested earlier in connection with the augmented newscast) and "matching to profile" (as used in systems for selective dissemination of information). In one approach, for example, the televised newspaper would periodically broadcast an index to forthcoming news items, on the basis of which "subscribers" would make selections and designate them to the control sections of their receiving sets. Each control section would add to the list of designated selections a list of calculated selections, the latter being arrived at by comparing viewers' expressed interests with available news items. (The calculating might be done by a multiple-access computing service and fed into the receiving set via telephone lines. Indeed, the control section of the receiving set might reside mainly or even exclusively in a central computer somewhere.) The receiving set would then copy the desired items "off the air" and present them in the form of a custom-made family newspaper or custom-made newspapers for individual members of the family.

The basic theme of the foregoing discussion is of course selectivity, and the basic problem is the one already encountered and discussed: the problem of broadcasting enough alternatives to provide a basis for truly sharp selection. It is important to note how much that problem is simplified by the switch from the moving pictures of conventional television to the mainly alphabetic text of the news

article. The amount of space in the frequency spectrum (a bandwidth of about 5 million Hertz) required to transmit a conventional television program will carry about a million alphanumeric characters (letters, numbers, punctuation marks, etc.) per second. A standard newspaper column of text contains about four thousand characters. Thus one conventional television channel could carry the alphanumeric contents of a thirty-page newspaper each second. Indeed, if a recent estimate is even approximately correct, one television channel could transmit — on a continuing basis, as it is published — every bit of text that is published in any newspaper, magazine, journal, or book that finds its way into any recognized library or document room in the world. (J. W. Senders's estimate in 1963 was about two million bits per second.*) Evidently, if we limit the discourse to alphanumeric text, it is not lack of bandwidth that stands in the way of offering the world's fund of news and knowledge to every man in his own home.

All the news may fall within it, but not all the world's fund of knowledge falls properly within the domain — even within the here considerably extended domain — of broadcast media. The categories of content that do seem worth considering include, in addition to news, all the schedules and advance announcements and all the background information and evaluative commentary that pertain to situations or events of widespread interest, for no other medium than television has the potential capacity and selectivity to make available to each person at the time and place of his choosing his own self-prescribed subset of the whole.

Balance

In the foregoing sections, we have examined several possible variations of broadcast television, ranging from high-resolution motion pictures, with viewer control of the field of view, to hard-copy alphanumeric text. Although we examined them separately, we should think of them as components that technology could make available for use in a coherent communication system. In communicat-

*See *Science*, Vol. 141 (1963), pp. 1067–1068.

ing the news, there is a place for live color and motion coverage, another place for text, and still other places for most of the other variations. During a performance by a symphony orchestra, the main need is for high-quality sound and good pictures, but before and after the performance some of the other variations would find roles to play — especially if the viewer's purpose included learning as well as enjoying.

INTERACTIVE "NARROWCAST" TELEVISION

The ideas discussed in the previous section suffered from the conflict between the effort to select material of interest to the individual and the commitment to broadcast to a mass audience. Indeed, the central concept of "interaction" had to be set aside (except insofar as interaction could be simulated through schemes based on selection) because broadcasting to a mass audience essentially precludes interaction.

Networks for Narrowcasting

For educational television, a basic and important question is whether to continue to plan in terms of broadcasting to a mass audience or to adopt a framework in which the overall audience divides itself into many subsets and communication with each subset is carried through its own channel or channels. In the latter case, educational television would be pluralistic operationally and technologically as well as philosophically, offering a multiplicity of programs, services, and techniques, and using a multiplicity of channels.

Here I should like to coin the term "narrowcasting," using it to emphasize the rejection or dissolution of the constraints imposed by commitment to a monolithic mass-appeal, broadcast approach. I do not mean to imply that educational television has been wholly dedicated to such an approach or such a philosophy; indeed, I recognize that educational television stations have for many years carried

programs designed for narrow sectors of the public. Narrowcasting, however, may suggest more efficient procedures than broadcasting throughout a wide area in order to reach a small, select audience, and it is meant to imply not only that the subject matter is designed to appeal to selected groups but also that the distribution channels are so arranged as to carry each program or service to its proper audience.

Although broadcasting throughout an area from a transmitting antenna to many receiving antennas is by no means ruled out of the picture, linear channels — channels consisting of coaxial cables or wave guides or microwave links — seem in principle to be better suited to the purpose of carrying messages to selected audiences. Wide-band linear communications channels will be expensive, but much less expensive than transportation channels. For the purposes of this section, let us make the assumptions (1) that in the near term educational television gets a large number of additional channels of some kind* and (2) that in the long term it has access to such a network as one can imagine by projecting and augmenting the development of community-antenna television. The cables of CATV will evolve into multipurpose local networks, and the local networks will be linked together to form regional, national, and even international networks. The linking may involve broadcast transmission, with satellite relays playing an important role, and it may involve additional cables, wave guides, microwave channels, and so on.

The CATV networks that have recently come into the limelight are of course unidirectional. Supplementary facilities are required to permit communication from the home back to the station. Fortunately, the supplementary channels need not be wide-band channels. For some "feedback" purposes, the existing telephone system is suitable, but it is not designed to function with a large fraction of its terminals and peripheral lines in use at the same time. Perhaps very simple transmitters can be devised that will

*UHF channels, microwave channels, channels made feasible by satellite relays, etc.

make it possible to use coaxial cables for "feedback" as well as "outward" signaling. If that should turn out not to be technically practicable and no alternative capable of serving the feedback function were made available, I think we could be correctly accused of having a blind spot in our foresight. What more appropriate contribution could technology make to democracy than good channels of communication directed from every man to the foci of the society?

In present-day CATV, the aim (only slightly oversimplified) is to connect as many homes as possible through one cable to one antenna station. The network for narrowcasting, however, should approach as closely as is economically possible – which for a time may not be very closely – the ideal of a private cable to every home. The compromise I have in mind is one in which the quasi-geographical hierarchy of governmental and political organization, down to the level of neighborhoods, is reflected in a flexible organization of the network. That would provide a basis for effective selection of audiences at any local, regional, or national level in support of society-wide functions, such as government, education, and supply, that are organized mainly upon a geographical framework. Special functions not so organized, and not of wide enough interest to warrant being made available to everyone at his own property line, are served by main channels that extend as far as local tapping points, where connections are made to local cables owned by or leased or charged to individual subscribers.

Consider, now, the problem of achieving high educational purposes – and of being effective throughout the socioeconomic range as well as across the geographical span of the nation – with the help of such transmission facilities as we have just assumed. What can we hope to do when the bandwidth constraint is loosened?

Functions and Services

Based on a philosophy that appreciates the interaction value of diversity among the personalities, attitudes, and interest patterns of individuals as well as the cohesion value

of community in language and cultural heritage – and a philosophy that prefers active participation to passive observation – narrowcast television would endeavor not merely to present programs of general interest but to fulfill functions and provide services of special interest to groups of medium and even small size. The standard television functions would grow deeper roots: The news would include neighborhood and community news as well as regional, national, and international. The high-school football game and the local tennis finals as well as the bowl games and national championships would be on television. Community theater would have a chance to compete, if not with Broadway, with Hollywood. Extension of such functions to the local level might promote not only the personal involvement of viewers in the programs but also the participation of many people outside professional television in the preparation and presentation of television programs.

In the fields of government and politics, the impact of narrowcasting might be profound. Town meetings could be not merely televised but *held* via television. Every representative at every level of government could report periodically to his constituency. Every administrative official could explain the objectives of his agency and the significance of his executive actions. Every candidate could count on opportunities to reach the voters "live," and every voter could expect to see and hear live candidates under circumstances that would let him see through the "images" into the men.

In the performing arts, narrowcasting would probably do more for performers than for audiences. It would provide to many more performers the opportunity to have an audience and to profit from audience reaction. It would introduce a new factor into the dynamics of community theater. Especially at community and regional levels, performing artists make excellent audiences for other performing artists. Putting that fact together with the availability of links connecting local and regional networks suggests that narrowcast television might serve the performing arts best by permitting the members of community groups all over

the country to see and hear one another in action — symphony musicians communicating with symphony musicians, dancers with dancers, actors with actors, and so on. Thus facilitated, and with local, regional, and national lay audiences potentially available to them, the performing arts might burgeon like Australian tennis.

In the fine arts, narrowcasting could bring all the nation's, perhaps even much of the world's, great treasures into the home. Educational television would continue, of course, to present visits to the great museums under the guidance and with the commentary of distinguished authorities, and it would continue to present courses in history and appreciation of art. However, it would not stop there. Every museum would have a camera, lights, and connections to the network. In data bases accessible through the network, the inventories of all the museums would be held. With the assistance of a group of its members, or perhaps with the cooperation of an art school, each museum would feed into the network, according to schedules and directions arranged with programming offices, images of its works of art. The requests might originate either with official television agencies or with informal groups of viewers such as art clubs, or even with individual viewers. This approach would put some of the initiative for programming into the hands of groups outside professional television.

All the professions are concerned with continuing education of their members, in which narrowcast television could play an important role, and all have responsibilities to their publics, to which narrowcast television could provide selective channels. For science and engineering, indeed, narrowcasting might offer the first promising approach to the problem of educating the general public to comprehend the social impact of technology.

Finally, we come to the two fields in which nonconventional television appears to offer the clearest promises: the field of the library and the field of deliberate teaching and learning. The promises are offered jointly by narrowcast television and intercommunicational television. Let us consider here a few ideas pertinent to the former.

Narrowcast Television and Libraries

The community libraries suffer from a difficulty that is very familiar to broadcast television: economic considerations make it impracticable to offer much that is not sure to appeal to a large audience. In the case of the libraries the trouble stems from the fact that the distribution procedure is set up backwards, so to speak. First, many copies of each book are produced. Then the books are stored near where they may be wanted. And finally, prospective users go to nearby repositories, make requests, and, if the books requested are available there, borrow the books, read them, and return them. The economic disadvantages of duplicating, distributing, and storing books that may never be read is obvious. Some of the techniques of what is currently known as the "non-Gutenberg technology" make it possible to avoid most of that disadvantage.

Modern library science and technology deal, of course, with other problems than physical access to specified books. In the scientist's and engineer's use of the library, and probably also in most of the uses that arise in everyman's everyday life, the basic objective is not a document but the answer to a question or the solution to a problem. Even if the user is constrained (by the partly technical and partly economic infeasibility of automatic question answerers and problem solvers) from demanding direct access to his basic objective, he needs as much help in finding out which documents to ask for as he does in obtaining copies of the documents he requests. Fortunately, documentation experts are making fair progress in mastering the process of finding documents pertinent to a given request. The techniques — which include augmented cataloguing, deep subject-matter indexing, citation indexing and "bibliographic coupling" through citations, matching of profiles and prescriptions, and of course abstracting — require trained people, programmed computers, and a steady work load. They are, as the library system is currently organized, beyond the means of most community (and indeed many other) libraries.

Narrowcast television fits neatly into an obvious solution of the problem just posed. Master copies of documents

are held at central repositories: a national archive for infrequently used items, regional centers for moderately active items, and so on. All the libraries and document centers are netted together, and many of the nodes of their network communicate with nodes of the educational television network – and of course with nodes of other networks serving governmental agencies, universities, and business and industry. To use the library from his home, a person would communicate with a local station of the library network, through either his telephone or a feedback channel associated with his home information center, and describe his request to a person (perhaps eventually to a machine) at the station. The contents of the specified documents would be read automatically from the masters. The control system of the requester's home information center would be notified of the scheduled transmission time. At the designated time, the information would flow from the library's buffer memory through wide-band channels into the television network and thence to the automatically readied receiving set and recorder. Finally, the requester would play the record back through his display subsystem and study the documents at his leisure.

Many technical problems would arise in the development of such a system. Yet almost everyone agrees that they could be solved. And, as mentioned, progress on the "intellectual" problems of retrieval and dissemination is promising enough to encourage anticipation of some kind of matching of library and television within the next two decades. The main justifications for adopting a skeptical attitude are economic. Most of the functions envisaged require sophisticated equipment at the receiving location. There is little doubt that, if it were guaranteed a mass market, American industry would quickly develop the capability of manufacturing the sophisticated equipment at low cost. However, the economics of advanced home information systems will probably suffer, as the economics of conventional broadcast television did in its early days, from a chicken-and-egg dilemma. The needed equipment

would be inexpensive if there were a mass market, and there would be a mass market if the needed equipment were inexpensive, but since neither antecedent prevails, neither consequence follows. To anyone who thinks he sees in technology's potential armamentarium the weapons that can win the war against poverty – or even battles against delinquency or unskilledness – the inhibitory effect of that modest mixture of logic and economics is likely to be most frustrating.

Instructional Television

The concept of narrowcasting makes room for – and indeed calls for – great extension and augmentation of instructional television. The thing that, in my assessment, offers the most credible promise of making deliberate instruction and deliberate study attractive to almost everyone is a combination of inspiration through exposure to great minds and reinforcement through interaction with a rich and well-programmed base of information under the aegis of a skilled tutor. (I use the term "reinforcement" in the sense developed by Skinnerian psychologists, and I have in mind an awareness, derived from experience with computer-assisted instruction, that motivation is strengthened and learning fostered almost magically by close interaction with a partner that presents precisely appropriate answers, acknowledgments, rewards, and even punishments at precisely the right times. Indeed, a large part of the skilled tutoring will doubtless be done, in future educational systems, by programmed digital computers.)

The central idea to be developed under the heading of instructional television, then, is the idea of using augmented television facilities in an all-out effort to provide a self-motivating, self-rewarding kind of educational opportunity on a wide scale. The effort would of course have to be coordinated with schools and colleges. Indeed, it would have to involve a considerable fraction of the intellectual resources of the country.

Most of the ideas about devices and techniques that

have been mentioned are pertinent to the development of coherent systems to facilitate instruction and learning. Color motion pictures will be vital because they can convey into the home the personalities of distinguished men and the dynamic performances of skilled lecturers, and because they can show how intricate things work. The televised library will play an important role because it will be responsive to, and will foster, initiative on the part of the student. However, the basic task of instructing – of building structures of knowledge within the minds of students and training into their nervous systems the skills required in adjustment to modern life – will fall upon instructional programs with which students can interact.

The major technical question, I think, is how much interaction between students and contingently adapting and responding instructional programs can be accomplished through narrowcast television. Such programs will rely heavily upon transmission schemes of the kind described earlier as offering to each viewer a wide selection of lantern-slide sequences with audio accompaniment. It may turn out that sufficiently dynamic interaction with each one of many students can be achieved within the framework of the scheme in which the selection of the next picture together with its accompanying sound is carried out by the control subsystem of the student's receiving set. If so, then it will be possible to serve an audience of a few thousand with a single program. On the other hand, it might turn out to be necessary, in order to make the program truly adaptive and responsive to the students, to use "feedback" channels from the students' homes to the narrowcasting stations. That would make it possible to transmit program material selected from a large store on a moment-to-moment basis and thereby to give each student a truly custom-made course, but it would limit the number of students that could be handled by a single transmission to a few hundred. When so few participants are to be accommodated, and when they all reside in the same area, it becomes likely that the best solution throughout the foreseeable future

will be to bring the students together in one place and thereby simplify the communication problem. However, many technically competent people are unwilling to turn that statement of likelihood into a conclusion at this time, and more than a few think that, in fields that deal primarily with information, a modern version of "cottage industry" will prevail within a decade or two.

In any event, my hope is that enough channels will in due course become available to carry all the interactive power of computer-assisted teaching and learning into the home. Given enough channels, televised instructional systems – balanced systems in which the most highly interactive and the most dramatically dynamic techniques support and complement each other – will markedly improve the standard of education, the level of skill, and the quality of intellectual life in America.

INTERCOMMUNICATIONAL TELEVISION

From a point of view that is being taken by an increasing number of educators, "educational television" is perceived as the set of all the informational and communicational tools that can be fabricated out of wide-band channels. The prefix of "television" is taken literally, and the root is interpreted as meaning a large amount of communication channel capacity that should be put to the best possible use.

The applications of television envisaged from the viewpoint just described have to do more with communication within and among educational institutions than with communication between television stations and homes. It seems likely, therefore, that these applications will be developed sooner than applications based on similar techniques but requiring channels to receivers that are distributed throughout broad areas. Nevertheless, in the long term, there are clearly two parts to the idea of intercommunicational television. One of them focuses upon educational institutions – schools, colleges, universities, student bodies, faculties,

laboratories, libraries, and so on. The other focuses upon community information centers and home information systems. In concept, the community information center is a projection and augmentation of the educational television station, and the home information system is a projection and augmentation of the television-radio-phonograph-tape-recorder console.

At the present time, intercommunicational television is hardly an actuality at all. It is a collection of rich and attractive images that form part of a concept that is developing in the minds of a growing number of people. Closed-circuit television is an important part of the concept, but by no means the essence of it. The essence is a comprehensive, flexible, interactive, multipurpose information network that includes large collections of information and advanced facilities for storing, processing, transmitting, and displaying it. The media are diverse but coordinated, television playing its role in concert with speech communication, facsimile communication, and communication with and among digital computers. Indeed, computer-processible data bases loom large in the overall concept of the information network of the future. It is appropriate that educational television is studying (e.g., in the EDUCOM Summer Study on Information Networks*) its place within the overall picture and its interrelations with the other media.

"Overall process" is more descriptive than "overall picture," for an educational information network would be an active, dynamic, ever-changing thing. It would deal with many different kinds of information, stored in many different places and flowing among many different kinds of communicators through many different media and channels. Education uses printed documents, video records, computer programs, data, drawings, graphs, diagrams, still pictures, moving pictures, sound recordings, and live person-to-person, person-to-group, and group-to-group communications. The communicators are students, teachers,

*EDUCOM is the Interuniversity Communications Council. The report of the Summer Study (1966) will be published by John Wiley and Sons, New York.

research workers, librarians, documentalists, computer programmers, programmed computers, administrators, and managers. The functional tools used in teaching and research include lectures, demonstrations, documentaries, computer-assisted instruction, computer-facilitated learning, computer-mediated research, information retrieval, selective dissemination of information, computer-aided design, computer-assisted experimentation, "reactive mathematics," and "teleconferences." "Reactive mathematics" is mathematical thinking "at the console" – the computer reacts by carrying out whatever operation one writes down just as soon as he has written it. "Teleconferences" are conferences in which the participants remain in their homes or offices yet, with the aid of teletype, telephone, and television, work together in close interaction.

Not all of the foregoing require wide-band communication, but all can take advantage of it. All are seen as components of a comprehensive information network that would serve the classroom, the study, the library, the laboratory, the conference room, and the convention hall in an integrated way, each component supporting others and being supported by them. The planning and design of such a network (or networks) are currently of great interest, and one of the main questions concerns the role to be played by television. For the long term, it seems clear that television and the narrower-band media should operate in synergy as complementary channels in a coherent system. For the short term, however, it is difficult to see how to bring together in a meaningful way the narrow-band facilities available from the telephone and telegraph companies, the wide-band facilities owned or leased by educational television organizations, and other wide-band channels (including satellite channels) available from common carriers. A small but important part of the overall problem is whether all the so-called "television satellite" channels will be reserved for broadcast television or whether some of them will be assigned for use in multi-media educational networks.

Looking up again at the broad horizons, we may sense that, although the resolution of problems such as those just

mentioned may have very significant near-term consequences, they are unlikely to determine the basic structure of educational communication in the long term. The amount of communication will increase. The faster media and the media of higher capacity will grow in importance, both in relative measure and in absolute measure. The various media will be used in more coordinated ways. Information will, more and more, be encoded for processing by computers. Computers will enter into more and more phases of educational communication (and, indeed, into more and more phases of everyday life). When people communicate with each other, in teaching and learning or in dealing with complex problems of almost any kind, they will not merely transmit information back and forth; they will employ computers to transform and test the information and to relate their present ideas and facts to those already recorded. Communications between men and machines will constitute an increasing fraction of the total. Many people will have personal computer programs, "alter egos in the machine," to serve them as representatives and secretaries, and some of the communications that now involve people will be taken care of by those programs. Indeed, a large fraction of all communications will be communications between computers.

Most of the foregoing "prediction" is simply projection into the future of what now exists and is familiar to many. Nothing in the list of statements is beyond the range of technical feasibility. The uncertainties are mainly uncertainties of time scale, and they stem mainly from difficulties in predicting the interactions among economic, social, and psychological factors. On the one hand are those who see in modern informational technology a firm promise of making education not only universally available but universally achievable and universally attractive. On the other hand are those who hold that our rate of progress toward any such goals is limited essentially not by any lack of material resources or facilities, but by lack of basic understanding of the educational process. The position of wisdom no doubt lies somewhere between the polar extremes, but wherever

it lies, it calls for continual examination of the full range of possibilities offered by technology and periodic reassessment of our plans and courses of action in the light of those possibilities.

As a conclusion to this paper, let me presume to offer a tentative assessment. The main trend of educational television is somewhat too conservative in its estimation of the feasibility of selective, interactive, and intercommunicational television systems and of the achievability, with the aid of such systems, of a significant breakthrough in education. The main factor that is not sufficiently appreciated, I believe, is the effectiveness of interactive participation in a well-designed, strongly reinforcing educational process. Advances in technology are making it possible for the first time to set up such a process without depending upon lavish use of scarce human resources. Other advances are making it at least conceivable that we may be able to set up such processes on a broad enough scale to reach almost every educable member of the society. My conclusion, therefore, is that the situation calls for intensive research in two complementary fields: the exploitability of informational technology in support of education, and education within the new context offered by informational technology.